Buckwheat: A Cool-Season Cover Crop for Florida Vegetable Systems[1]

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Buckwheat [*Fagropyrum esculentum* (Moench)] (Figure 1) is a cool-season annual introduced to the New World by European colonists in the 17th century. Evidence suggests it may have been cultivated in China as early as 5000 B.C. (Ohnishi, 1998). Species of buckwheat grown commercially include *F. sagittatum* Gilib, *F. emarginatum* Moench, *F.esculentum*, and *F. tartaricum* (L.) Gaertn. It is a multipurpose crop mainly cultivated as forage or milled into flour for human consumption. Buckwheat is unique among commercial grains because it is a member of the Polygonaceae family, rather than Poaceae, and as such is often referred to as a "pseudocereal." Diseases of dicot cereals are not important for buckwheat, nor are insects a problem (Robinson, 1980). Wild buckwheat (*Polygonum convolvulus* L.) is an annual weed resembling buckwheat but with smaller seeds and a vining growth habit.

Figure 1. Commercially available buckwheat, *F. esculentum*.

Credits: Image from the Atlas of Florida Vascular Plants, Institute for Systematic Botany, University of South Florida. http://www.plantatlas.usf.edu/default.asp

Buckwheat Industry Overview

In Japan, Russia, and northern China, buckwheat is an important cash crop and food source, with a substantial effort by researchers to develop more nutritious and pathogen-resistant varieties. In Manitoba, Canada, most buckwheat production is targeted for export to Japan for soba noodle production. Over 1.5 million hectares are

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produced worldwide (Myers and Meinke, 1994), and Russia has the greatest area in production.

In the U.S., buckwheat reached the height of its popularity in 1866, when 204,120 metric tons on over 404,800 ha were produced for use as a forage crop as well as a grain for making flour (Bailey, 1912). Production declined to 18,200 ha in 1964, the same year the USDA stopped recording estimates of buckwheat production (Robinson, 1980). In the 1970s, buckwheat had a slight resurgence in popularity as the interest in healthy and natural foods developed, increasing demands for buckwheat flour used domestically in breakfast cereals (Oplinger et al., 1989).

The grain has an amino acid composition that is nutritionally superior to other popular grains, and is especially high in the amino acid lysine, which is essential to human nutrition and notably deficient in rice (*Oryza sativa* L.) and wheat (*Triticum aestivum* L. subsp. *aestivum*) (Robinson, 1980). The middlings (cotyledons and seed coats) are used as food for livestock or made into flour for human consumption. Buckwheat hulls are sometimes combined with the middlings and marketed as buckwheat bran. Domestically, the hulls are more often used as soil mulch and poultry litter, while in Japan they are used as a fill for pillows (Oplinger et al., 1989). In the U.S., buckwheat is used as a nectar source for honeybees, and a hectare of buckwheat can produce nectar sufficient for 168 kg (370 lbs) of honey. Today, buckwheat grown for grain is produced in Minnesota, Pennsylvania, New York, and to a lesser degree in Michigan, Wisconsin and North Dakota (Björkman, 2002). In the southeast, buckwheat is mostly grown as a cover crop.

Growth Habits and Environmental Requirements

In Florida, *F. esculentum* populations occur within the state (Figure 2). Climbing false buckwheat [*Polygonum scandens* L. *var cristatum* (Engelm. & A. Gray) Gleason] is native to our state, and populations are found in 11 counties north of Marion County (Figure 3). Varieties of *F. esculentum* available include new semi-dwarf types such as 'Manor' and 'Mancan'. These are large-seeded varieties that have larger stems and leaves and are prolific seed producers. Seed is readily available from many outlets including Birkett Mills, Johnny's Selected Seeds, and Peaceful Valley Farm Supply.

Buckwheat has an indeterminate growth habit, growing up to 90 cm (35 in) vegetatively, and flowering continuously until natural senescence, or termination by frost (Figure 4). It germinates in three to five days (Figure 5), and flowers in

