

Indigo Planting & Harvesting

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Photo by Paige Green



FIBERSHED

Local Fiber, Local Dye, Local Labor

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Introduction

THIS REPORT was completed with funding generously provided by the Jena and Michael King Foundation as part of Fibershed’s True Blue project. The project aims to support bio-regional manufacturing systems for natural indigo dye and indigo-dyed textiles in the Northern California fibershed and beyond. It is one project of many that support Fibershed’s larger mission:

“Fibershed develops regional and regenerative fiber systems on behalf of independent working producers, by expanding opportunities to implement carbon farming, forming catalytic foundations to rebuild regional manufacturing, and through connecting end-users to farms and ranches through public education.”

In particular, this document aims to support regional farmers in their efforts to bring indigo farming forward as a viable economic option. We give a detailed review of the planting and harvesting steps of indigo dye production and consider how to scale production using appropriate tools and technology. We focus on planting and harvesting because these steps have represented significant bottlenecks in indigo production in Northern California due to the labor content of the manual methods currently employed.

We give equipment recommendations for a range of capital costs and for scales of operation from backyard gardens to multiple acres. The recommendations in this report are applicable to both the compost and water extraction dye production processes, which are explored in detail in another report.

Much of the agronomical information comes from studies carried out in central Italy by Prof. Luciana Angelini of the University of Pisa, who worked with both Japanese indigo (*Persicaria tinctoria*) and woad (*Isatis tinctoria*) as part of the EU-funded Spindigo Project from 2001-2004. The climate in central Italy is very similar to that of northern California, and insights from the Spindigo Project apply well to the region.

Primary research was conducted throughout the 2017 growing season on a 0.1 acre plot through the hard work and generosity of indigo farmer Craig Wilkinson and those at Open Field Farm in Petaluma.

While we cover planting and harvesting in this document, we do not deal deeply with other agricultural considerations. For more information, “The Handbook of Natural Colorants”¹ gives many results from the Spindigo Project, including illustrations of plant developmental stages and information about weeds, pests, diseases, fertilization, irrigation, and seed production.

¹Bechtold, T ; Mussak, R (2009) “Handbook of Natural Colorants”

Planting

Growing Seedlings

GERMINATION in *Persicaria tinctoria* (syn. *Polygonum tinctorium*) requires a warm, moist soil, with temperatures above 50°F.² While indigo can be planted directly in the field, it is usually desirable based on climate to start seedlings in a greenhouse and to later transplant them into the field. Such seedlings can be started by broadcasting seeds onto open beds or by planting into flats. While the broadcasting method is the simplest, the seedlings produced are generally only transplantable by hand. Starting seedlings in flats allows for greater flexibility and the possibility of automation in the transplanting step.

BROADCASTING SEEDLINGS

One method for broadcasting seedlings is described by Rowland Ricketts, an artisan and professional indigo dyer who trained extensively in the traditional Japanese indigo process. With permission, we paraphrase this method here:

- Start seeds in a greenhouse 5-6 weeks before the last frost date for earliest outdoor planting.
- Till and mix the soil with composted manure and a balanced organic fertilizer.
- Work soil into beds that are about 36" wide.
- Broadcast seed densely on soil, with about one seed per ¼" square.
- Cover with sand and tamp/pat down. Use enough sand to cover the seeds (~1/8 to ¼ inch). This sand layer will keep the soil loose and help minimize root damage when transplanting.

- Use seed cloth to keep wind/bugs out and moisture in. (This isn't necessary, but greatly improves consistency and quality.)
- Water the seeds/seedlings daily.
- Remove all weeds.
- After approximately 5-6 weeks, the seedlings will be ready for transplanting.³

PLANTING IN FLATS

Most producers in the Northern California Fibershed currently order flats of indigo seedlings from Headstart Nursery in Gilroy, CA. At \$0.08 per seedling (including shipping), producers have found the savings in labor to be worth the cost. Having seedlings in flats also allows for more possibilities in automating the transplanting step.



Broadcasted seedlings just before transplanting⁴



Indigo starts from Headstart Nursery in Gilroy, CA. (Photo by Matt Forkin)

²Bechtold, T ; Mussak, R (2009) "Handbook of Natural Colorants"

³Ricketts, Rowland. "Polygonum tinctorium: Instructions for starting seeds, transplanting, and general growing guidelines" IndiGrowing Blue, www.indigrowingblue.com/Polygonum_tinctorium_Growing_Guidelines.pdf

⁴Ricketts, Rowland. "Polygonum tinctorium: Instructions for starting seeds, transplanting, and general growing guidelines" IndiGrowing Blue, www.indigrowingblue.com/Polygonum_tinctorium_Growing_Guidelines.pdf



Left: Pulling up seedlings from the base in small groups in preparation for transplanting.
Right: Bundling seedlings⁵

Transplanting

EVOLVING ORIGINALLY in Vietnam and Southern China, *Persicaria tinctoria* is frost-sensitive, and seedlings must be transplanted outdoors after the last threat of frost. Transplanting as early as possible will help maximize yields throughout the season, and ideally the process would be completed as soon as frost risk is low and the soil is workable. In the Northern California Fibershed, indigo can be transplanted as early as April. For example, the 10% frost date in Petaluma, California is around April 15.⁶ The effect of sowing date on plant yield in central Italy can be seen in the following chart. Presumably, plants were transplanted into the field 5 - 6 weeks after the listed sowing date.

