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AGREEN Community for climate-smart agriculture

Black Sea CROSS BORDER COOPERATION

AGREEN

CROSS-BORDER ALLIANCE FOR CLIMATE-SMART AND GREEN AGRICULTURE IN THE BLACK SEA BASIN

Subsidy Contract No. BSB 1135

CROP MODEL

CROP MODELLING FOR SYNTROPIC FARMING

Common borders. Common solutions.

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CROP MODELLING FOR SYNTROPIC FARMING

Climate-smart crop models, adapted to the environmental, social and economic conditions in the BSB region

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A. Choice of crop and method of experiment implementation

The effects of climate change highly challenge the productivity of the agricultural sector. In this respect the stallholders are the most affected. They are vulnerable to the impacts of climate change - decreased yields threaten their livelihoods. There is an urgent need to identify approaches which strengthen development efforts and enhance the adaptive capacity of farmers. Suggested model of syntropic farming is a model that enables farmers to withstand climate change impacts and produce more for own food security and additional income.

The Syntropic farming is a type of regenerative agriculture developed by Ernst Götsch (Switzerland) in Brazil. Through understanding of complex systems of the nature the Syntropic agriculture imitates natural regeneration of forests, enabling people to create dynamic and economically viable ecosystems that restore degraded soil biodiversity, while also integrating them with productive agricultural systems. This is an agroforestry approach designed to mimic a forest: first of all, like in a forest, plants are densely placed to maximize both horizontal and vertical space, which enables the system to capture the sun's energy in a best possible way. Plants and trees are carefully selected taking into consideration a process of succession; some of the initial plants will grow and die relatively faster, while others will grow slowly over the years. In time the system matures and the mix of plants become more and more diverse and productive.

Intense pruning is a unique aspect of syntropic farming. Pruned branches are used as mulch, which suppresses weeds, feeds soil microorganisms, and regulates temperature and moisture. Decomposition of pruned branches forces the tree to increase root activity, produce more gibberellic acid (growth hormone that stimulate nearby plants to grow faster), increase the amount of plant nutrients in the soil, increase the efficiency of the process of photosynthesis, which means absorbing more carbon dioxide and solar energy.

The syntropic farming gives possibility to produce food and/or cash crops, and therefore is a good model for smallholder farmers. For example, they can grow fruits as cash crop and grow stable plants between the fruit trees for food security. In addition, the syntropic farming helps to rehabilitate and regenerate the land. The positive results of sytropic farming are the following: healthy soil, profitable harvests, carbon sequestration, efficient land use, diverse farming, increased resources, ecosystem regeneration, low dependency on external inputs (including irrigation), and increased financial returns.

The introduction of the syntropic farming method is the first in Georgia and is an experiment in terms of the method itself, as well as the selection and testing of different staple plants. It is planned to test development of various cereal, legume and vegetable crops in fruit orchard. Based on the obtained results recommendations will be developed to consult farmers.

Georgian fruit farmers will have the opportunity to see, get acquainted, study and introduce a system of syntropic farming in their orchards. The model will be implemented on Elkana conservation farm “Seed Ark” located in village Tsnisi, Akhaltsikhe municipality, Samtskhe-Javakheti region. This is a land of 4.2 ha, used for multiplication of heritage wheat and other indigenous varieties of crops, as well as indigenous varieties fruit trees – apples, pears, plum.

The region Samtskhe–Javakheti is located in southern Georgia. It stretches over area of 6,413 km^2 with a population of 151.110. Samtskhe-Javakheti is a strictly agrarian region where the share of agriculture in total value added is largest in the country - 32%. Most of the human resources (about 64%) are employed in agriculture. The region’s agriculture is made up of family farms and commercial farms. Over 90% of production is accounted for by family farms. 73% of family farms produce agricultural products for own use, and for the remaining 27% - agriculture is a source of income. Irrigation is rather problematic and most of the farmers practice rain-fed agriculture in the region. In most of the region the summers are cool (+15 + 20 ℃), with little precipitation and cloudiness, with not much rains. The winters are cold and snowy.