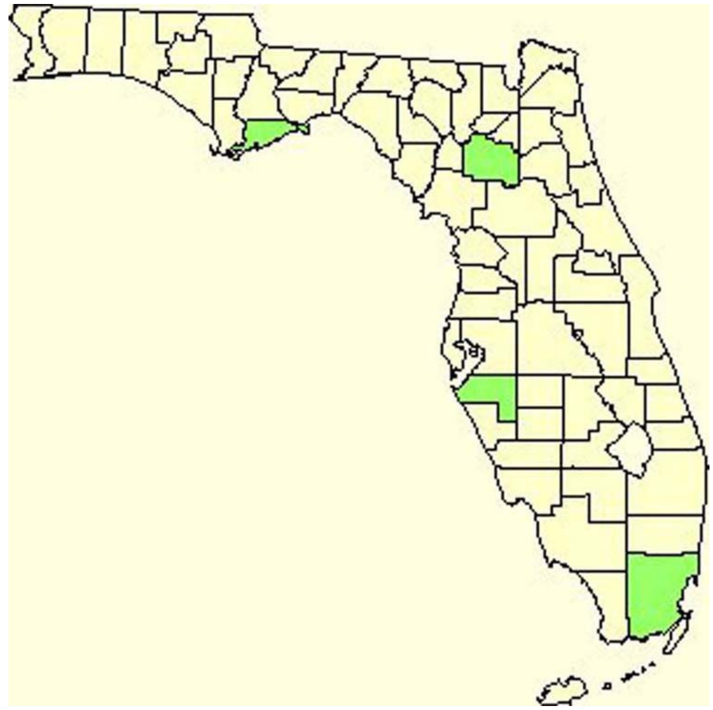

Figure 2. Distribution of Fagopyrum esculentum (Moench) in Florida.

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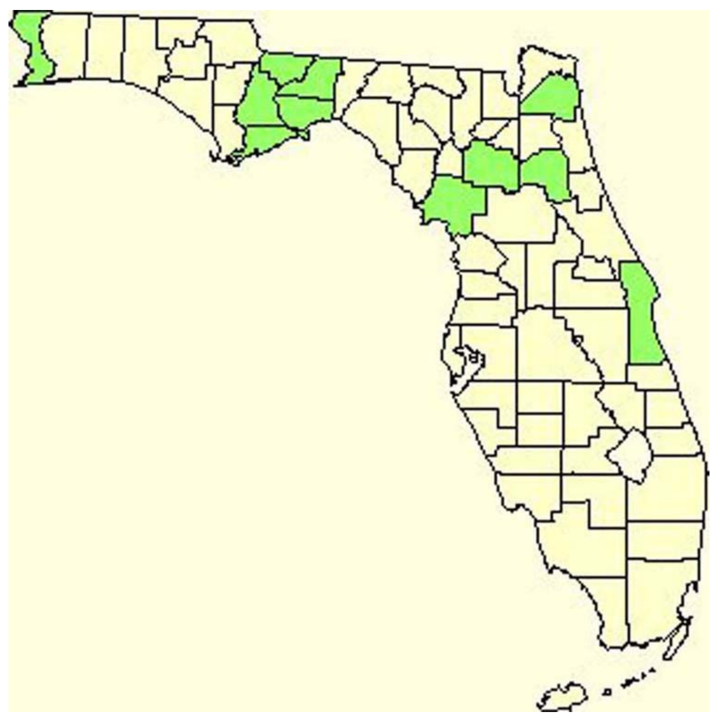

Figure 3. Distribution of Polygonum scandens var. cristatum in Florida.

Credits: Image from the Atlas of Florida Vascular Plants, Institute for Systematic Botany, University of South Florida. http://www.plantatlas.usf.edu/default.asp approximately three to five weeks. In ongoing experiments on buckwheat as a weed-suppressive cover crop in Citra, Florida, flowers appeared in three weeks in late spring, and four weeks in the fall (Huang, unpublished data). In those same experiments, mature seeds formed in six weeks in late spring, and eight weeks in the fall (Huang, unpublished data) (Figure 6). The crop requires 12 weeks to harvest mature seed. Buckwheat is tolerant of a wide range of soil types and fertility levels, but performs best when the climate is cool and moist. It germinates at temperatures between 7° and 40°C (45 – 104°F). It is well suited to production on sandy soils, as clayey or nutrient-rich soils may cause irreversible lodging. Although the crop will perform well on residual fertilizer, some nitrogen is needed to ensure optimal response. For grain production, recommended nitrogen rates in Wisconsin and Minnesota range from 1 to 58 kg ha^{-1} (1 – 52 lb a^{-1}) when organic matter is less than two percent (Oplinger et al., 1989). Buckwheat can tolerate acidic soils and will respond to liming when the pH is less than five.

Figure 4. Four-week-old buckwheat in flower in Citra, Florida. This buckwheat was planted on March 13.
Credits: Photo by Pei-wen Huang.