Sowing date	Number of harvests	Plant yield (lbs/acre)
3/11	2	100816
4/11	2	104385
5/10	1	73159
6/11	1	51746

The effect of sowing date on yield from trials in central Italy in 2001⁷

Persicaria tinctoria grows well in full sun with weekly watering in well-drained neutral soils. The shallow roots of the plant make it quite susceptible to drought. One study from central Italy concluded that leaf biomass is the most important agricultural factor in indigo dye production and showed that leaf yield was reduced by over 50% in drought conditions.⁸

Sources for seeds of *Polygonum tinctorium* (aka *Persicaria tinctoria*)

ROWLAND RICKETTS
RICKETTS INDIGO
<http://www.rickettsindigo.com/indigo-seed-availability/>

GRAHAM KEEGAN
<http://www.grahamkeegan.com/shop/indigo-seed-packet>

MONICA PAZ SOLDAN
TINY TEXTILES
<https://ecohabitude.com/products/26401/indigo-seeds>

KORI HARGREAVES
ECOTONE THREADS
<http://www.ecotonethreads.com>

BUAISOU (SHIPS FROM JAPAN)
<http://www.buaisou-i.com/product-page/indigo-seeds>

ELIZABETH MERRILL
<http://www.elizabethanonymous.com/indigo>

FEDCO SEED CO.
<https://www.fedcoseeds.com/seeds/search?item=5911>

Transplanting can be completed with varying levels of automation, and the ideal solution for a given producer will depend on the size of the cultivated area and the availability of capital.

For home-scale to tens of acres, methods range from transplanting by hand to using hand-held tools, walk-behind machines, semi-automated tractor-mounted machines, and fully-automated machines.

⁵Ricketts, Rowland. "Polygonum tinctorium: Instructions for starting seeds, transplanting, and general growing guidelines" IndiGrowing Blue, www.indigrowingblue.com/Polygonum_tinctorium_Growing_Guidelines.pdf

⁶"Frost Dates" <https://garden.org/apps/frost-dates/Petaluma%2C+California/>

⁷Bechtold, T ; Mussak, R (2009) "Handbook of Natural Colorants"

⁸Campeol, E. et al. (2005) "Seasonal variation of indigo precursors in *Isatis tinctoria* L. and *Polygonum tinctorium* Ait. as affected by water deficit"

TRANSPLANTING BY HAND

One method for transplanting by hand is paraphrased here with permission from guidelines produced by Rowland Ricketts:⁹

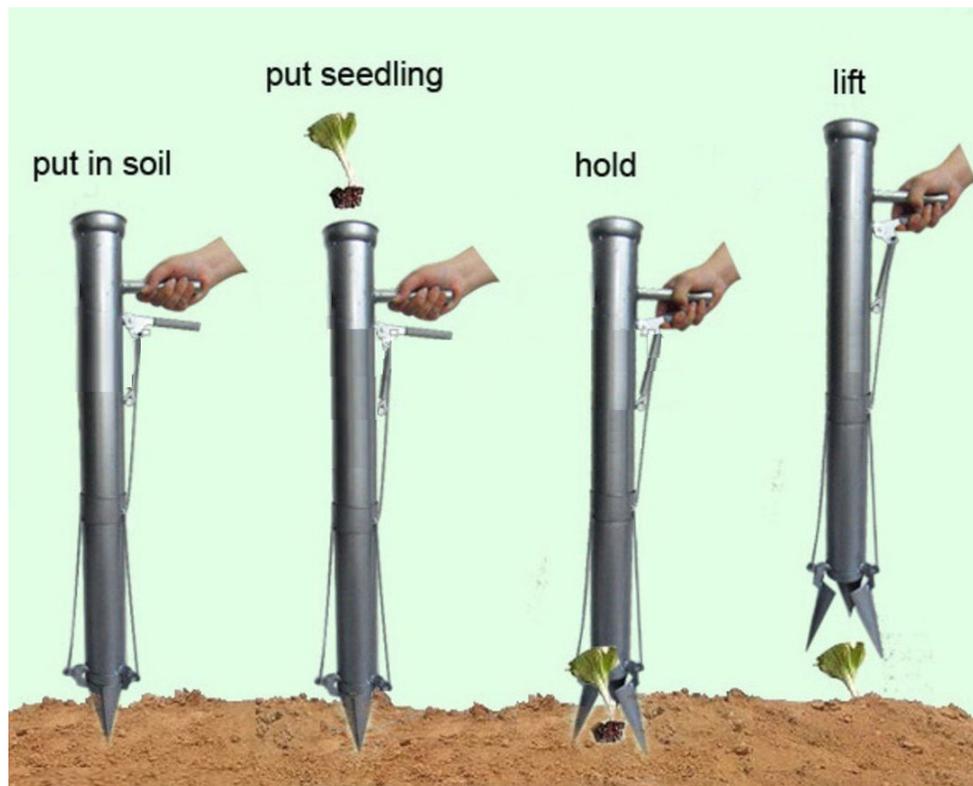
- Transplant outdoors after the last threat of frost.
- Just prior to transplanting, create rows 36 inches apart across the entire growing space by making a divot with a hoe.
- Before pulling up seedlings, generously water the seedling bed until it is soaked. This (combined with the layer of sand applied when broadcasting the seeds) will make the seedlings easy to remove without excessive root damage.
- Pull seedlings in small bunches by grabbing them near the base. Try to keep them orderly for easy transport and transplanting.

