United States Department of Agriculture

FINAL STUDY REPORT
(Cape May PMC, Cape May Courthouse, NJ)

Millet Adaptation Trial in Coastal Plain Sandy Loam Following Fall-Seeded Cover Crops in Southern NJ

Chris Sheahan, Soil Conservationist

ABSTRACT

As the USDA-NRCS promotes the use of diverse cover crop rotations and greater use of cocktail mixes to help improve soil health and farm resiliency through crop diversification, more information is needed on growth performance and basic physiological attributes of alternative or less commonly used cover crop species such as millet. New Jersey field office staff have expressed an interest in identifying suitable millet species to grow in the state. This study compares five species of millet for potential use as a quick-growing, warm-season grain that can serve as an alternative or compliment to grain sorghum or sorghum x Sudangrass for cover crop use. Five species of millet were planted on May 22, 2015; they included: browntop millet (*Urochloa ramosa*), pearl millet (*Pennisetum glaucum*), Japanese millet (*Echinochloa esculenta*), foxtail millet (*Setaria italica*), and proso millet (*Panicum miliaceum*). Each species was planted in 30’ rod rows in 12 completely randomized blocks that were 30’ x 30’ or ~ 0.021 ac. Measurements were taken of percent germination, vigor, plant height, and stem width (pearl millet) and analyzed using ANOVA in Statistix software. Any potential influence of previous fall-planted cover crop on the study plots were described. Data in this study suggest that Japanese millet and browntop millet have the potential to be good quick-growing, weed-suppressing cover crops due to their high germination rate and good vigor. Pearl millet produced the tallest, longest-lived plants with the greatest biomass of the 5 millet species investigated. NJ FOTG (Field Office Technical Guide) recommendations should be updated to include Japanese millet, browntop millet, and pearl millet as viable options for summer cover crop use in southern NJ counties. Future studies with millet at the Plant Materials Center can include a trial to test specific commercially available varieties of millet (especially pearl millet) for use in the region.

INTRODUCTION

In Coastal Plain soils, low levels of carbon and soil organic matter in the soils lead to a range of crop production problems including high disease rates, low yields, compacted soils, and erosion issues. While millet is not commonly promoted in Coastal Plain soils, it is often used in cover crop combinations with cowpea; a crop that is being more widely promoted. Millet species have a versatile planting window and may be planted in late spring and as late as Aug 1 in northern NJ and August 15 in Maryland and Virginia (Orton et al., 2015). In NJ, these versatile and compressed growing schedules have the potential to work well with growers who plant high value short season vegetables twice a year in spring and fall. Currently grain sorghum or sorghum x Sudangrass is the more popular option for a summer grass cover crop in the region. However, sorghum varieties are woodier than millet species and contain allelopathic properties that may interfere directly with the subsequent fall crop through its residue or indirectly by requiring at least a two-week delay in planting after incorporation.

Millet can be planted as a quick, weed-suppressing biomass cover crop that is well-suited for summer mixes with a legume such as cowpea. Although some growers are concerned about millet’s weediness, it

Sheahan, C., Soil Conservationist, 1536 Route 9 North, Cape May Court House, NJ 08210, chris.sheahan@nj.usda.gov

has also been valued and used as a weed suppressing cover crop since the early 1900's (Agge, 1915). Millets have the potential to become high-value niche market products in diversified, alternative, small-farm settings (Gold and Thompson, 2009). More specifically, there is a growing interest in and promotion of millet species such as pearl millet as a food grain in whole grain diets, and as birdseed (proso millet).

As the USDA-NRCS promotes the use of diverse cover crop rotations and greater use of cocktail mixes to help improve soil health and farm resiliency through crop diversification, more information is needed on growth performance and basic physiological attributes of alternative or less commonly used cover crop species. NRCS field office staff and resource specialists identified the need for more information regarding potential use of millet species in New Jersey and the wider northeastern region. This study compares five species of millet for potential use as a quick-growing, warm-season grain that can serve as an alternative or compliment to grain sorghum or sorghum x Sudangrass for cover crop use.