B. Objectives and tasks of the experiment

The main objective of the experiment is to introduce syntropic farming model to farmers in Samtskhe-Javakheti and select best staple plants to cultivate in fruit orchards in Samtskhe-Javakheti.

This objective implies the following tasks:

- To arrange Syntropic farming model on Elkana “Seed Ark” farm – optimal use of land with diversity of staple plants;

- To observe and record performance of different staple plants used in Syntropic farming model;

- To select best staple plants for syntropic farming in fruit orchards of Samtskhe-Javakheti;

- To develop information package for syntropic farming development in Samtskhe-Javakheti and introduce it to local farmers.

C. Materials and methods

1. Area selected for model implementation

The model will be implemented on Elkana conservation farm "Seed Ark" located in village Tsnisi, Akhaltsikhe municipality, Samtskhe-Javakheti region. This is a land of 4.2 ha, used for multiplication of heritage wheat and other indigenous varieties of crops, as well as indigenous varieties fruit trees – apples, pears, plum. Since the establishment the "Seed Ark" farm, including fruit orchards, is managed based on organic farming principles.

An area of 0.5 ha (5,000 m^2), planted with indigenous varieties of apples will be used for syntropic farming model purposes.

Length of the model plot - 200 meters, width - 25 meters.

2. Description of the plot selected for the model (orchard)

Five rows of 15-year-old indigenous apple (different varieties) orchard will be allotted for the syntropic farming model.

There are 40 trees in each row (200 trees in total);

Distance between trees in rows: 5 meters;

Distance between rows of trees: 6 meters; under the shade of trees - 2 + 2 meters;

Between the rows of trees, the width of the area to be used for growing staple plants - 2 meters;

In total, in the orchard, the area to be used for growing staple plants: 1,600 m^2;

The area between the trees at present is covered by grass (edible grasses grow naturally), which is mowed twice a year (May, September);

According to the laboratory analysis of the soil, in the area selected for the implementation of the model, the soil type is brown-carbonate; pH is the alkaline (8.05); organic matter content is low (2.83%). The nitrogen content available to the plant is very low (25.16 mg / kg); Phosphorus content is low (15.96 mg / kg); Potassium content is very high (438.26 mg / kg).

3. Project importance and design

3.1. Soil Fertility

Up to 80% of Georgia's agricultural lands are poor in nutrients, therefore models that work on soil improvement are very important in Georgian context. The project aims establishment of syntropic farming model - one complete system of living organisms, which, in parallel to optimal use of the model plot area - creating diversity instead of monoculture, saving water resources, increasing the income of the farmer, is focused on improvement of the soil fertility. The main "element that creates soil fertility - edaphon (a combination of organisms living in the soil) or life in the soil, as without living organisms in the soil, there is no soil.

The upper layer of the soil should maintain optimal conditions for the survival of microorganisms and beneficial organisms as only in such conditions the decomposition of organic matter occurs, resulting in the formation of complex compounds of substances essential for plant growth and development. As far as the soil and plants are part of one whole system, in the proposed model, plants will have optimal conditions for good growth (light, warmth, moisture, nutrients). Only plants grown in optimal conditions have high immunity and can therefore cope with adverse environmental conditions.

Maintaining soil fertility through returning crop nutrients lost after harvest to the soil by returning pruned & chopped branches of trees and other plant residues. Recycling of plant and animal waste is important in organic farming. When the crop and vegetation are removed from the area, the soil loses energy and nutrients. Therefore, the main mass of plants grown in a given area, after harvesting, must be returned to the same soil. In this way living organisms existing in the soil are fed and through their metabolism substances important for the normal growth and development of crops - like carbon dioxide, amino acids, phytoncides, vitamins, phytohormones, etc., are released. For this purpose, proposed model will use pruned & chopped apples tree branches as mulch for staple plants, and as a fertilizer after harvesting vegetable crops. Also, the plant residues left after the harvest (scattering on the soil surface, and raked in) will be returned into the soil.

