

Spirulina

GROWING MANUAL

REQUIREMENTS

GROWING PREMISE

Spirulina is grown in water and does not come in contact with land. It requires a pool or a container which can be placed in a yard or on a balcony, windowsill or roof.

Spirulina needs sunlight. 350 microeinsteins is the most suitable level for Spirulina.

It is also important that the growing premise be able to provide shade, as direct sunlight may harm Spirulina, especially in its early stages. A removable cover can provide the shade needed.

GROWING FACILITY

Spirulina is grown in water, in containers or pools that are relatively shallow.

Containers (such as aquariums) can be made of plastic or glass (note that glass is less practical as it breaks easily). Spirulina needs sunlight so a transparent container is a good way to increase exposure.

Pools can be built using a variety of materials. They are usually built from a **construction** – a frame which can be made of wood, metal, even sacks filled with sand or soil; and **lining** – for which greenhouse tarp can be used, as well as any sheet of rubber or HDPE (High-density polyethylene). Generally speaking, plastics that are polyethylene based are the best option as there are no known health hazards related to their use.

Cement is not recommended, unless it is lined with greenhouse tarp in a way that it does not come in direct contact with the Spirulina.

Pool measurements depend on the number of people expected to consume the Spirulina: Each square meter pool will provide approximately 10g of harvested and pressed Spirulina a day.

A **greenhouse** is needed to protect Spirulina from rain, as rain will dilute the growing culture and alter pH level; From dust and sand, as dust and sand tangles in the Spirulina making it heavy and causing it to sink to the bottom where it is less exposed to light; From flies and insects; And from strong sunlight, as direct sunlight may harm Spirulina, especially during its first stages, when it has not yet matured.

WATER

Spirulina is grown in a culture medium that is made of water and fertilizers.

Due to the high pH of this culture medium, Spirulina has almost no competitors. This means that it is not “fussy” regarding the water it needs: drinking water, brackish water, water from a natural body of water or rainwater can be used. Almost all parasites, germs and viruses cannot survive the alkaline environment in which Spirulina strives. It is important to note that excluded from this are water containing heavy metals, as Spirulina will absorb them.

FERTILIZERS

The culture medium in which the Spirulina is grown consists of water and fertilizers. The specific 'recipe' can vary according to environment, type of Spirulina and availability of fertilizers. All 'recipes' are a variation of the Zarouk Medium defined in 1966 and it should be the reference for Spirulina farmers that want to experiment with the culture medium.

The following fertilizers are required:

Sodium Bicarbonate (NaHCO₃) – Drinking soda powder which can be found at any market. **Potassium Nitrate (KNO₃)** – Can be substituted with urea (which is made up of ammonia and CO₂), though it is recommended for more experienced growers as its concentration in the medium must be kept low (below 60 mg per liter); Or with any nitrogen containing fertilizer, in which case potassium sulfate should be added.

Sodium Chloride (NaCl) – Any cooking salt.

Potassium Dihydrogenate Phosphate (KH₂PO₄) – Can be substituted with any agricultural phosphate (Diammonium phosphate or Monoammonium phosphate; Phosphoric acid can also be used but is recommended for experienced growers, as it must be used with caution).

Iron Sulfate (FeSO₄) – Pentahydrate, not the type used for lawns.

Magnesium Sulfate (MgSO₄) – Pentahydrate.

* When growing Spirulina in pools a source of calcium must be added from lime, calcium chloride or gypsum.

* If fertilizer grade chemicals are used, they should be of the “soluble” or “crystallized” type, not of the “slow release”, granulated type.

*Fertilizers should be of **food grade** quality at least.

Micronutrients solution is not a necessity, but it will enhance the nutritional value of the Spirulina and will enable easier harvesting.

FRESH SPIRULINA

At least the quantity of a test tube is required to begin with. A few jerrycans will make the beginning easier.

A portion of strong and mature LIVE Spirulina (i.e. Spirulina that is ready for harvesting or multiplying) can be purchased - or better yet - passed from one Spirulina grower to another so that the latter can start a new Spirulina culture.

Spirulina can also be bought. There are a number of Spirulina culture collections around the world that will send Spirulina by mail.

LITMUS PAPER (or any other method for examining pH)

The culture medium in which Spirulina is grown is highly alkaline, an environment that ensures Spirulina's dominance and protection from most contaminants, as the vast majority of parasites, germs and viruses cannot survive it.

The pH level of the growing culture should be maintained at 10-10.5.