- Tie handfuls into bundles and dip the bundles' roots in water. Put the bundles in a box or container for easy transporting to the field.
- Once all seedlings are harvested and at the field, go down each row placing 5-6 seedlings at a time into the tilled divot with about 1 foot between each group of seedlings.
- Let the stems rest on one side of the divot and scoop dirt from the opposite side onto the roots and the majority of the stem so that it holds the bunch in place and only the leaves stick out.
- *Persicaria tinctoria* is a noded plant and will root from the nodes on the stem, so burying the nodes simply helps the plant to root better. Leaving the stems exposed to harsh sunlight at this stage can kill the plants.

HAND-HELD TOOLS

Simple and inexpensive hand-held planting tools like the one shown below can ease the transplanting process and minimize the need for bending over while planting seedlings. Such tools can be purchased for \$50-\$150 from many sources.

While such hand-held tools may be useful for certain small scales and situations, they may not support a process that is significantly easier than hand-planting. For scales larger than the home garden, producers can consider a larger step up in automation and investment: walk-behind machines.



The operation of a hand-held manual planter¹⁰

⁹ Ricketts, Rowland. "Polygonum tinctorium: Instructions for starting seeds, transplanting, and general growing guidelines" IndiGrowing Blue, www.indigrowingblue.com/Polygonum_tinctorium_Growing_Guidelines.pdf

¹⁰ Image source: <https://www.ebay.com/i/232393577704?chn=ps&dispItem=1>

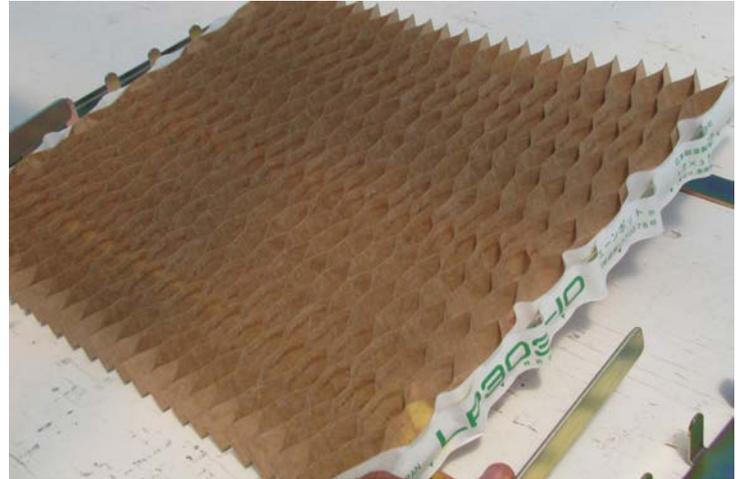
WALK-BEHIND MACHINES

There are a number of walk-behind machines for transplanting various types and sizes of seedlings. Here, we showcase one reasonably-priced and innovative option that is well-suited to indigo: the Paperpot Transplanter. This

is an imported Japanese tool that was originally developed for the sugar beet industry.

The Paperpot Transplanter uses paper seeding trays that are unraveled into a chain and planted directly into the

ground by the machine, depositing the seedlings at constant spacing. One limitation is that the trays are currently available only in 2" and 6" spacing. The 6" spacing is usable but somewhat tight for *Persicaria tinctoria* and may affect efficiency and yield.



The Paperpot Transplanter¹¹

¹¹ Image source: <http://www.johnnyseeds.com/tools-supplies/transplanters/paperpot-transplanter-7601.html>

The Paperpot Transplanter costs about \$1000, and with planting trays and seeding tools the total upfront cost comes to about \$1600.

Additional annual costs for paper-pot units are less than those for ordering seedlings from a nursery. At 3' row spacing and 6" plant spacing, 1 acre of indigo can carry about 30,000 indigo plants. Each paper-pot unit holds 264 starts at 6" spacing, and a pack of 75 units (~\$400) can accommodate about 20,000 seedlings. One could therefore expect an on-going annual cost of about \$300 per half-acre of indigo, or about \$0.02 per seedling. Ordering indigo starts from a nursery costs about \$0.08 per seedling in Northern California. While paper-pots require more labor than nursery starts, they are roughly one-quarter the price.

According to Sara Runkel of The Seed Farm and Pennsylvania State University, 1 person takes 1 hour to transplant ~800 row-feet of plants using the Paperpot Transplanter.¹² At a 6" spacing, that is 1600 starts in 1 hour (or about 2 seconds per start). At about 30,000 plants per acre, this translates to about 20 hours of planting labor per acre. Runkel notes that the transplanter works well only in loose and well-prepared soil. We recommend this machine at scales up to about 0.5 acre.

If resources are limited and/or the scale of production is relatively small, transplanters like the Paperpot Transplanter are good options for facilitating the planting of indigo seedlings in well-prepared soils.

More automated versions of walk-behind transplanting machines are also available. For example, Japanese indigo producer Buaisou uses what appears to be a rice transplanting machine. Such machines may be difficult to source in the United States and subject to significant import taxes.