3.2. Optimal use of light energy and temperature in the area

Plants receive light energy from the sun and use it for photosynthesis. Light intensity affects plant growth and development. In the absence of light, the process of photosynthesis is inhibited and plant development is stopped. Excess light causes burns and plant depletion. This will be avoided due to the partial shading established in syntropic farming model.

According to the need for light, agricultural crops are divided into three groups: light-loving, semi-shade-tolerant and shade-tolerant - respectively, some crops need long days for growth and development (wheat, barley, potatoes, tomatoes, etc.) and some - relatively short (beans, millet, herbs, etc.). The model proposes selection of shade-tolerant crops with relatively short vegetation periods.

Only certain temperature conditions are normal for plant growth, photosynthesis, nutrition, respiration. The temperature sensitivity varies according to the phases of plant development.

According to the dependence on temperature, vegetable crops are divided into three groups: hardy /low temperature tolerant (rye, barley, wheat, alfalfa, peas, cabbage, onions, etc.); semi hardy / moderate temperatures (potatoes, beets, sunflower, lentils, flax, etc.); tender / summer crops (beans, watermelon, melon, etc.). Soil microorganisms also need certain temperature conditions - their vitality is inhibited at low or high temperatures. Optimal functioning is at 25°C.

3.3. Selection of crops

It is planned to select semi-hardy, shade-tolerant and relatively short-growing crops for the proposed model. Since shady plants harvest late, for the model implementation it required to organic fertilizer, minimal watering. Protection from locusts and snails is also needed.

On the selected plot, it is planned to sow different grain and vegetable crops and to plant vegetable seedlings between rows of trees (4 rows, total 1,600 m^2; 4 lanes in each row).

Vegetables - various salads, mangold, cucumber, mint, horseradish, sorrel, coriander, parsley, basil, etc. will be grown in two rows (800 m^2)

Distance between lanes - 0.5 m;

Distance between plants - 0.5 m;

Feeding area - 0.25 m.

It is planned to sow/plant 400 plants in one lane;

In total (4 lanes) - 1,600 plants;

For two rows - 3,200 plants.

Also cereal and legume crops (millet, flax, cow pea, chick pea) will be cultivated.

It is planned to sow one row (400 m^2) of millet and another row (400 m^2) with flax, cow pea and chick pea.

D. Activities

D1. Soil Cultivation for Sowing Between the Trees

The main purpose of soil cultivation is to create favorable conditions for the normal growth and development of agricultural crops (improvement of physical, chemical and biological properties of topsoil, water and air regimes), i.e. existence in soil of solid, liquid and gaseous components at the volumetric ratio (1:1:1), for which loose soil is necessary.

When there is air between the clogs and they are saturated with moisture, the plant root system develops well, the number of microorganisms grows and their vitality is activated, the processes of converting organic matter and mineral salts into plant nutrients are activated, the roots are better propagated both wide and deep, absorbing nutrients from more area.

Loose soil is especially important for root, bulbous, and tuberous plants (the better and faster growth of their productive part occurs).

In the case of deep tillage, the movement of the topsoil downwards and of the bottom soil layer upwards, their loosening and stirring took place concurrently. In loose soil, the root system of plants grows well, but the use of this method of soil cultivation has negative consequences: the structure and biological cycle of the soil are disturbed, the content of organic matter is reduced, different microorganisms (aerobic, anaerobic) live at different depths of the soil, and their number decreases when the clog is turned over.

Subsoiling (rototilling) is a better method (if the soil structure and the crop allow it), because the top, fertile layer (where good conditions for soil microorganisms are already created) does not move down, the soil structure is not disturbed, and earthworms are active; the soil is rich in humus, water easily penetrates into the soil, moisture evaporates gradually and not all at once; the root system develops well; soil self-renewal processes are active, etc. Therefore, when this is possible, soil loosening should be done lightly, without turning the clog.