MATERIALS AND METHODS

Site Location The location for the study was the USDA-NRCS Cape May Plant Materials Center, in Cape May County, NJ (Field 31). The study area was 0.4 acres of a well-drained, slightly acidic (6.19), downer sandy loam soil with <1% slope. The mean annual precipitation of the area is 28–59 in. and the mean annual air temperature is 46–79° F. The Rutgers Soil Testing Laboratory analyzed soil samples using Mehlich 3 extraction and reported phosphorus levels above optimum (262), calcium below optimum (706), and potassium and magnesium at optimum levels (166 and 185 respectively). All micronutrients were at adequate levels except boron (B), which was low (0.33) and iron (Fe) which was high (223.50). No soil amendments or supplementary irrigation were used during this study.

Methods Five species of millet were planted on May 22, 2015 with a handheld Planet Jr. push seeder into 30' rod rows in 12 completely randomized blocks that were 30' x 30' or ~ 0.021 ac. The millet species were browntop millet (*Urochloa ramosa*), pearl millet (*Pennisetum glaucum*), Japanese millet (*Echinochloa esculenta*), foxtail millet (*Setaria italica*), and proso millet (*Panicum miliaceum*). Each of the 12 blocks contained a fall-seeded cover crop or cover crop mix (planted on Oct. 03, 2014). The previous fall-seeded cover crops were cereal rye, winter triticale, oats, hairy vetch, annual ryegrass, tillage radish, crimson clover, phacelia, and the cover crop mixes TillageMax Indy, TillageMax Dover, and TillageMax Charlotte (Cover Crop Solutions). The previous cover crop residue was incorporated and mixed in 5 separate rows to at least 4 in. deep using a Troy-Bilt walk-behind rototiller 15 days prior to millet seeding. At this time the interrows were left untilled. The millet rows were then tilled a second time immediately before the millet seeding to ensure the previous cover crop residue was completely incorporated and the soil was conditioned. The interrows that contained standing fall-seeded cover crop residue were then terminated with a rollercrimper. Millet seed was planted according to recommended seeding rates and converted to pure live seed (PLS). Germination was recorded using a scale of 0, 1, and 2 with a corresponding estimated percentage of 0–25%, 26–60%, and 60–100% respectively. Vigor was recorded 18, 40, and 53 DOP using a seedling count to facilitate the quantification of the data. Vigor was determined by taking 3 x 1' line samples and averaging the result. Plant height (inches) was determined by taking 5 samples per row and averaging the result (measured at 17, 39, 52, and 95 DOP). Growth stages were recorded throughout the season, and stem width was sampled from pearl millet at the end of the study. All data were imported to Statistix software and analyzed using ANOVA.

RESULTS AND DISCUSSION

Findings from this study indicate that browntop millet and Japanese millet had the highest percent germination (65–85%) (Table 1). Japanese millet was also one of the most vigorous species tested. Although three species were vigorous initially, over time weaker seedlings tended to die back more often in the browntop millet and proso millet. As a group, the first measuring period (June 9) had significantly higher vigor/seedling counts then last two measurements (July 1st and 14th) (Table 2). There was a significant difference in total height by the last measurement taken on August 25, 2015 (Fig. 1). Pearl millet had the greatest height 38.17 in. (~ 3.2 ft) and by inference, the greatest above and belowground biomass (Table 3). Pearl millet produced an average of 12 flowering seedheads per 30 foot row; or approximately one seedhead every 2.5 linear feet by August 10, 2015. By August 25th the number of seedheads increased to 9 seedheads per linear foot. By this sampling date proso millet had produced seed in the soft dough stage, and Japanese millet and browntop millet had hard ripened seed ready to harvest. Browntop millet and Japanese millet were the first two species to form seed heads, and Japanese millet was the first species to die. A chart of the growth stages shows that the shortest to longest lived millet species were: Japanese millet, browntop millet, proso millet, and pearl millet respectively (Table 4). Although foxtail millet is often considered a vigorous plant recommended for use in restoration work in critical area planting, in this study it did not germinate well nor become established, and little data was measured.

