Alley cropping in a hillside terrace system

Final Report for FNC13-916

Project Type: Farmer/Rancher
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Region: North Central
State: Ohio
Project Coordinator:

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Project Information

Summary:

My grant project “Alley Cropping in a Hillside Terrace System” sought to transform the steep slopes of a newly planted fruit orchard into a sustainable agriculture system incorporating earth berm terraces, no till annual agriculture, with a cut-and-carry mulch system. Goals included creating access to and passive water harvesting for the entire landscape, obtaining an immediate yield of annual crops that could be repeated until the fruit trees matured many years later. Also this annual system needed to build soil rather than lose it to erosion, it needed to be cultivated with minimal effort, little to no outside inputs, and minimal equipment and capital needs.

To achieve this, I began by shaping the hillside into a series of flat cultivable terraces separated by earth retaining slopes. Placing the terraces on contour, the system was able to passively collect rainwater and any organic matter or nutrient runoff and hold it in the terrace beds. I then planted the slopes above the terraces with nitrogen fixing and deep rooted, mineral accumulating plants that would later be cut and used to mulch the crops planted on the terraces.

By planting butternut squash into small patches of disturbed earth within the established sod of the terraces, and then carefully mowing down the sod until the squash began to sprawl outside of the planting patch, and finally cutting the slope above the terrace and raking the detritus down onto the terrace and using it to smother the weeds around the squash, I was able to obtain a significant yield of squash without any weeding, tilling, outside fertilizer or herbicide application, or significant irrigation. With only a push mower, a scythe, shovel, and a rake I was able with minimal effort to raise a crop in a manner that is ecologically sound, cost effective, and quite possibly actually sustainable.

The question of long term sustainability is one that I set out to discover. I had hoped that the system would continuously enhance the nutrient profile and % organic matter of the soil in both the terrace and hillside (mulch producing) areas, but this I did not discover. The assumption I worked under and hoped to test was that by using the right plants I could somehow violate the so called “Law of Return”

of Albert Howard. By growing and harvesting perennial nitrogen fixing plants I hoped that atmospheric nutrients like carbon and nitrogen could be fixed into the soil creating an excess of these elements on the hillside plots, plus these same elements would be accumulated in the aerial parts of the plant and when used as mulch would add “free” nitrogen and carbon to the terrace. Growing deep rooted plants in the same area was intended to mine the soil minerals like Potassium and Phosphorus and the rest of the micronutrients from the subsoil. Repetitive cuttings of these crops, I thought, could speed up the rate at which the roots and soil biology could mineralize these nutrients from the earth and pull them from the subsoil and upon decomposition, add them to the topsoil. Some of this nutrient would be accumulated in the aerial parts and spread to the terrace as mulch and some would be re-dispersed in the hillside through root sloughing and winter dieback of the uncut portion. To measure this I conducted a series of soil tests, comparing two test plots to a control, however, the results of the test showed such variability (increases in some nutrients and decreases in others) that I could draw no conclusions.

Despite the lack of scientific rigour, the project anecdotally achieved all of its objectives and demonstrated to me that a sustainable annual agriculture system is possible in hilly regions of the world and it can be achieved by anyone with access to land and a few hand tools.

Introduction:

Conventional farming through mechanical tilling and harrowing when performed on even gently sloping terrain inevitably results in erosion and loss of topsoil during heavy rain events. Even heavy grazing of livestock on steep hillsides can result in erosion and the creation of gullies. Furthermore, mowing these areas can be quite hazardous to farmers as tractors can easily tip over if not used properly. The result is that these lands are often subject to degradation through erosion or left to return to forest. If one has plenty of flat arable land to work with, then leaving the hillsides to nature is a reasonable option, but if all the land in the region is on a slope as in SE Ohio, then a better method is necessary. Taking a lesson from ancient agricultural societies around the world, I devised a regional adaptation of the traditional terrace system. As labor is not as abundant, and time not as cheap as it once was, and given the typical resouce base of those in Appalachia, my project sought to quickly and cheaply create a terrace system using only the dirt from the site itself.

To make the project fit within my particular interest of working with hand tools and onsight resources, I further designed the system to produce all of its own fertilizer, weed control, and moisture retention via a cut-and-carry mulch application. Placing the terraces on contour, or perpendicular to the flow of water, allows them to naturally catch and hold rainwater as it flows downhill. Incorporating mulch allows this harvested rainwater to stay around longer. Growing the mulch directly above the terrace on the retaining bank, means that it only has to be raked a few feet downhill once cut. By employing a variety of nitrogen fixing and deep rooted perennial plants in the mulch patches I hoped to create the most nutrient rich mulch possible.

All of this combined results in "Alley Cropping in a Hillside Terrace System" or a low-cost, low-input, sustainable agriculture method for hilly regions around the world.