The use of the zero (no-till) tillage method (sowing of agricultural crops on uncultivated, untilled soil) is effective only on light soils and when the biological and mechanical methods used against weeds are effective.

In the proposed model the surface tillage or minimum cultivation method will be used:

1. Soil loosening to 15-cm death (02.2022, according to weather)

2. Cultivation (soil loosening) (02.2022)

3. Rototilling (soil loosening) (03.2022)

These operations are performed using the rotary tiller “Meccanica Benassi RL328-Kohler 7,0”.

4. Sowing (03-04.2022)

Flax, millet and greens will be sawn on rows.

5. Planting of seedlings (03-04.2022)

Seedlings of vegetable crops will be grown and transplanted on a cultivated plot.

6. Fruit tree pruning, chopping tree cutting (03.2022)

Fruit trees will be pruned; the tree cutting will be chopped (for mulching the soil in inter rows of vegetables and legumes);

7. Interplant hoeing & weeding (04-05. 2022)

Will take place to remove weeds and loosen the soil.

8. Mulching with the tree cutting (04-05.2022)

Mulching with organic matter will facilitate:

- inhibition of weeds and improvement of soil structure;
- protection of soil from erosion and prevention of nutrient leaching;
- protection of soil from sharp changes in temperature;
- development of a strong plant root system;
- protecting the soil from drying out, retaining moisture, producing dew and reducing irrigation frequency;
- generating more carbon dioxide and dew;
- delaying the development of fungal diseases;
- activating the process of photosynthesis, getting an early harvest, increasing the vegetation period and yield;
- getting a quality and tasty product.

Organic matter is food for microorganisms, fungi, and worms living in the soil and promotes their reproduction and vitality activation.

The model uses one of the best organic mulches (active mulch) - a chopped apple tree cutting, which will be layered on loose soil, at 5-7 cm, in rows of vegetables and legumes and moisturized; the material is rich in nitrogen, is the best food for microorganisms living in the soil, attracts worms, inhibits the emergence and development of weeds; the soil is always moist and loose.

During the vegetation period of the plant, part of the mulch is processed by soil microorganisms, while the rest is deposited in the soil after harvest; before mulching, the soil will be loosened at the depth of 10 cm and the vermicompost will be scattered in a thin layer on the soil surface; the use of this mulch is especially effective in hot (low humidity) regions, where irrigation of the so mulched soil will take 10 times less water than of the soil without mulch.

9. Irrigation (06-08.2022)

Water helps maintain plant cell turgor (tissue, cell tone), photosynthesis, absorption of nutrients, and their transport into plant tissues. Only a small part of the assimilated water is spent on the creation of organic matter; the largest part of the plant evaporates in the air (protecting itself from overheating); the need for watering is determined according to precipitation, the biological characteristics of the crop, the phases of its development.

The optimum soil moisture for good plant growth and development is: up to 90% during the seedling growth period; 50-70% before flowering, 30-50% during the flowering period. 60% humidity is optimal for the viability of soil microorganisms. Plants need only the required amount of moisture because in drought and excess moisture conditions, biological processes in the soil are inhibited or interrupted. It is planned to use the most efficient method of irrigation - drip irrigation system; since vegetables and cereals are grown in a semi-shaded area by fruit plants and are mulched - the need for watering will be much less.

In drought conditions, vegetable crops will need 2-3-times watering to be done through a drip irrigation system.

10. Application of organic fertilizer (05.2022)

The plant, like all living organisms, needs food from the soil, water and air to go through the life cycle. Plant food is organic and inorganic (mineral) substances present in the soil in assimilable form, the quantity and ratio of which determine the health and productivity of the plant. The amount of mineral salts in the soil is variable and depends on many factors (temperature, humidity, precursor culture, etc.). In the biochemical process of the plant (along with carbon, oxygen and hydrogen) 32 elements are identified today, of which the presence of macro and microelements in the soil is a necessary condition for normal plant growth and development, for which we use a unique microbiological fertilizer produced by worms, called vermicompost or biohumus, and which is the best fertilizer for plants and the best natural way to maintain living soil.