The dense, fibrous root system is concentrated in the top 25 cm (10 in) of the soil, and may perform better than cereal grains on low-fertility soils due in part to its root morphology (Bowman et al., 1998). The short taproot and its branches account for 3% to 8% of the dry weight of the plant (Robinson, 1980). The percent of dry weight is much less than the root system of small grains, which may comprise 6% to 15% of the total weight of the plant. Because of its small size, the root system acquires water from a limited volume of soil, which may be a partial explanation for wilting that occurs in hot, dry weather. It is planted in the northeastern states and Canada in the summer, and

Figure 5. Young seedlings of buckwheat in Citra, Florida. This buckwheat was seeded with a drill at a rate of 50 lbs/acre (56 kg/ha.)
Credits: Photo by Pei-wen Huang.

Figure 6. Six week old buckwheat in seed in Citra, Florida.
Credits: Photo by Pei-wen Huang.

in the southeastern U.S., it is typically planted in the early spring or fall.

Buckwheat produces a single stalk per seed and branching depends on seeding. Plants will develop more branches per plant in thin stands; thick stands result in less branching and lower stalk diameter, and are susceptible to lodging (Robinson, 1980). Because of its short life cycle, buckwheat can be included in rotations between cash crops. The unbranched basal stem is hollow in the center, and once incorporated into the soil decomposes rapidly, providing nutrients to the subsequent crop. Due to its rapid decomposition, it may not be suitable as surface mulch on erodible soils.

Typical biomass production for buckwheat ranges from 2.5 to 3.5 t ha^{-1} (2.2 to 3.0 t a^{-1}), In Pennsylvania, over 7 t ha^{-1} (6.25 t a^{-1}) dry matter per hectare can be produced in six to eight weeks (Oplinger et al., 1989). When planted as green manure or living mulch, typical planting densities range from 56-67 kg ha^{-1} drilled (50-60 lbs a^{-1}) to 108 kg ha^{-1} (96 lbs a^{-1}) broadcast. Domestically, seeding rates for *F. esculentum* grown as a grain crop are less, ranging from 40 to 80 kg ha^{-1} (36-71 lbs a^{-1}). Best results are obtained when buckwheat is drilled to a depth of 1.5 to 3.5 cm (0.5 – 1.5 in deep) in 15- to 20-cm rows (6- to 8-in rows), although some growers prefer to broadcast seed. Buckwheat is susceptible to frost and high heat/low moisture conditions, so to gain best benefits, it should be planted at least 60 days before the first expected frost date or before the hot and dry season. Buckwheat should be drilled into a clean field. If the buckwheat crop is to follow a winter cereal, perform additional tillage to eliminate volunteers before planting buckwheat. Till with a disk harrow or similar implement when flowers begin to turn brown to prevent seed maturation and subsequent volunteer buckwheat.

Buckwheat is day neutral in response to photoperiod, and consequently the number of days to flowering is equally influenced by soil fertility, temperature, and moisture (Robinson, 1980). Buckwheat is largely self-incompatible and primarily requires insect pollination to ensure cross-pollination (Adhikari and Campbell, 1998; Bjorkman, 1995). European honey bees (*Apis mellifera* L.) are frequently considered to be the most abundant pollinators, although research in central New York indicated the honey bee may not be the most effective pollinator due to its large size compared to the flower (Björkman, 1995). Approximately 40,000 bees ha^{-1} (or one hive every 2 acres) are needed to pollinate a buckwheat crop (Björkman, 1995).

Buckwheat as a Nutrient Catch Crop

Buckwheat has little ability to capture residual nitrogen, but some researchers have demonstrated buckwheat's ability to take up phosphorus (P) and other nutrients (including calcium) (Zhu et al., 2002), which are released back into the soil in a plant-available form following incorporation of buckwheat residue into the soil (Bowman et al., 1998). The roots of buckwheat exude oxalic acid that allows buckwheat to grow well in soils that are high in aluminum (Al). The mechanism for this resistance is believed to be related to the immobilization and detoxification of Al by P in the root tissues (Zhu et al., 2002). Additional support for P acquisition and release is provided by Annan and Amberger (1989), who hypothesized that the high activity of acid phosphatase in the rhizosphere contributed to the release of P acquired under low concentrations of soil P. Buckwheat also has the capability to use P from organic sources.

Interactions of Buckwheat and Insects

Buckwheat can be managed to promote flowering throughout the summer in cool climates. For this reason, it has been noted for its ability to attract a wide range of beneficial insects including predatory wasps (Hymenoptera: Sphecidae, Eumenidae, and Vespidae), syrphids, and tachinid parasitic flies (Bugg and Dutcher, 1989; Platt et al., 1999). Planting border strips of buckwheat near zucchini resulted in a decrease of aphid (*Aphis gossypii* Glover) densities and therefore a reduction in the incidence of aphid-transmitted viruses in the cash crop (Hooks et al., 1998). Buckwheat has few insect pests.