Influence of Previous Fall-Seeded Cover Crop

Although this study was not designed to replicate the influence of previous fall-seeded cover crop treatments on the growth of millet (each of the 5 millet species only underwent one block or treatment per cover crop species), there is some anecdotal evidence that suggests the previous cover crop may have had some influence on the subsequent planting. If there was no influence of the previous cover crop on the millet species then the mean height of the millet should be homogeneous across each block and not significantly different than the control block. This was not the case. In fact, when the data was organized to compare millet plant height between blocks (cover crop treatments), two blocks recorded plant heights significantly higher than the fallow (control), and one species, annual ryegrass, had coincided with shorter plant heights in millet (Table 5). This would suggest that a fall-planted annual ryegrass may have negative influence on a subsequent late-spring planting of each species of millet tested here. While annual ryegrass performed well limiting the intrusion of Canadian horseweed (*Conyza canadensis*), it was not winterkilled in this area (Mid-Atlantic), and as it is considered a late-maturing plant (Clark, 2007), may have locked up too much N or utilized too much moisture for the millet plants in the spring. This could be an area for further study.

CONCLUSION

Field office staff have expressed an interest in identifying suitable millet species to grow in New Jersey. Quick growing summer annual grasses such as millet can be used in crop rotations designed to follow short-season vegetables or cool-season spring cover crops and proceed a late summer/early fall planting of vegetables or fall cover crops. Typically grain sorghum or sorghum x Sudangrass are used in the area, but may take longer to establish and may not be as versatile. This study investigated the potential for millet to be grown as a quick midsummer cover between spring and fall short-season vegetable or cover crops. Data in this study suggest that Japanese millet and browntop millet have the potential to be good quick-growing, weed-suppressing cover crops due to their high germination rate and good vigor. Additionally, both species die back earliest in summer (early August) allowing for more management flexibility and easier termination. Although these species are a viable option in southern NJ, it is unclear if they will be a viable option further north. Pearl millet could be another candidate for more expanded use if the long length of its growing season is suitable for a farmer's fall planting schedule. Data in the

study suggests that pearl millet produces the tallest, longest-lived plants with the greatest biomass of the 5 millet species investigated. Pearl millet can be potentially harvested for grain leaving substantial stalk residue behind. This residue has a C:N ratio greater than 50 (Sheahan, 2014), average stem width of (9 mm), can help improve the soil's organic carbon, reduce weed populations, and create the opportunity for a fall planting with a no-till drill or transplanter. Current NJ FOTG recommends the use of proso millet as a cover crop option in this area. This guidance should be updated to include Japanese millet, browntop millet, and pearl millet as viable options for summer cover crop use in southern NJ counties. Future studies with millet at the Plant Materials Center can include a trial to test specific commercially available varieties of millet, especially pearl millet, for use in the region.

Table 1. Germination summary ranking stage 1; measured on 06/08/15 at the Cape May, PMC.[1]

Germination Rating	Species	
GOOD Germ 65-85%	Browntop Millet	Japanese Millet
MODERATE Germ 30-60%	Pearl Millet	Proso Millet
POOR Germ < 25%	Foxtail Millet	

[1] Germination was subjectively recorded using a scale of 0, 1, and 2 with a corresponding estimated percentage of 0–25%, 26–60%, and 60–100% respectively.

Table 2. Comparison of vigor for 5 species of millet planted on 5/22/2015 at the Cape May Plant Materials Center, Cape May NJ.

