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Cultivation of Mixed Summer Cover Crops (Buckwheat, Cowpea, and Teff Grass) In High Tunnels

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Introduction

Cover crops are grown to cover the soil surface. They are planted between main crops or as an alternative to cash crops and provide many benefits ranging from soil erosion control, improved soil fertility, soil health (Reeves, 1994; Wang and Nolte, 2010), and increased biodiversity (Drinkwater et al., 1995). The use of cover crops among small-scale farmers can be challenging due to the limited space, resource, equipment needs, and the nature of operations. In high tunnel production systems, the use of tractors is limited, and growing cover crops requires careful crop selection, termination timing, and management for maximum benefits. High tunnels are plastic-covered structures that provide a partial controlled environment passively heated in winter and ventilated in summer. For environmental protection and control, high tunnels are between the open-field (natural environment) and completely controlled environments in a greenhouse. Compared to a standard greenhouse, a high tunnel is a low-cost structure, often with in-ground production, and low operating costs. This study determined biomass production and shoot mineral composition of mixed summer cover crops (buckwheat, cowpeas, and teff grass) to determine the optimum termination time while minimizing management inputs and obtaining maximum soil health benefits from the cover crops. Recommendations outline how small-scale farmers can grow cover crops in high tunnels.

Materials and Methods

Study Location: The study reported here was conducted in Yavapai county at Whipstone Farms in Paulden, Arizona at an elevation of 4,400 feet.

Soil history, preparation, seeding rate, and irrigation: The previous crop in the high tunnel were ranunculus plants, an annual plant grown for cut flowers. Soil-borne diseases were confirmed in spring 2020, causing damage to plant (Fig. 5). Recommendations were to improve soil fertility and health by using cover crops to break the disease cycle. The farmer applied 266 cubic feet of horse manure per 1000 ft^2, incorporated it to a depth of 3 inches with minimum tillage as is the regular practice for this operation, and allowed the soil to condition for a week before planting. The high tunnel has no history of synthetic fertilizers or pesticide use based on the information provided by the farmer. A mixed summer cover crop (buckwheat, cowpea, and teff grass) was planted on August 15th, 2020, at a seeding rate of 8 Ibs/ 1000 ft^2 (2 lbs cowpea, 5.5 Ibs buckwheat, and 0.5 lbs teff grass). Sprinkler irrigation lines were used to deliver water to the cover crops three times a week as needed for germination and optimum growth.

Data collection: Beginning at 21 days after planting (DAP), weekly data was collected on fresh and dry shoot biomass on September 7th, 14th, and 21st, 2020 (week 3, 4, and 5). The shoot samples were collected using a meter square quadrat in three random locations in the field and weighed separately as replicates to determine the fresh biomass per meter square (Figure 1a-c).

One-third of the each fresh sample was oven-dried at 65 oC to obtain dry biomass after weighing the dried samples on an electronic scale. Dry biomass was then multiplied by 3 to obtain total dry biomass per sampled area. The dry samples were sent to the Texas A&M soil and foliage lab for mineral shoot analysis using their commercially available protocols. Plant shoot N was determined by high-temperature combustion (Nelson and Sommer, 1973). In contrast, B, Ca, Cu, Fe, K, Mg, Mn, Na, P, S, and Zn were determined by ICP analysis of a nitric acid digest (Havlin and Soltanpour, 1989) and reported on a dry plant basis.

Pictures were taken each week at the time of each sampling time to document cover crop stand density, flowering, and rooting density. While crop stand and flowering buckwheat

Figure 1: Shoot sample collection at Whipstone Farms in Paulden, Arizona (Photos by Dr Isaac Mpanga)

pictures were taken in situ, for root density, the crop stands were pulled out by hands to capture the pictures on rooting density and nodulation.

Results and discussion

Cover crop biomass

Biomass production was greatest at week five (Fig. 2 and 3), with greater root density that held the soil intact than weeks three and four (Fig. 2 a-f). At week 5, cowpeas had nodulation formation (Fig. 2f) and 100% of the buckwheat was flowering (Fig. 2e).

At week five, the cover crops were still small enough that simple tools and approaches such as BSC (two wheeled walked-behind small tractors that is mostly used by market gardeners) or plastic mulch, respectively, could terminate the cover crops in the high tunnel with no difficulty. Allowing the cover crops to attain the ideal amount of biomass, root growth, and nodule formation (in nitrogen-fixing crops) is essential to earn the maximum benefits. For example, 75 days after planting, cowpeas can produce 1.5 – 2.5 tons/acre of biomass containing 80 – 130 Ibs/acre of nitrogen in the above-ground biomass and fix a total of 100-150 Ibs/acre of nitrogen (Wang and Nolte, 2010).