Dry organic mass in biohumus is 50%, humus - 18%, pH = 6.8-7.5.

Biohumus contains all the nutrients necessary for plant growth and development and biologically active substances, enzymes, protects the plant from stress, accelerates seed germination, increases plant resistance to pests and diseases, etc. Biohumus quickly restores agro-technical indicators of "tired soil", reduces nitrates and chemical wastes in it, prevents the development of abnormal microflora, etc. Biohumus can be applied to the soil in any quantity; biohumus (unlike manure) does not contain weed seeds and pathogenic microflora; it is not washed out from the soil; the plant responds immediately after its application, which increases the vegetation period by 15-20 days.

11. Measures against the spread of pests of agricultural crops

Agricultural pests are species of insects, mites, nematodes, mollusks and animals that are harmful to plants and are one of the major problems in agriculture. They damage the plant, transmit viral and fungal diseases, reduce yields.

Biocontrol of plant pests is a regenerative method by which we enhance the processes that take place in nature by themselves, significantly reducing the number of pests in the area by beneficial parasites and predatory insects. The predatory insects are spiders, predatory flies, ground beetles, bombardier beetles, mites, odonata (dragonflies and damselflies), green lacewings, bugs, wasps, mantises, ladybugs (one ladybug worm destroys 100 aphids a day, and one pair during sexual activity destroys 1,600 aphids a month). Beneficial parasites are parasites of the body of pests, for example, aphid parasite ichneumonid wasps lay eggs in the body of aphids (one aphid parasite destroys 200 - 1,000 pests).

The project will attract entomophagi (beneficial insects) and promote their reproduction. For this purpose, a shelter for beneficial insects ("guest") will be set up in the apple orchard, where straw, cones, broken bricks, finely chopped pieces of large tree branches will be placed. Insects live and stay permanently in this "guesthouse", feeding or parasitizing on pests and their eggs, and significantly reducing their number.

12. Spraying of bioinsecticides against pests (05.2022)

It is planned to use the organic pesticide of lavracidal action "Lepidine" against harmful insects.

This organic pesticide is against pests: fall webworm, apple and fruit moths, totrtix moths, silkworms, codling moths, box tree moth, sod webworm, potato tuber moth –tuberworm, tomato moth, cabbage moth, geometer moths, brown-tail moths, green moths, aphids, mites, as well as other summer-autumn scale pests.

In addition, "Neem Oil" which is a biological insecticide-acaricide (the main active ingredient is azadirachtin, it also contains other limonoids) is planned to be used. The preparation uses neem oil and saponins extracted from the fruit of the soap tree, so it is water-soluble, ready-to-use form. It is used in agricultural crops, forestry and greenhouse nurseries, by spraying on leaves and / or by direct application to soil. The biopreparation is used against caterpillars, mites, whitefly, greenfly, aphids, thrips, mealybugs. scale insects, grasshoppers.

These pesticides are not phytotoxic, are safe for humans, animals, birds, bees and other beneficial insects, are eco-friendly and help maintain an ecological balance, also are non-waste.

13. Spraying biofungicide against fungal diseases (05-07.2022)

Fungal diseases affect plant stems, fruits, new and old leaves. The disease-causing agent penetrates mainly the plant as a result of mechanical damage (by hail, pests, animals, humans). The disease develops much faster in organically poor soils.

Fungi and bacteria enter the plant and start producing enzymes that break down its tissues, which reduces the amount of potassium and lowers immunity. These enzymes are inhibited by the presence of the required amount of calcium ions in the plant).

When infected by a fungus, the plant "activates" the defense mechanism, the effectiveness of which depends mainly on the number in the plant of elements (K, Si, Mn, Cu, Zn, B).