Tukey HSD All-Pairwise Comparisons Test of Vigor[1] for 5 Species of Millet				
(06/09/15)				
	Mean	Seedlings/ Linear Ft	Control	Homogeneous Groups
Browntop Millet	48.65	49	57	A
Proso Millet	43.37	43	48	A
Japanese Millet	42.33	42	51	A
Pearl Millet	33.08	33	27	B
(07/01/15)				
	Mean	Seedlings/ Linear Ft	Control	Homogeneous Groups
Japanese Millet	34.36	34	35	A
Browntop Millet	30.11	30	32	AB
Proso Millet	25.35	25	25	B
Pearl Millet	23.31	23	24	B
(07/14/15)				
	Mean	Seedlings/ Linear Ft	Control	Homogeneous Groups
Japanese Millet	31.61	32	35	A
Browntop Millet	24.53	25	23	B
Pearl Millet	24.39	24	22	B
Proso Millet	21.3	21	20	B

[1] In this study vigor is quantified as seedlings per linear ft.

Table 3. Comparison of total average plant height across 5 millet species.

Comparison of Total Average Plant Height (inches) Across 5 Species of Millet				
	Measured on 07/13/15		Measured on 08/25/15	
Species	Mean	Homogeneous Groups	Mean	Homogeneous Groups
Pearl Millet	24.52	A	38.17	A
Proso Millet	20.91	AB	20.45	B
Japanese Millet	20.88	AB	18.52	B
Browntop Millet	18.97	B	18.02	B
Foxtail Millet	17.98	B	na[1]	na

[1] Foxtail millet did not survive into August; so measurements for height were not taken.

Table 4. Table of millet growth stages for Cape May County, NJ. Vegetative growth stages are denoted with corresponding numbers (1–13).

	Month of Year							
						Fall Cover Crop Planting Window		
Millet Species	Late May	Early June	Late June	Early July	Late July	Early Aug	Late Aug	Early Sept
Japanese	1	2	3	10.5	11	Dead	Dead	Dead
Browntop	1	2	3	10	10.5	11 Dead	Dead	Dead
Proso	1	2	3	8	10.5	11	11 Dead	Dead
Pearl	1	2	3	7	10	10.5	11	?
Foxtail	1	2	3	8	10.5	na	na	na

Table 5. Potential influence of previous fall-planted cover crop on the mean height (in) of 5 species of late spring-planted millet.

Treat	Previous Crop	Mean (in)	Homogeneous Groups
12	Phacelia	16.7	A
10	Tillage Max Dover	15.7	A
1	Cereal Rye	15.4	AB
8	Crimson Clover	14.5	AB
11	Tillage Max Charlotte	14.4	AB
7	Tillage Radish	13.9	AB
4	Hairy Vetch	13.5	AB
6	Fallow	13	AB
2	Winter Triticale	12.7	AB
9	Tillage Max Indy	12	AB
3	Oats	12	AB
5	Annual Ryegrass	10	B
Sampling Date 7/13/15			
12	Phacelia	29.2	A
11	Tillage Max Charlotte	26.6	AB
10	Tillage Max Dover	25.8	ABC
1	Cereal Rye	23.4	ABC
8	Crimson Clover	22.8	ABC
7	Tillage Radish	21.2	ABCD
9	Tillage Max Indy	20.4	ABCD
2	Winter Triticale	20	ABCD
4	Hairy Vetch	19.2	BCD
6	Fallow	18.3	BCD
3	Oats	16.2	CD
5	Annual Ryegrass	12.8	D
Sampling Date 8/25/15			
12	Phacelia	31	A
11	Tillage Max Charlotte	29.9	A
10	Tillage Max Dover	28.7	A
1	Cereal Rye	27.4	A
8	Crimson Clover	25.7	AB
9	Tillage Max Indy	24.78	AB
2	Winter Triticale	23.4	AB
7	Tillage Radish	22	AB
6	Fallow	20.63	AB
4	Hairy Vetch	20	AB
3	Oats	19.58	AB
5	Annual Ryegrass	13.58	B