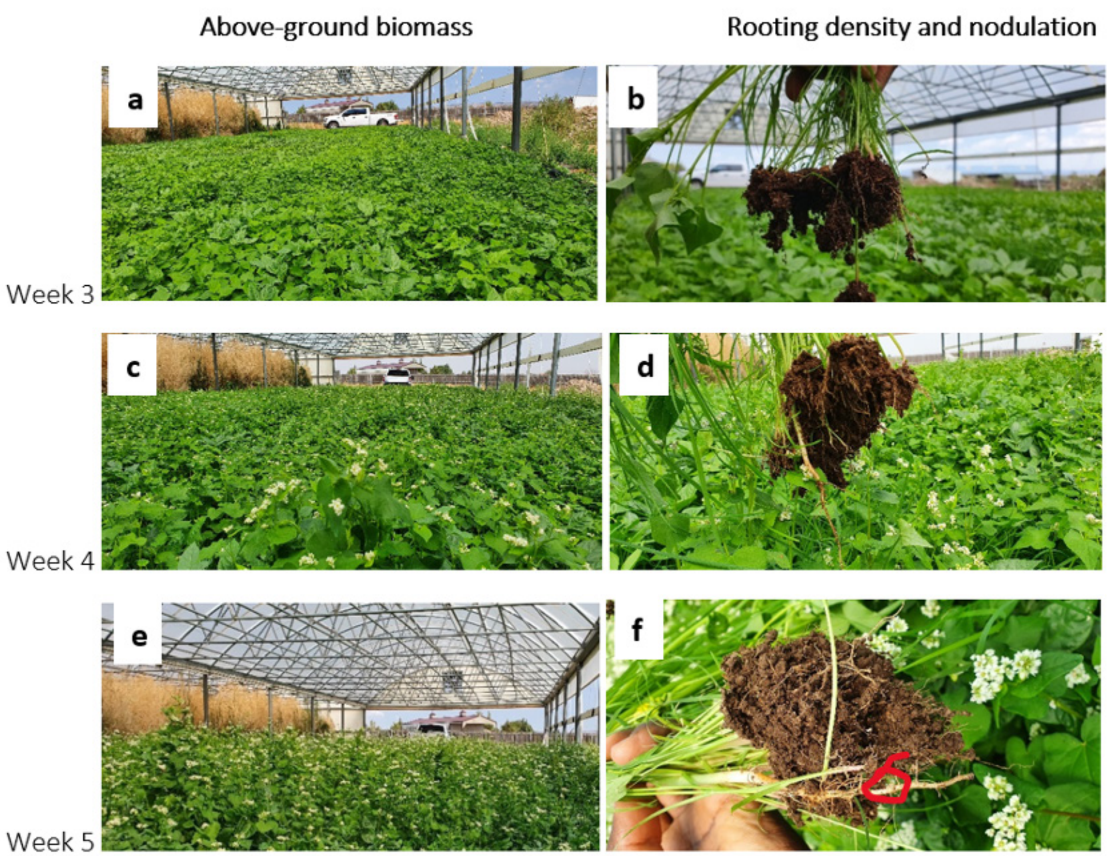

Figure 2: Above ground biomass and rooting densities of summer cover crops (teff, cowpea, and buckwheat) under the high tunnel at Whipstone Farms in Arizona on week three, four, and five after seeding. The red circle on f indicates nodulation on the cowpea roots (Photos by Dr Isaac Mpanga).