Project Objectives:

1. To test the economy, stability, and functionality of earth-bermed terraces.

2. To test the suitability of various plant combinations for use as cut-and-carry mulch and to discover how much area needs to be devoted to mulch production to provide sufficient mulch coverage to suppress weeds.
3. To discover if the combination of deep rooted plants and Nitrogen fixing plants could be continuously cut and removed from an area without depleting the soil in violation of the “law of return”.
4. To determine the overall performance and energy requirements of farming in this fashion and assess its viability as an agriculture system for hilly regions.

Cooperators

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Research

Materials and methods:

To begin the project, we built a series of terraces on the hillside of my new fruit orchard with a Bobcat track hoe (a detailed description of this process can be found in the annual report of this project). This resulted in six 5'-7' wide terraces across the width of the land supported by steep earth-berms and separated by at least 10' of sloping hillside land (see attached pictures). Within this area, three plots were created (two experimental plots and one control plot), each consisting of a length of terrace approximately 50' long and 6' wide (these plots were denoted 2A, 2B, and 2C). Directly above each of these terrace plots on the hillside, three plots of the same length and about 8' wide were created (these are denoted 1A, 1B, and 1C. Thus 1A is the hillside above terrace 2A and so forth). Next each of the three hillside plots (the areas above the terraces) was planted with a combination of perennial mulch plants. In the Spring immediately after the excavation of the terraces, one hillside plot was successfully populated with comfrey, stinging nettle, and white clover (1A), another was populated with comfrey, yarrow, and goumi shrubs (1B), and the third was left to the existing cover of mostly blackberry, purple knapweed, and goldenrod (1C). The hope was to establish a variety of deep rooted plants designed among them to accumulate all significant micro and macro nutrients (Against our best efforts some of the desired species did not survive well enough to be used in the experiment unfortunately -- read more on this in the annual report).

Below each of these hillside plots, the terrace beds, in order to get the rocky subsoil

to a suitable state, were covered with compost and then sown with a mixed Winter kill cover crop. The following Spring soil tests were taken from each terrace plot and each hillside plot to establish a baseline (see attached excel sheet for soil test results). Next the terrace was mown with a push mower to clear it of weeds that had come up during the Fall and Winter, and then every five linear feet a one-foot-diameter area was stabbed repetitively with a shovel to kill the existing sod. Into this "tilled" area, several butternut squash seeds were sown and watered (June 23). A few waterings and three weeks later when the squash plants were several inches high, the terrace was again mown (the area around the squash plants) to allow the squash to get ahead of the weeds that were now blanketing the terrace plots. At this point in the experiment, the mulch plants had grown to a considerable size (having now been in the ground establishing roots for a little over a year). On July 21, before the squash spread too far, each hillside test plot was hand cut with a scythe and then the cuttings raked down onto the terrace and gently placed around the sprawling squash plants to smother the encroaching weeds. Although another mulching was planned for the end of August, by this time the squash had gotten so far ahead of the weeds and also so sprawling that further mulching became impractical.

At the end of September the squash was harvested from among the weeds, counted, weighed and analyzed to see which test plot if any yielded the best. Next a final soil test was taken to determine if in fact we had increased nutrient levels in both the hillside and terrace plots as we had hoped. Chickens were then let in to clean up the debris and the area is now blanketed in snow and awaiting the Spring when the whole process can begin again.

- Terraces in orchard

Research results and discussion:

By hiring my neighbor and his bobcat track hoe, for about $600 I was able to create terrace beds 6 feet wide that encompassed over 800 linear feet. These terraces and the earth berms supporting them have held up extremely well to the freezing and thawing of two winters, to considerable rain, to constant foot traffic, and to some light machinery use, with every indication that they will remain useful for generations to come. Immediate planting of the earth berms ensured they were held in place by plant roots and prevented loss from erosion.

As far as passive irrigation is concerned, during and for many hours after a rain event up to one inch of standing water could be observed collecting on the terraces. Because they were reasonably level no erosion was observed and water was successfully collected and absorbed into the landscape (I did not collect moisture readings to compare the performance of the terraces to a hillside plot as I had hoped).

Although the mechanical creation of the terraces resulted in a compacted subsoil as a growing bed, with a little compost and cover cropping, they have all become suitable for agricultural use (except for one that is still mostly rock). The extra terrace beds created during the project that were not used for the grant have all produced crops of potatoes, beets, and turnips with no irrigation other than the moderate rainfall we received during the growing season. Creating these terraces on the steep hillside of my young fruit orchard, has greatly increased the amount of tillable land on my farm, and provided opportunity to grow annual crops in the abundant time and space between the planting and maturing of the orchard trees.

Additionally the terraces have created perfect access paths between the rows of trees upon which I can drive a small tractor or push a wheelbarrow. Overall creating the terraces was a supreme success offering many benefits to the site.

Anecdotally the rest of the experiment was a huge success as well. I successfully grew high quality butternut squash using only passive irrigation (the water used to germinate the seeds was collected in rain barrels and gravity fed to the site), onsite mulch, and hand tools (and a push mower) in a no-till alley cropping system on a hill that is too steep to even drive a tractor. The work required was minimal and the crops harvested were adequate given the soil conditions (averaging about 8 lbs per plant in the test plots and 4.5 in the control (The soil in the control ended up being considerably thinner than the test plots and possibly more shady).