A walk-behind transplanting machine used by Japanese indigo producer Buaisou¹³

¹² DuPont, Tianna. "Paper Pot Transplanter" YouTube, 5 October 2012, https://youtu.be/gMSpNoE8_H8.

¹³ Image source: https://www.instagram.com/buaisou_i/

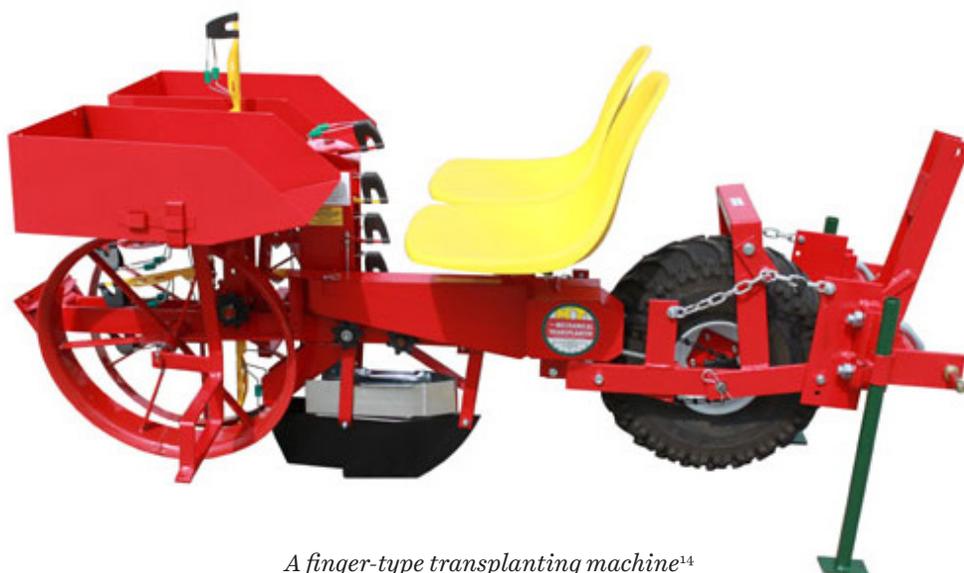
SEMI-AUTOMATED TRACTOR-MOUNTED MACHINES

For larger-scale producers with access to a tractor, semi-automated tractor-mounted machines may represent the wisest investment for indigo planting. With these machines, one or multiple people are seated and manually feed starts into a planting mechanism while another person operates the tractor.

Hand-set, finger, and carousel planters are three types of transplanting machines that may be useful for indigo.

With hand-set planters, plants are hand-set into a furrow opened by shoes ahead of the operator. Soil is then packed in around the plant by the machines. Such planters can manage very large and/or inconsistent plants and allow the operator to precisely control the depth of each plant. However, they have no mechanism for controlling the spacing, which is set by the operator. It would be feasible to use broadcasted seedlings with such machines, but homogeneity and transportability likely make starting seedlings in flats preferable. Typical prices for such machines are around \$2000.

Finger planters use a rotating chain of pockets for the transplants. The operator places each seedling into a pocket, and each is conveyed down, into the soil, and released. Seedlings can be transplanted in cells or with bare roots, although these machines typically cannot be used with large cells, as the seedlings are held by the stem and could be damaged by the weight and movement of heavy plugs. Typical row spacing for these machines is 18 inches and up. Cited planting rates are about 300 plants per worker per hour for a single-row machine¹⁶, and prices

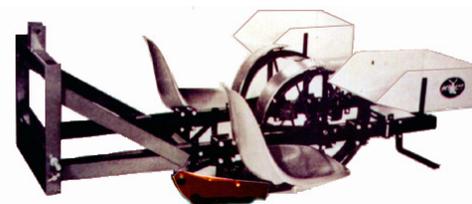


A finger-type transplanting machine¹⁴

can range from \$1500-\$2500 for the same. At 30,000 indigo plants per acre, a single-row finger planter with two operators (one to drive the tractor and one to place transplants), could cover an acre of indigo in about 50 hours.

With carousel planters, the operator loads a horizontally-rotating carousel with seedlings, which are automatically dropped and pressed into place. The mechanisms usually rely on the structure of the transplant plug, requiring that seedlings be transplanted in cells rather than with bare roots. Row spacing typically goes as low as 12 inches. Cited planting rates range from about 650-1500 plants per worker per hour for a single-row machine, and prices can range from \$4000-\$6000. A single acre of indigo could be planted in as little as 10 hours with a single-row carousel planter and two operators.

Many transplanting machines have options for multiple planting units that allow one to plant multiple rows in



A hand-set-type transplanting machine¹⁵

parallel. This allows for faster planting of a field and with fewer tractor passes, and may be worth considering for larger operations.

For any type of planter, we recommend having a spotter follow behind the machine to make any small corrections and spot issues quickly. The spotter can also fill in any gaps should the operator miss a start placement.

There are many tractor-mounted transplanters on the market. Choosing the correct machine will depend on many things, including the scale of the operation, the available capital, and the needs of any other crops in production.