Though it can be done using sophisticated laboratory equipment, the easiest and cheapest method of examining pH level is done by dipping (for 2-3 seconds) litmus paper in the culture medium containing the Spirulina: The colors of the paper will change. Comparing the colors of the paper to the scale on the litmus paper box will indicate the pH level of the culture medium.

Litmus paper can be found at school labs and at stores that sell aquariums.

FILTRATION CLOTH

Harvesting Spirulina is essentially separating it from the culture medium in which it grows.

A filter device is used.

Cloth with a density of 30-40 microns in diameter, made of polypropylene, nylon or polyester is a good solution.

AGITATION DEVICE

Spirulina tends to gather at the top of the growing culture, where sunlight exposure is maximal. Due to this, Spirulina that cannot reach the top will ultimately die.

In order to maximize Spirulina exposure to sunlight, the water in which it is grown must be agitated so that all Spirulina filaments are exposed to sunlight.

Agitating can be done manually, using a stick or – better yet – a broom (both must be cleaned before use). This should be done gently, in circular motions that maintain the same direction (clockwise or counterclockwise).

Another option is a small pump, the simplest kind used for aquariums will do.

MICROSCOPE

A microscope will enable close inspection of the culture.

GLOVES

The cleanest possible environment is needed to grow Spirulina. This means that all caretakers must be gloved when tending to the Spirulina.

FUNDAMENTALS OF GROWING SPIRULINA

As described above, Spirulina needs sunlight, water, fertilizers and agitation - the practicalities of which will be explained hereafter.

REDUNDANCY

It is important to have more than one pool (or container).

This minimizes the risk of large Spirulina loss in case of culture contamination. Redundancy is also important when cleaning pools.

CLEANING

Pool (or container) should be cleaned from sediment every 4 to 6 months (or sooner, if needed).

Spirulina is transferred from one pool to another. The empty pool is cleaned, and then the Spirulina is returned to the first pool. The same procedure is done with the second (and third, and so forth) pool.

Water and bleach are used for cleaning the pool or basin.

All tools that come in contact with the culture must be cleaned before and after each use.

MEASUREMENTS OF POOLS

Depth of pools should be approximately twice the depth of the culture in which Spirulina is grown.

Depth of culture should be approximately 20 cm.

Measurements of pools depend on available space and on the number of people expected to consume Spirulina. As noted above, each meter square will produce approximately 10 grams of fresh Spirulina.

2 pools of 2 meters x 2 meters are a reasonable beginning.

PREPARING GROWING CULTURE

As noted above, the following is one of a variety of chemical environments that Spirulina can live in.

All Spirulina culture mediums are based on the Zarouk Medium and consist of the following elements: Nitrogen, phosphorus and potassium in large quantities; Sulfur,

magnesium and calcium in smaller quantities; And boron, chlorine, manganese, iron, zinc, copper, nickel, molybdenum in very small (micro) quantities.

WEIGH AND MIX FERTILIZERS WITH WATER

- The following measurements are for 1 liter water:
- 16g Sodium Bicarbonate (NaHCO₃)
- 2g Potassium Nitrate (KNO₃)
- 1g Sodium Chloride (NaCl)
- 0.1g Potassium Dihydrogenate Phosphate (KH₂PO₄) – comes as granules so needs to be crushed into powder.
- 0.1g Iron Sulfate (FeSO₄)
- 0.1g Magnesium Sulfate (MgSO₄) – may need to be crumbled.

The color of the growing culture should be a pail shade of yellow.

*It is advisable to use gloves when coming in contact with these fertilizers, Potassium Dihydrogenate Phosphate (KH₂PO₄) in particular. If gloves are not available, it is advisable to use a spoon or any other means to avoid direct contact with skin.

MONITORING

As in any agriculture crop, it is important to keep track of the status of the Spirulina and of the environment. This close monitoring will enable quality control, early detection of problems and continuous improvement in farming methods. It will also enable all caretakers of the Spirulina to share this knowledge.

The crucial elements that need to be monitored are: temperature (of culture and of air), pH level, culture depth, radiation (amount of light), salinity, density.

Besides temperature of air in greenhouse and radiation (which will be the same for all pools or containers in it), these measurements should be taken and kept track of separately for each pool or container. Measurements should be taken twice a day.

Tools that come in contact with culture (thermometer, for instance) should be cleaned between pools, preferably with distilled water if available.

It is also advisable to monitor the amount of Spirulina that is harvested at each harvest (and for every pool).