In a Florida trial, a living mulch of buckwheat was compared to bare ground, reflective and white mulches to control homopteran pests in zucchini (Frank and Liburd, 2005). The living mulch of buckwheat did reduce the number of whiteflies, and had higher natural enemy populations than synthetic mulch or bare ground treatments, but also significantly lowered zucchini yields.

Buckwheat is reported to be an alternate host of several important economic pests of vegetable and ornamental crops including chili thrips (Funderburk et al., 2007), European corn borer (Capinera, 2005), rice weevil (Koehler, 2005) and fall armyworm (Capinera, 2005), and root legion nematode *Pratylynchus penetrans* (Marks and Townsend, 1973; McSorley and Kruger, 2007; Noling, 2005).

Weed Control and Weed Suppression by Buckwheat

There are currently no herbicides registered in the U.S. for weed control in buckwheat (Myers and Meinke, 1994). Weeds commonly a problem in northeastern states include redroot pigweed (*Amaranthus retroflexus L.*) and common lambsquarters (*Chenopodium album L.*). Growers maximize the weed control potential by timing the planting date early enough that buckwheat successfully competes with slower emerging weeds. Often, thick stands are planted to out compete weeds, but that can interfere with mechanical cultivation. In Canada, only diclofop methyl is registered for control of some annual grasses in buckwheat, and no labels exist for broadleaf weed control (Wall and Smith, 1999). Buckwheat is sensitive to broadleaf herbicides, and germination may be hindered by residues of atrazine, trifluralin, and sulfonylurea herbicides.

Because buckwheat germinates quickly, it produces a dense canopy quickly, shading the soil and acting as a good competitor against weeds. Scientists have reported effective control of Canada thistle [*Cirsium arvense* (L.) Scop.], sowthistle (*Sonchus oleraceus* L.), leafy spurge (*Euphorbia esula* L.), Russian napweed (*Centaurea repens* L.), and perennial peppergrass (*Lepidium latifolium* L.) by buckwheat (Marshall and Pomeranz, 1982). Samson (1991) evaluated cover crops following winter wheat in Quebec and found buckwheat and oilseed radish (*Raphanus sativus* L. var. *oleiferus* Stokes) on cultivated soil reduced weed biomass more than application of glyphosate herbicide.

Several scientists have suggested allelopathy as the possible mechanism of weed inhibition (Cook, 1989, Eskelsen and Crabtree, 1995), and recent research supports this hypothesis. Iqbal et al. (2002) identified three phenolic acids, (ferulic acid, caffeic acid, and chlorogenic acid), four fatty acids, (palmitic acid, stearic acid, arachidic acid, and behenic acid), and three other chemicals that function as allelochemicals in buckwheat. Iqbal et al. (2003) isolated and identified other allelopathic constituents including gallic acid and (+)- catechin in the ethyl acetate phase. In the laboratory, lettuce seed germination and development was suppressed when exposed to these chemicals (Iqbal et al. 2002). In the field, Tsuzuki and Dong (2003) conducted an experiment to determine if buckwheat could suppress two major weeds in Japanese rice fields. In this trial, buckwheat suppressed both barnyardgrass (*Echinochloa crusgalli* L.) and monochoria (*Monochoria vaginallis* P.). Additional research on buckwheat's weed suppressive effects will continue to identify weed species most sensitive to the allelochemicals produced by buckwheat.

Economics

Total domestic production was 52.8 million tons in 2000 (Björkman, 2001). Total cost of production ranges from $8.00 to $32.00 per acre, including operation and labor. Typical grain yields in the northeastern U.S. range from 1100 to 1700 kg ha^{-1} (980 to 1520 lb a^{-1}).

Buckwheat is moderately priced, and will reseed in northern climates to produce a crop the following year. In Florida, germination of seed can occur immediately following seed drop in warm wet weather, so producers should be prepared to follow with light tillage to eliminate unwanted volunteers. The succulent stems of buckwheat allow for easy plow down. Using typical seeding rates for the southeastern U.S., 50 lbs per acre buckwheat is more expensive than the same rate of rye ($14.00 versus $10.00 per hectare) but less than hairy vetch at 34 kg ha^{-1} (30 lb a^{-1} at a cost of $27.00 per acre).

Summary

In Florida, buckwheat will most likely thrive in areas that have cool and wet conditions, such as north central and north Florida in spring or early fall. Although the USDA reports at least one wild population of *F. esculentum* in south Florida (Fig.1), previous research does not recommend integration of buckwheat in the farming system based on observations of poor germination and growth (Li et al., 2006). Despite this report, buckwheat is occasionally grown during fall in south Florida with success. Buckwheat is best grown as a weed suppressive cover between high value crops in spring or fall.

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