¹⁴ Image source: <http://www.mechanicaltransplanter.com/veg.html>

¹⁵ Image source: <http://www.marketfarm.com/HTOldFLG.jpg>

¹⁶ Blanchard, C (2013) "Transplant Production Decision Tool"



A carousel-type transplanting machine¹⁷



A multi-row transplanting machine¹⁸

¹⁷ Image source: <http://www.mechanicaltransplanter.com/cellveg.html>

¹⁸ Image source: <http://www.mechanicaltransplanter.com/image/5000W4RA.JPG>

FULLY-AUTOMATED MACHINES

There are a number of suppliers that offer fully-automated transplanters that utilize robotic handling to remove starts from trays, load them into feeders, and insert them into the rows. Transplant Systems of Australia claims up to 9000 plants per hour for a 3-row machine, with capabilities as large 18-rows and 30,000 plants per hour (roughly 1 acre of indigo in 1 hour). This approach requires specialized trays and a very significant investment and would likely make economic sense only for industrial indigo production at scales of tens or hundreds of acres.



Fully automated transplanter from Transplant Systems of Australia¹⁹

¹⁹ Image source: <http://www.transplantsystems.com.au/field/automatic-planters/Auto>

Harvesting

JAPANESE INDIGO is typically harvested two or even three times per season. The timing of these harvests is quite important, as the indigo concentration in the plants can vary greatly throughout the year, as does, of course, the size of the plants themselves.

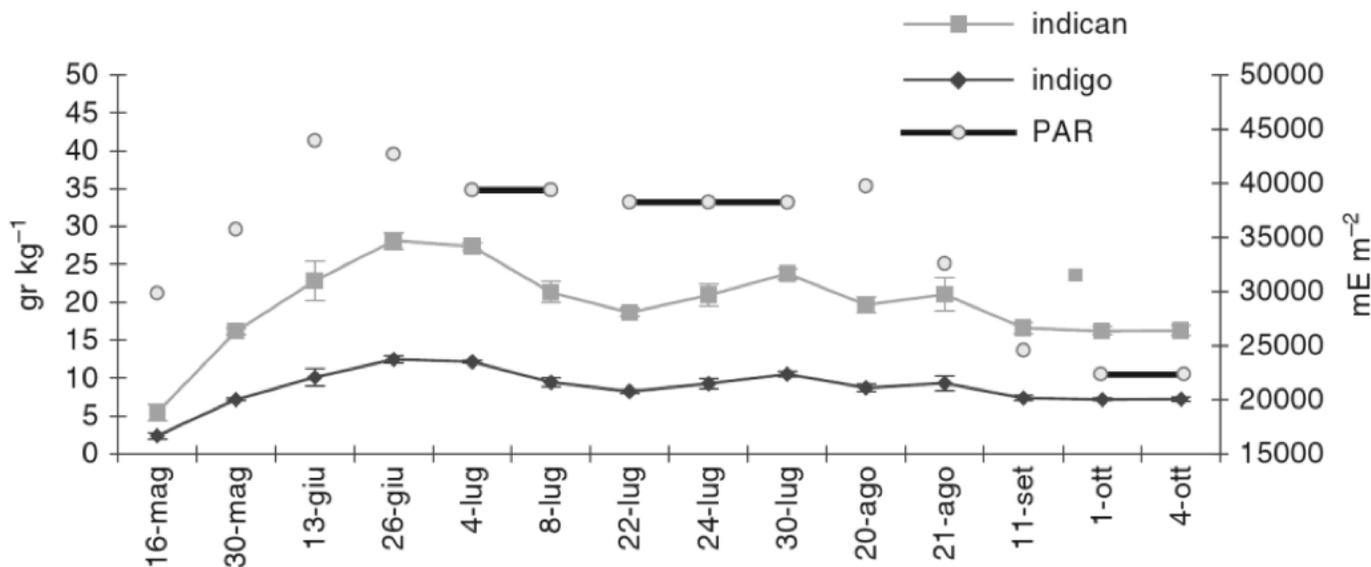
As seen below, indigo concentration over time in *Persicaria tinctoria* is related to the amount of light available to the plants as they grow, known as photosynthetically active radiation.

Indican, the precursor to indigo, is found almost exclusively in the leaves of the plant, particularly in the young leaves.²¹ In the later stages of growth, weight increase in the plant results mainly from increases in the mass of the stems.²² After many trials,

researchers in central Italy concluded that the ideal time for the first harvest is “when the ratio between leaves and stalks is about 1:1, when the crop rows are closed by the developing *Persicaria* (*Polygonum*) plants.” In Italy, this occurs in the beginning to middle of July. They state that the plant needs at least six weeks to regrow for a second harvest, which would be in mid-August to the beginning of September. Under the conditions of central Italy, three harvests are possible from July to November.²³

Due to the greater concentration of indigo in young leaves, French natural dyer Michel Garcia recommends harvesting small amounts of material more frequently. Specifically, he suggests harvesting the top 4" of the plants every 2 weeks.²⁴

There is an opportunity to optimize indigo yield by varying the number and timing of harvests, and the ideal parameters will depend on the conditions of place. To further the understanding of local conditions, Garcia offers a method for making in-field qualitative measurement of indigo content: Individual leaves can be hammered or otherwise pressed against white fabric, and when this fabric is allowed to sit for at least a few minutes and then washed, an indigo “leaf print” will remain that roughly correlates to the indigo content of those leaves. If the process is standardized, this could provide a practical method for conducting in-field analysis and decision-making.