SPIRULINA FARMING CYCLES

Spirulina's reproduction is asexual. Given the right conditions (temperature, lights, fertilizers, agitation) it doubles itself approximately every 48 hours.

When Spirulina is mature and dense (this can be estimated by the dark green color of the culture, with a microscope or with a graduated cylinder, as will be described in next section) it is ready for one of two procedures (which will also be described hereafter):

Increasing amount of Spirulina - This is done when the desired quantity of Spirulina has not yet been reached (usually in the first stages of establishing a Spirulina site);

Harvesting Spirulina - In order to consume it. Important also in order to renew Spirulina culture.

ESTABLISHING A SPIRULINA GROWING SITE

In most cases, a Spirulina site is started with a small portion of fresh and mature Spirulina culture. This initial quantity is gradually increased until the desirable quantity is reached.

DAILY CARE OF SPIRULINA

Agitation - Spirulina is a photosynthesizing organism. It tends to gather at the top of the pool or container, where exposure to light is maximal. This means that Spirulina that cannot reach the top will die. In order to enable all of the Spirulina exposure to light, the culture needs to be agitated - either constantly (with a pump or paddle wheel) or manually (with a stick or broom). If using a manual device it is important to clean it before and after each use. Manual agitation should be done in gentle but thorough circular motions, maintaining the same direction, every 2-3 hours (during the day, when there is light).

Light - Spirulina needs sunlight. Having said that, it is important to note that during the first week or so, when the Spirulina is not yet dense as well as immediately after harvest or increasing quantity, exposure to direct sunlight should be limited, especially strong sunlight during the hours that it is direct. During rainy seasons or in colder climates it is possible to provide the Spirulina with the light it requires artificially, though this is less energy and economically efficient. Light that is used in greenhouses that grow flowers is suitable.

Culture level - Spirulina grows in water and it is important to maintain culture level and to add water to compensate for evaporation. This can be done using a ruler (that should be cleaned before and after each use). It is important that the culture be still when depth is measured so make sure to wait a few minutes after agitation (if done manually) or after turning off pump or paddle wheel (if automated, but remember to turn it back on after taking measurement).

Temperature - Optimal temperature for Spirulina is 30-35c. Spirulina can survive lower (not below 20c) and slightly higher temperatures (up to 38c), but it is not advisable as its metabolism will be harmed and it may suffer from a state of 'shock'. Temperatures can be measured with a thermometer.

pH level – Spirulina can live in a pH level that ranges 8 to 11, but it is at its best at 10.5-11., which is the level that needs to be maintained, as below 10.5 it is at risk of being contaminated and over 11 it undergoes chemical changes.

Light - There are several devices for measuring level of radiation. A Lux meter is a simple and relatively cheap option. When using this device it is held over a set point (make sure that it is always the same one) on the rim of the pool or container. Make sure it is steady and that the person taking the measurement does not cast shade

over the device. Comparing radiation levels to status of Spirulina (amount harvested, for example) is a good way to learn about optimal ranges. This information is useful for controlling some of the environment, for instance: If radiation level is too high shade can be provided and vice versa, if radiation is too low greenhouse can be opened or artificial light added.

Salinity - Salinity is a good indication of culture status. Healthy salinity ranges between 15 to 20 PPT. Several devices can be used. A refractometer is a simple and relatively cheap option (its measurements are digital and a healthy range is between 1 to 2).

Density - Amount of light that passed through the culture gives a good indication to the density of it, indicating if it is ready for harvest (or for increasing its amount) or if density is dangerously low. There are several ways to estimate density: Color of the culture - the darker green the culture the denser it is. A second option is looking at a sample from the culture in the microscope - the number of Spirulina filaments and their proximity to one another is a good indication to the culture density. A third option - an X is written on a white sheet of paper. A transparent graduated cylinder is placed over the X. Spirulina culture is poured into the cylinder until the X is no longer visible from the top of the cylinder. The higher the level at which the X is seen the lower the density.

PREPARING CULTURE MEDIUM

Culture medium provides Spirulina with the nourishment it needs. It is added when increasing quantity of Spirulina and after harvesting.

Mix water and fertilizers according to quantities described above. The amount of culture medium depends on the quantity of Spirulina and should be roughly at a ratio of 1:1. For example: For 20 liters Spirulina, prepare 20 liters growing culture.

Fertilizers should be fully dissolved in the water before adding it to the Spirulina. This may take a few hours, depending on the specific fertilizers used. Agitation can speed up the process.