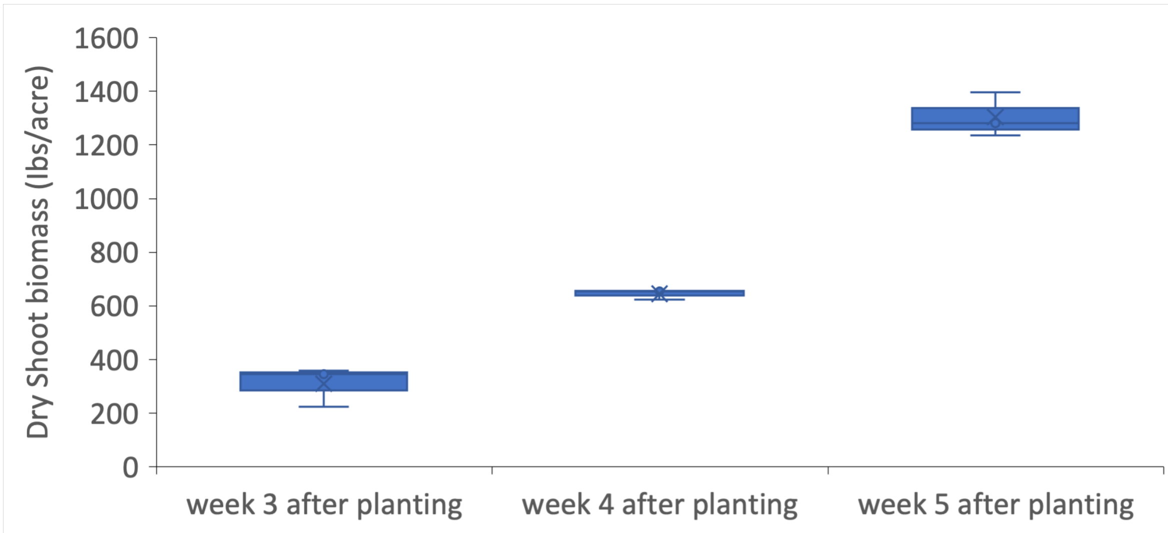

Figure 3: Dry biomass weight of summer cover crops (teff, buckwheat, and cowpea) at weeks 3, 4, and 5 after planting in a high tunnel with horse manure application.

Mineral composition of the cover crops

The mineral content of the mixed summer cover crops increased rapidly from week three to week four and from week four to week five (Table 1). The shoot N in the mixed summer cover crops at day 35 was about half of what cowpea alone could produce at 75 days (Wang and Nolte, 2010). This means that the maximum benefit of the cover crop in making nutrients available for the next crop is at week five or later, which corresponds to more biomass production as observed in week five data in Fig. 2 and 3. However, allowing cover crops to grow longer may make it difficult to use simple tools and approaches to terminate and incorporate the cover crops back into the soil in high tunnels. Hence, timing is critical, depending on the cropping system, types of cover crops, and how to quickly terminate and manage cover crop with ease.

Table 1: Cover crops (teff, buckwheat, and cowpeas) shoot mineral composition at week 3, 4, and 5 after planting in the high tunnel. SAS, Turkey test at p=0.05, same letters in the same row mean no significant differences.

	Week 3	Week 4	Week 5	Change from Week 3 to Week 5 (%)
N (lbs/acre)	12.49 c	22.20 b	40.62 a	225.3
P (lbs/acre)	1.89 c	2.60 bc	7.34 a	288.8
K (lbs/acre)	19.32 c	39.48 b	72.67 a	276.2
Ca (lbs/acre)	3.84 c	7.68 b	16.04 a	317.8
Mg (lbs/acre)	2.29 c	4.26 b	7.56 a	230.1
Na (lbs/acre)	0.14 b	0.28 a	0.30 a	116.6
Zn (lbs/acre)	0.03 c	0.05 b	0.07 a	171.0
Fe (lbs/acre)	0.04 c	0.10 abc	0.14 a	214.9
Cu (lbs/acre)	0.00 a	0.01 a	0.01 a	321.2
Mn (lbs/acre)	0.03 b	0.04 b	0.06 a	135.8
S (lbs/acre)	0.86 c	1.71 b	3.02 a	252.7
B (lbs/acre)	0.01 a	0.02 a	0.03 a	237.6

Figure 4: Pictures of Ranunculus asiaticus before with soil born disease infestation (a) and after the summer mixed cover crop (buckwheat, teff grass, and cowpea) with healthy plants (b) in the high tunnel (Pictures by Shanti Cory, Whipstone Farm, Paulden AZ).

Benefits and concerns of cover crops

1. The cover crop could serve as a host to plant disease and pests. For example, leguminous cover crops (lablab and hairy vetch) are reported to be a host for plant-parasitic nematodes. Avoid using such crops in the soils and cropping systems with a history of nematode related issues (Idowu and Grower, 2014).
2. Planting cover crops after raw manure application and before the main crops such as vegetables can reduce the possible potential of transmissible manure-borne pathogens such as E. coli and salmonella contaminants.
3. Cover crops serve as a fallow period for soil rejuvenation, which may help break disease and pest cycles between main crops and seasons. For example, fig. 4 shows a diseased ranunculus plant in 2020 due to continues cropping (Fig. 4a), but after the summer cover crops (buckwheat, teff, and cowpea), the plant stands in spring 2021 shows healthy plants (Fig. 4b).
4. Cover crops add organic matter and help break down organic materials such as manure, increasing the availability of nutrients to the main crops that will follow.
5. Cover crops improve soil aeration and water infiltration through their growing roots, which penetrate the soil and leave spaces for water and airflow after decay.
6. Cover crops control both wind and water erosion by providing a surface cover and improved water infiltration resulting from cover crop root systems.
7. Cover crops increase biological activity and diversity in the soil, improving soil health. Root exudates are carbon sources for soil microbes, which stimulate beneficial soil microbial communities.
8. Legume cover crops such as peas convert or ‘fix’ atmospheric nitrogen into plant-available forms through symbiotic relationships with Rhizobium bacteria in root nodules (cowpea in Fig. 2f and pea in Fig. 5).
9. Cover crops serve as catch crops by holding minerals from leaching for the subsequent main crop, which could reduce fertilization requirements for that season.
10. Cover crops provide pollinator habitat for bees (Fig. 4a) and other beneficial insects such as ladybugs (Fig. 4b). These beneficial insects may help pollinate the main crops and control detrimental insects.