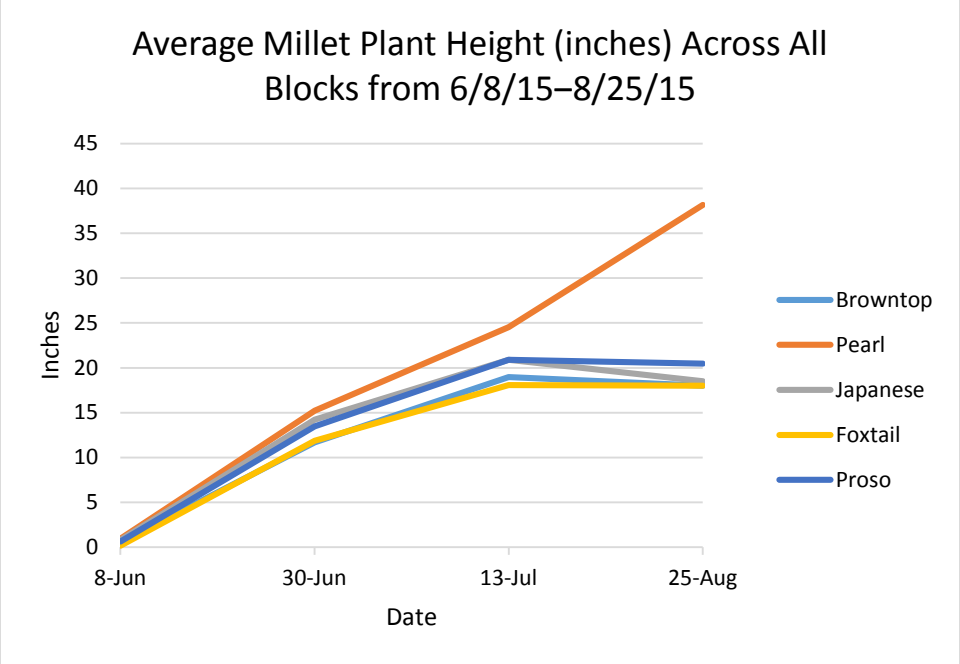

Figure 1. Comparison of average millet plant height from Jun. 8–Aug 25, 2015 at the Cape May Plant Materials Center, Cape May, NJ.

Figure 2. Photograph showing all five rows of millet installed per 30 ft^2 plot. There were twelve plots altogether; with one as control. Millets are (from left to right) browntop millet, pearl millet, proso millet, Japanese millet, and foxtail millet.

Literature Cited

Agge, A. 1915. New Jersey State Agricultural College Extension Bulletin. 1(1). Annual Report of Dir. Of Extension. Ext. Bull. Issues 1-29. Rutgers Univ. Coop. Ext. Service. Division of Extension in Agriculture and Home Economics. New Brunswick, NJ.

Clark, A. 2007. Annual ryegrass. *In* A. Clark (ed.) Managing cover crops profitably, 3rd ed. Sustainable Agriculture Network. Beltsville, MD.

Gold, M., and R. S. Thompson. 2009. List of alternative crops & enterprises for small farm diversification. AFSIC-NAL. Beltsville, MD. http://afsic.nal.usda.gov/list-alternative-crops-enterprises-small-farm-diversification (accessed 25 Oct. 2015).

Orton, T., G. Hamilton, B. Majek, J. Whalen, and A. Wyenandt. 2015. Soil and nutrient management *in* Commercial Vegetable Production Recommendations for New Jersey, 2015. Pub. # E001. Rutgers Univ. Ext. http://njaes.rutgers.edu/pubs/publication.asp?pid=E001 (accessed 25 Oct. 2015).

Sheahan, C. 2014. Plant guide for pearl millet (*Pennisetum glaucum)*. USDA-Natural Resources Conservation Service, Cape May Plant Materials Center. Cape May, NJ. http://plants.usda.gov/plantguide/pdf/pg_pegl2.pdf (accessed 25 Oct. 2015).