Culture medium can be prepared in large quantities in advance and used upon need, but should be stored in closed containers and in the shade.

The pH level of the culture medium should be 8-8.5. This can be tested with litmus paper. If pH level is lower, add Sodium Bicarbonate. A higher level is fine.

*After preparing growing culture a number of times, this stage of examining the pH level of the growing culture will not be necessary, as the color of the solution will be a sufficient indicator.

INCREASING THE QUANTITY OF SPIRULINA

Increasing the quantity of Spirulina is done with a Spirulina culture that is mature and dense. In optimal conditions, Spirulina reaches this state within 24-48 hours. In less than optimal conditions, it may take longer.

To increase the amount of Spirulina, mature and dense Spirulina is diluted with culture medium (water and fertilizers) in a ratio that is roughly 1:1., thus multiplying the quantity. For example: 100 liters culture medium are added to 100 liters of mature and dense Spirulina. The new quantity of 200 liters will be diluted and thin, but given the proper care and approximately 48 hours it will once again be mature and dense and then ready for yet another multiplication.

When increasing the quantity of Spirulina, the measurement of the pool or container must be adapted.

In a pool this can be done by placing a board or some other partition in the pool. This partition functions as a dam, and Spirulina is grown in the smaller area it creates. When Spirulina is mature and ready for multiplication, the partition is moved to create a larger and larger pool until it reaches its full size and Spirulina quantity. It is then ready for further increasing of quantity (another pool, for instance) or harvesting.

When growing Spirulina in a container this can be done by moving the Spirulina to a larger container.

Dividing Spirulina and adding growing culture will have lowered pH level. Due to chemical changes that result in its metabolism it will again reach its optimal level of 10-10.5.

During this period, Spirulina needs to be tended to as it was during the first stage, i.e. agitating and adding water to compensate for evaporation.

Examining pH level is done as it was done during the previous stage.

When pH level has returned to 10-10.5, it is advisable to give it a week or so to further strengthen and stabilize and it is then ready for another cycle of multiplication or for harvesting.

HARVESTING

Harvesting during morning hours is best for both nutritional and practical reasons.

Harvesting is done in the following manner:

Hold filtration cloth over the pool or container;

Pour culture onto cloth. This can be done using a bucket or any container, but make sure it is cleaned before and after use;

The Spirulina will remain on the cloth. The culture medium will flow through the cloth and return to the pool;

The Spirulina on the cloth will at this point still have some residue of the culture medium. In order to bring the Spirulina to a pH level that is healthy for consumption (7pH), these residues need to be eliminated. To do so press the filtering cloth (with the Spirulina in it) evenly and gently. The culture medium - which is transparent - will drain from the cloth. When the water draining through the filtering cloth is no longer transparent but green, stop squeezing - this means that all the culture medium has been squeezed out and the Spirulina is at a healthy pH level.

The drained and pressed Spirulina should at this stage be similar in texture to paste.

*Filtration cloth should be thoroughly rinsed with water after harvesting until there is no green residue on it and it has regained its original white color.

After harvesting, the nutrients that the Spirulina fed on must be replaced by adding culture medium to the pool or container. The amount of culture medium that needs to be added depends on the amount that was harvested, for instance: After harvesting 100 liters from the culture add 100 liters of culture medium to the pool.

CONSUMING SPIRULINA

Spirulina is at its nutritional best at this stage, freshly harvested. At this stage it is also almost odorless and tasteless, and can be mixed with and beverage or food (preferably not hot, as heating decreases some of its nutritional values).

Spirulina that is not consumed immediately after harvest can be frozen (in sealed plastic bags or containers) and kept for 2-3 weeks. It can also be dried.

DRYING SPIRULINA

Drying Spirulina is a more efficient and long lasting option. In its dried form it can be kept for many months, as long as it stored in clean and damp free containers.

Drying is done in the following manner:

Spread Spirulina on net - Using a finger (gloved), knife or spatula (cleaned before use), a plastic bag or syringe (disposable or cleaned before use) spread Spirulina on net in noodle-like stripes.

A net enables drying from top and bottom. This will shorten the time needed to dry and lessen the danger of contaminators (when Spirulina is harvested it is no longer protected by the high pH level of the culture medium).

It is best that this net be placed inside the greenhouse. This will further protect the Spirulina from contaminants.

Approximately 2 days should be sufficient for drying.

SPEED DRYING

Drying can also be done in an oven - electrical or solar.

Dry at 40°C for 16 hours or at 60°C for 4 hours (the lower the temperature the more nutritional value).