Changes in photosynthetically active radiation (PAR), indican content and potential indigo yield in *Persicaria tinctoria* from trials in central Italy²⁰

²⁰ Angelini, LG et al. “Environmental factors affecting productivity, indican content, and indigo yield in *Polygonum tinctorium* Ait., a subtropical crop grown under temperate conditions.” *Journal of Agricultural and Food Chemistry*, vol. 52, no. 25, 2004, pp. 7541-7547.

²¹ Minami, et al. (2000) “Tissue and intracellular localization of indican and the purification and characterization of indican synthase from indigo plants”

²² Bechtold, T ; Mussak, R (2009) “Handbook of Natural Colorants”

²³ Bechtold, T ; Mussak, R (2009) “Handbook of Natural Colorants”

²⁴ Personal communication.

In Fibershed's 2017 trials in northern California, *Persicaria tinctoria* was harvested twice and gave yields of about 43,300 lbs of fresh plant material per acre. For comparison, trials in central Italy gave yields up to 104,000 lbs per acre from two harvests.²⁵ Due to a wet spring and limited access to equipment, the California crop was not transplanted until late May, which was about 40 days later than might be expected. With earlier transplanting and well-timed harvests we might expect significantly increased yields from California crops.

For northern California, we currently recommend harvesting twice per year, once in early to mid-July and once

in mid- to late-August. For the first harvest, cut the plants when they are about 1-2 feet tall, cutting the stems several nodes up from the ground. The plants will resprout from those nodes for the second harvest, which should be completed before or shortly after the plants flower. A third harvest may be possible in early to mid-October, but indigo concentration may be low by this point. Any remaining plants can be left to go to seed. *Persicaria tinctoria* requires short daylight hours (<14 hours) to flower.²⁶ In northern California flowering begins by about mid-August, and seeds may mature and be ready for harvest by November. Seed yields in Italy can amount to about 360 lbs/acre.²⁷

Depending on scale of production and available capital, the ideal harvesting method can range from hand-harvesting to using walk-behind, tractor-mounted, or self-propelled machines. Given the crop-specificity of harvesting machines and the lack of indigo-specific machinery, we recommend adapting several types of harvesting machines for other crops to indigo.



The first harvest at an indigo field in Marin County, CA (Photo by Paige Green)

²⁵ Bechtold, T ; Mussak, R (2009) "Handbook of Natural Colorants"

²⁶ Bechtold, T ; Mussak, R (2009) "Handbook of Natural Colorants"

²⁷ Bechtold, T ; Mussak, R (2009) "Handbook of Natural Colorants"

HARVESTING BY HAND

Many small-scale growers harvest *Persicaria tinctoria* by hand using a serrated Japanese sickle, grabbing a handful of stems at a time and cutting a few nodes up from the ground to allow for secondary growth.

Such serrated sickles can be easily found for \$15-\$20 and represent an attractive low-capital method for harvesting indigo. We recommend this tool for the garden scale. In the Northern California fibershed, producers at the 0.1 acre scale have used sickles for harvesting, but found the process to be a significant pain-point and bottleneck in the overall process, especially when harvests coincide with the intense heats of summer.

In northern California, we measured harvesting rates with various methods during the summer of 2017. When plants were harvested by two people with sickles and harvesting bags, we measured harvesting rates of about 40 hours per acre (or 80 person-hours per acre). It is also possible to harvest using a hand-held hedge trimmer. When plants were harvested by two people using a hedge trimmer while dragging a narrow tarp between the rows, cutting the plants onto the tarp as much as possible, and tossing the remainder onto the tarp before moving onto the next section, we measured about the same harvesting rate as with a sickle, and the process was easier physically.



Persicaria tinctoria and a serrated Japanese sickle, top, and Rebecca Burgess harvesting *Persicaria tinctoria* with a sickle, above (Photos by Paige Green)



Craig Wilkinson harvesting with a sickle and harvesting bag, left, and harvesting with a hedge trimmer and tarp, right (Photos by Nicholas Wenner)

For larger scales of production, we recommend investing in larger machines, which can greatly increase the speed and ease of the harvesting process.

WALK-BEHIND MACHINES

While we found no walk-behind machines developed specifically for indigo, there are various harvesting machines for other crops that may be used as-is or with minor modification. In particular, walk-behind soybean harvesters and reapers may be well-suited to indigo harvest.

Soybean harvesters are commonly used for indigo harvesting in Japan after slight modification. The machine funnels stems against a rotating serrated blade and conveys them up and off to one side, neatly depositing stalks in bundles with a single orientation. The unit shown costs ~\$6000, but with import and handling the total cost may approach \$10,000, as was the case for a similar machine purchased by Rowland Ricketts. Ricketts reported the machine



A soybean harvester being used to harvest indigo²⁸

²⁸ Image source: <http://www.buaisou-i.com/videos>

to function reasonably well, but expressed disappointment in the high price and the difficulty of obtaining the machine from Japan.

One might imagine harvesting indigo with sickle-bar mowers, which can be relatively simple, inexpensive, and readily available from domestic producers/distributors. Fibershed's experiments in Northern California indicated, however, that sickle bar mowers fail to neatly orient cut stalks and that this significantly complicates the process of gathering the cut material. One might make custom modifications by adding attachments that direct cut stems to one side, and experiments to that effect indicated that mechanizing this process - as opposed to simply adding static components - appears necessary. In fact, such mechanical improvement already exists in the form of a walk-behind reaper, which is typically used for grain crops, but can also serve for larger-stemmed plants like indigo.