Although not all of the desired species were established in the cut-and-carry mulch patches, the ones that took flourished and will continue to produce mulch for an indefinite period. Of all the plants used, the best performer by far was comfrey, and it was the only plant tested that rebounded quickly enough after the initial cutting to produce enough growth for a significant second cutting that same season.

The effort and cost of establishing the mulch patches was further justified when the amount of biomass produced and the quickness of regrowth (in the case of the comfrey) was compared with the established patch of weeds (which hardly regrew at all). Not only did the test plots provide better coverage per area cut, but they also provided a more easily spread mulch that did not have painful thorns like the blackberry. In July when plants were probably at about full size, an approximately 8’ wide swath of mulch plants from either of the test plots could provide an approximately 2” deep mulch over most of a 4’ wide bed of the same length (see pictures in attached powerpoint). This suppressed the weeds entirely for several weeks and then slowed down weed growth long enough that they could not catch up with the squash. The control mulch plot of the same size (8’ wide) could only be put down roughly 1” thick over the same 4’ wide bed. Furthermore, due to the more slender growth of the stalks and stems of the species in the control group compared with the broad leaves of the comfrey, the weeds were not suppressed as well in the control plot. And the best part of establishing these mulch plots is that now they are there and ready to use next year and for years to come.

As to whether the test plots cycled nutrients better or enriched the soil more than the control remains inconclusive (see attached spread sheet for results). The soil tests exhibited such great variability that no conclusions could be drawn (increases in some nutrients, decreases in others, and overall very random changes that may be the result of sampling errors), and I believe that only a more controlled longitudinal study could answer the question of sustainable nutrient management.

Ultimately, I learned to try to test one thing at a time and that the complexities of nature are hard to isolate in field trials, especially for amateurs such as myself. Still it was a very interesting and edifying experiment for me and the results although not as scientific as I had hoped are very encouraging to me.

- squash after second mowing
- squash among the weeds
- Comfrey and nettles
- Soil test results
- mulched terraces

Impact of Results/Outcomes

Successfully demonstrated a sustainable annual agriculture system that uses only hand tools and onsite inputs.

Participation Summary

Educational & Outreach Activities

PARTICIPATION SUMMARY:

Education/outreach description:

I shared this exciting alternative farming method with over 50 children at my farm summer camps. We even ate some of the comfrey and nettles and used the yarrow to make a salve. I also used the site and experiment as a teaching tool and demonstration piece at my permaculture design class and for my students at Hocking College. From the site I was able to teach about earthworks and water harvesting, soil building and nutrient cycling, alley cropping and agroforestry, no-till agriculture, the soil food web, and other general permaculture principles. The site has also become a primary feature of my regular farm tours and has been discussed regularly on my farm facebook page: https://www.facebook.com/TransitionToOffGrid?fref=ts .

Additionally, I gave a lecture on the topic of this grant at the Ohio Pawpaw Festival in 2013 and then an update in 2014 (updated powerpoint attached), and am scheduled to present the subject at the 2015 OEFFA Conference under the title “Post Carbon Agriculture” as well as at the Beachdale Garden Symposium (will send presentation when completed).

- Presentation given at Ohio Pawpaw Festival

Project Outcomes

Recommendations:

Potential Contributions

Based on the experience gained during this experiment, I do think that if refined and further developed, this system could provide low-resource farmers on hilly, marginal land with a low-capital farming strategy ideal for homesteading or small scale agriculture. With a minimal upfront investment of hiring an excavator and acquiring planting stock, a system can be created that requires only a scythe and shovel to manage. And if no capital exists, the terraces can be hand-built with the same shovel and the existing weeds used as mulch or useful native species transplanted into the area.

While the data regarding the soil building potential of the system is inconclusive, I still believe that this approach may provide a form of closed-loop agriculture that could persist in the face of oil and resource shortages (higher transportation and

input costs), or simply for those of limited means. Growing one's own fertilizer, weed suppression, and moisture retention right next to one's crops results in a system with minimal required energy inputs and thus minimal environmental impact.

Future Recommendations

When I develop my next terrace system, I will be more careful of how the topsoil is placed and try to create an uncompacted bed ready for planting. I will definitely use more comfrey for mulch and also try to integrate burdock and perhaps poke weed as they are both deep rooted and tenacious--quickly producing a lot of biomass. Studying what the best combination of plants for quick biomass production is an exciting prospect as well. I will also make the beds wider next time so that there is sufficient room for a planting bed as well as paths on either side (at least 8’ or 9’ wide). I will pay more attention to ensuring that the terraces are all connected so that one can drive a mower easily from one terrace to the next. I will also experiment with other crops. Quick growing plants such as squash and other vines seem ideal, compared to smaller plants like lettuce and beets. I suspect corn would do great in this system, as could tomatoes, peppers, or other vertically oriented plants.