Figure 5: Cluster nodules on pea in a mixed stand with triticale and vetch. This picture was taken in the open field at Whipstone Farm (Picture by Dr Isaac Mpanga).

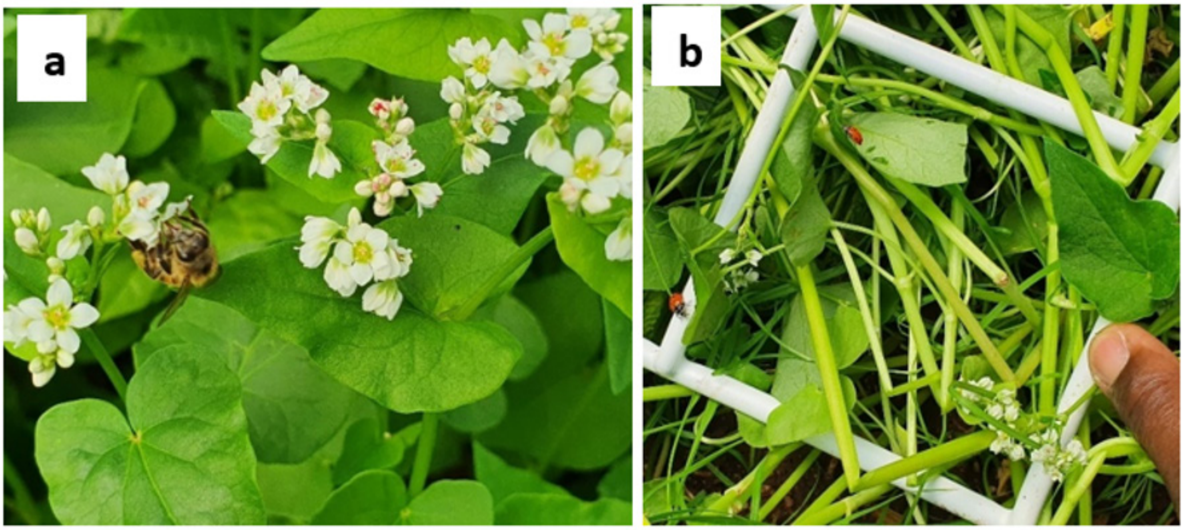

Figure 4: Cover Crops serve as a habitat for beneficial insects (Picture by Dr Isaac Mpanga).

Recommendations for growing cover crops in high tunnels

1. Allow summer cover crops enough time (5-8 weeks) for good rooting, nodulation (nitrogen-fixing legumes), and biomass production (Fig. 2). The roots will help to aerate the soil and hold minerals from leaching. Nodules (Fig 2f and 5) of legume cover crops fix nitrogen, and the biomass takes up minerals (Table 1) that are returned to the topsoil for your main crop.
2. Do not let cover crops overgrow in the high tunnel. Overgrown cover crops will make incorporation into the soil difficult since heavy equipment may not be possible to use.
3. For maximum potential of legume cover crops, inoculate the seeds with Rhizobium bacteria before planting to ensure proper nodulation.
4. Use fast-growing but succulent plants such as cowpeas, peas, buckwheat, and teff, which are easy to incorporate into the soil with simple equipment.
5. Do not grow cover crops, such as Sudan grass and millet, that are aggressive growers. Termination of these crops could be challenging without heavy machinery such as tractor.
6. Use mixed cover crops with different rooting depth, structure, and growth habits. Examples are cereal grains such as teff and nitrogen-fixing legumes such as cowpeas and peas.
7. Use cover crops with low demand for water and supplemental fertilization—for example, teff, cowpeas, buckwheat, mung beans, etc.
8. Grow cover crops between your main harvest seasons, so you do not interrupt your main crop production system. If there is not enough time between your main growing seasons, rotate a fallow plot around your field for your cover crops.

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Additional Resources

1. For additional resources on warm and cold season cover crops that can be grown in semi-arid areas, how to select the right cover crop, and their planting rates, refer to the factsheet below.

Idowu J and Grover K (2014). Principles of Cover Cropping for Arid and Semi-arid Farming Systems. New Mexico State University Extension Service. Guide A-150.

2. For more information on how to estimate plant available Nitrogen from cover crops, consult the material below.

Sullivan DM and Andrews ND (2012). Estimating plant-available nitrogen release from cover crops. PNW 636

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