Walk-behind reapers cut the crop using a sickle bar cutter and convey the stalks to one side using a belt-drive. Typical prices range from about \$1000-\$3000. Like walk-behind soybean harvesters, no domestic producers were found, and more research is necessary to understand the function, availability, and import costs on these machines.



(Left to right) A walk-behind sickle-bar mower²⁹ and a walk-behind reaper³⁰

²⁹ Image source: <https://bcsamerica.com/product/model-620-max>

³⁰ Image source: https://www.alibaba.com/product-detail/2015-new-design-rice-reaper-machine_60357033631.html?spm=a2700.7724838/old.2017115.120.iCvPg

TRACTOR-MOUNTED MACHINES AND SELF-PROPELLED MACHINES

Tractor-mounted machines allow for much greater harvesting speeds and larger areas of cultivation. One example is a tractor-mounted reaper binder from BCS.

The BCS Tractor-Mounted Reaper Binder is available from various manufacturers abroad for around \$4,500, or approximately \$12,000 if imported through BCS America. In operation, moving tines direct material toward the center and a sickle bar cuts the plants. Once a large enough bundle of plants is collected, it is bound in a loop of twine, conveyed out the back, and dropped on the ground behind the tractor. While binding may be helpful, it is not obligatory, and unbound bundles can be made simply by leaving twine unloaded. There are multiple videos online showing the operation of the machine.³¹

BCS in Europe (and other knock-off brands in India and China) makes a stand-alone self-driving version of this reaper binder (BCS Model 622). It cannot, however, be imported to the USA due to emissions standards.

The cutting width of the mechanism is 55". With a planting row width of 36" it would be possible to use the machine to harvest 1 or 2 rows of indigo per pass. Without testing, however, it is unclear how well the moving tines on this machine will gather and convey rows of indigo material, and it is possible that more densely and evenly planted crops like hay are necessary for correct functioning.



The BCS Tractor-Mounted Reaper Binder³²

³¹ e.g. "BCS Tractor Mounted Reaper Binder" YouTube, uploaded by BCS India, 11 May 2016, <https://youtu.be/bIHNKSL5Sfs>

³² Image source: <http://www.alvanblanchgroup.com/tractor-mounted-harvester-reaper-binder-th1400>

Rather than leaving cut material in bundles in the field, it would be desirable to convey material into a trailer for ease of transportation. Here we identify two types of machines that could accomplish this: lavender harvesters and plot combines.

Lavender harvesters would require little or no modification for use on indigo. For example, Bizon-Ins Ltd. in Bulgaria makes many models of lavender harvesters that can be successfully used on crops similar to indigo. For indigo, they recommend the MKL 3R (pictured below). The machine mounts to a tractor, uses a belt drive to direct plants into a sickle bar cutter, and conveys cut material into a trailer. Such machines cost around \$20,000, without shipping. They can harvest an acre of plants in as little as 45 minutes.

Self-propelled machines for non-indigo crops may be adapted or used directly with indigo. In particular, plot combines provide a relatively inexpensive option for large-scale indigo harvesting.

Plot combines are intended for harvesting grain at small scales, and—with modification—they could be useful for indigo. Plot combines usually employ a rotating drum (the “reel”) to direct plants into a sickle bar cutter. The cut plants are then taken into the machine via a conveyor belt. Typically, this conveyor leads into a threshing drum, which helps separate grain from chaff. Removing this component and conveying the entire plant through the machine and out the back onto a trailer may allow the machine to be used with indigo.



A lavender harvester being used to harvest melissa onto a trailer³³ (top) and a plot combine being used to harvest alfalfa³⁴ (above)

³³ Image source: “Harvesting melissa with Bizon Ins MKL 3R” YouTube, uploaded by Bizon-Ins Ltd., 25 June 2017, <https://www.youtube.com/watch?v=9AjubQxAoRA&t=55s>

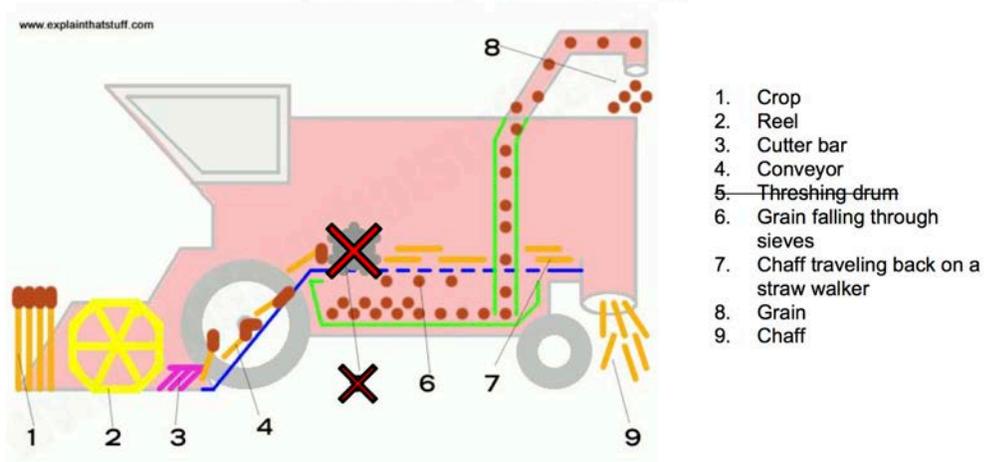
³⁴ Image source: “Fauche luzerne avec Hege 140 le 05 juin 2013” YouTube, uploaded by artem21, 15 March 2014, <https://www.youtube.com/watch?v=iAQaji6QyZY>