A sharp drop in temperature, high humidity, thick-set crops and wind promote the rapid spread of the fungus.

In order not to create conditions for the spread of fungal diseases in the plot, we will use the following methods and measures:

- Use of organic mulch;
- Avoid adverse effects due to sharp changes in day-night temperature (correct sowing dates);
- Planting seedlings at an optimal time (late transplanted, overgrown seedlings are damaged more intensively);
- Use of drip irrigation system;
- Maintain optimal soil moisture;
- Attracting entomophages (arranging a "guesthouse");
- Use of ready-made biofungicides.

In case of fungal diseases (powdery mildew, red spot, scab, leaf rot, anthracnose, phytophthora, perenosporosis) we will use the drug "Cuproxat", use of which is permitted in organic farming. The premium cooper fungicide formulation readily mixes in water and stays suspended longer than any other liquid formulation. The action of the fungicide is directed against the germination of disease-causing spores, so it prevents the development of the pathogen at an early stage.

14. Harvesting-storage-sale of vegetables and cereals (07-11. 2022)

D2. Required materials

1. Drip irrigation system 1,600 m^2 (16 lanes);
2. Tree prune mass chipper (for mulching);
3. Seedlings of vegetable crops;
4. Seeds of vegetables, cereals and legumes;
5. Biofertilizer "Vermicompost", 500 kg
6. Bioinsecticide Lepidine
7. Bioinsecto-acaricide "Neem Oil", 2 liters
8. Contact fungicide "Cuproxat", 2 liters
9. Construction and arrangement of a shelter for beneficial insects ("Guesthouse") in the plot.

D3. Number of workers - man-day

1. Tillage (with machinery) - 1
2. Cultivation (rototiller) - 1;
3. Rotary tilling (rototiller) - 1;
4. Sowing (by hand) - 2 workers / 1 day;
5. Planting seedlings - 2 workers / 1 day;
6. Fruit pruning - 1 worker / 3 days;
7. Packing the tree cutting, removing it from the plot, handling it in a shredder, placing it in sacks, storing - 1 worker / 3 days;
8. Hoeing (loosening, removal of weeds) - 3 workers / 5 days;
9. Bio-fertilizer application - 1 worker / 1 day;
10. Crop mulching (transportation of mulch in the plot, equal distribution in the rows of plants - 3 workers / 2 days;
11. Watering - 1 worker / 1 day ;;
12. Spraying of bioinsecticides - 1 worker / 2 days;
13. Spraying of biofungicide - 1 worker / 1 day;
14. Harvesting, handling grain threshing-drying-storage - 3 workers / 3 days;
15. Disassembling the drip irrigation system, cleaning, removal from the area, packing, storage - 1 worker / 1 day;
16. Cultivation in the area, mulching and turning plant waste into the soil - 1 worker / 1 day;

E. Expected results and impact

Introduction of the syntropic farming system will facilitate:

- Diversifying the existing (mainly monoculture) agro-ecosystem, rapid and constant growth of its resources and vitality;
- Optimal use of land area and arrangement of multidisciplinary and diverse farms;
- Saving water resources, reducing irrigation frequency (twice watering instead of six-times watering);
- Maintaining soil fertility, increasing the number of plant nutrients, the number and vitality of edaphons in it;
- Return of food and energy extracted from the soil to the soil (turning the pruned fruit mulch into the soil);
- Increasing fruit productivity by using nitrogen accumulated by Rhizobium bacteria inhabiting the root nodules of legumes;
- For vegetable crops, avoiding the negative effects of excessive solar radiation (due to shading by neighboring trees) and, consequently, increasing the crop quantity and quality;
- Increasing the photosynthesis process efficiency, reducing the high temperature of the environment due to the absorption of more carbon dioxide and solar energy by plants;
- Increasing the activity of tree and plant roots, producing more gibberellic acid (growth hormone, stimulant), increasing productivity;
- Increasing the range and quality of agricultural products, increasing the farmer's income.

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