Small research combines can be purchased used for \$4000 - \$6000. We estimate it would take approximately \$3000 to modify the machine for use with indigo, making for a total cost of \$7000 - \$9000. While we have not proven the efficacy of plot combines for indigo, inspecting a local machine, seeing it in operation, and finding videos of various crops being harvested with plot combines convince us of the strong potential of these machines.

Large harvesting machines like plot combines, lavender harvesters, and reaper binders may be very useful for large-scale indigo harvesting. Before investing in such large equipment, we recommend borrowing or leasing and testing any equipment that may be in one's area.

Plot Combine

(Remove threshing drum to adapt to indigo)



Summary and Recommendations

IN THIS DOCUMENT, we have outlined options and considerations for indigo harvesting and planting at various scales and levels of investment.

Planting

Transplanting as early as possible will help maximize yields throughout the season, and ideally the process would be completed as soon as frost risk is low and the soil is workable. In the Northern California Fibershed, indigo can be transplanted as early as April, with sowing in a greenhouse occurring 5-6 weeks earlier.

For garden and small-scale planting, we recommend starting seeds either broadcasting or in flats and transplanting them by hand or with hand-held planting tools. Costs range from \$0 - \$150.

For mid-scale production (up to about 0.5 acres) in well-prepared soils, walk-behind planters are attractive options, particularly the Paperpot Transplanter, with its integrated seeding trays. All told, one could expect for the Paperpot Transplanter an upfront cost of about \$1,600, with an on-going annual cost of about \$300 for paper-pots at the 0.5 acre scale. Planting can be done by a single person at a rate of about 20 hours per acre.

For large-scale operations, we recommend starting seeds in flats for ease of automation and using any of a number of tractor-mounted transplanting machines. There are many tractor-mounted transplanters on the market, ranging in price from about \$1500 to \$6000 for single-row machines. A single acre of indigo could be planted in as little as 10 hours with such machines. Choosing a particular machine will depend on many things, including the scale of the operation, the available capital, and the needs of any other crops in production.



Tending a Northern California crop of Persicaria tinctoria (Photo by Kalie Cassel-Feiss)

Harvesting

For northern California, we currently recommend harvesting twice per year, once in early to mid-July and once in mid- to late-August.

For the garden and small scale, we recommend harvesting with the traditional serrated sickles used by many artisan-scale growers or with gas-powered hedge-trimmers.

For mid-scale production (up to about 1 acre), walk-behind machines such as soybean harvesters and reapers may give good results. Walk-behind soybean harvesters are used for indigo harvest in Japan, and they are well-proven in

function. The options identified thus far for both machines, however, may be cost-prohibitive, costing as much as \$10,000 total with import and handling fees. We found no domestic producers/distributors for either type of machine, and more research is needed to identify sources, reliability, efficacy, and fully-loaded costs for both types.

For larger-scale production, tractor-mounted and self-propelled harvesting machines for other crops may be adapted to indigo with minor or no modification. The least expensive option we identified is to modify a plot combine by removing the threshing components. All told, this strategy

could cost \$7000 - \$9000. Tractor-mounted reaper binders may be useful with little or no modification, and such machines cost around \$12,000. Tractor-mounted lavender harvesters would likely require no modification and could harvest an acre in as little as 45 minutes. Such machines could cost around \$23,000 with shipping.

Before investing in large equipment, we recommend first borrowing or leasing and testing any equipment that may be in one's area.

Summary and Recommendations

The following charts summarize our recommendations and the estimated costs for starting seeds, transplanting, and harvesting for a range of scales.

STARTING SEEDS			
Acreage	Method	Plants	Costs
0 - 0.04	By hand; flats or broadcast	0 - 1000	< \$50
0.04 - 0.25	Paper-pots	1000 - 7500	\$0.02/seedling
Any	Nursery flats	Any	\$0.08/seedling

TRANSPLANTING			
Acreage	Method	Time	Costs
0 - 0.1	By hand; hand-held tools	40 hours per acre (with two people)	\$0 - 150
0.1 - 0.5	Walk-behind machines	20 hours per acre	\$1600
> 0.1	Tractor-mounted machines	10 - 50 hours per acre (with two people operating a single-row machine)	\$1500 - \$6000 (for a single-row machine)

HARVESTING			
Acreage	Method	Time	Costs
0 - 0.25	Serrated sickle or hedge trimmer	40 hrs per acre (with two people)	\$20 - \$200
0.25 - 1	Walk-behind machines	2.5 - 5 hrs per acre (with two people)	\$5000 - \$10000
> 1	Tractor-mounted and self-propelled machines	0.75 - 2.5 hrs per acre (with two people)	\$7000 - \$23000