Need Fuel? Hire a Halophyte!

They Multi-Task Where Others Can't

Halophyte Biotechnology Center

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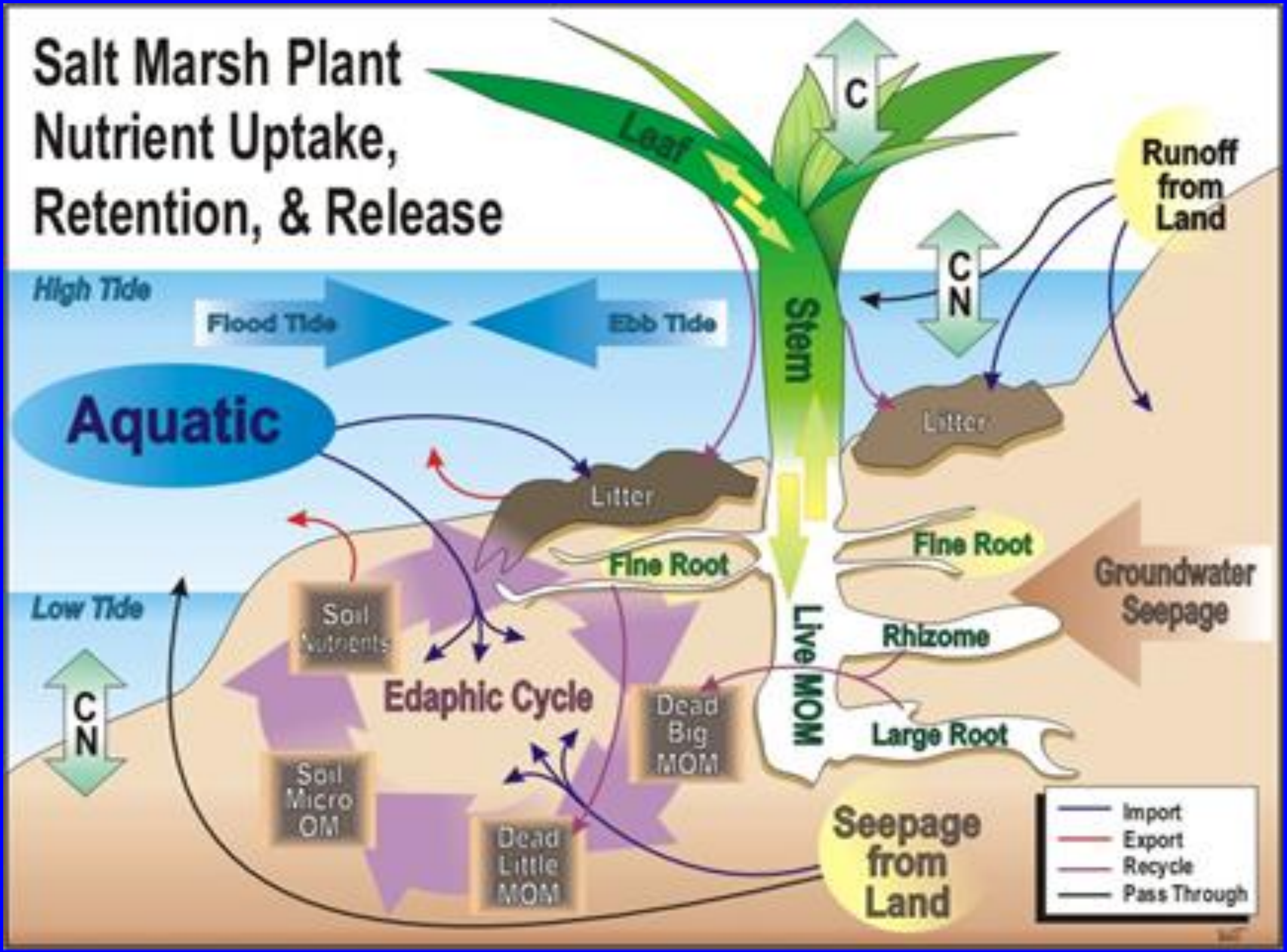


Diagram by Kayti Tigani

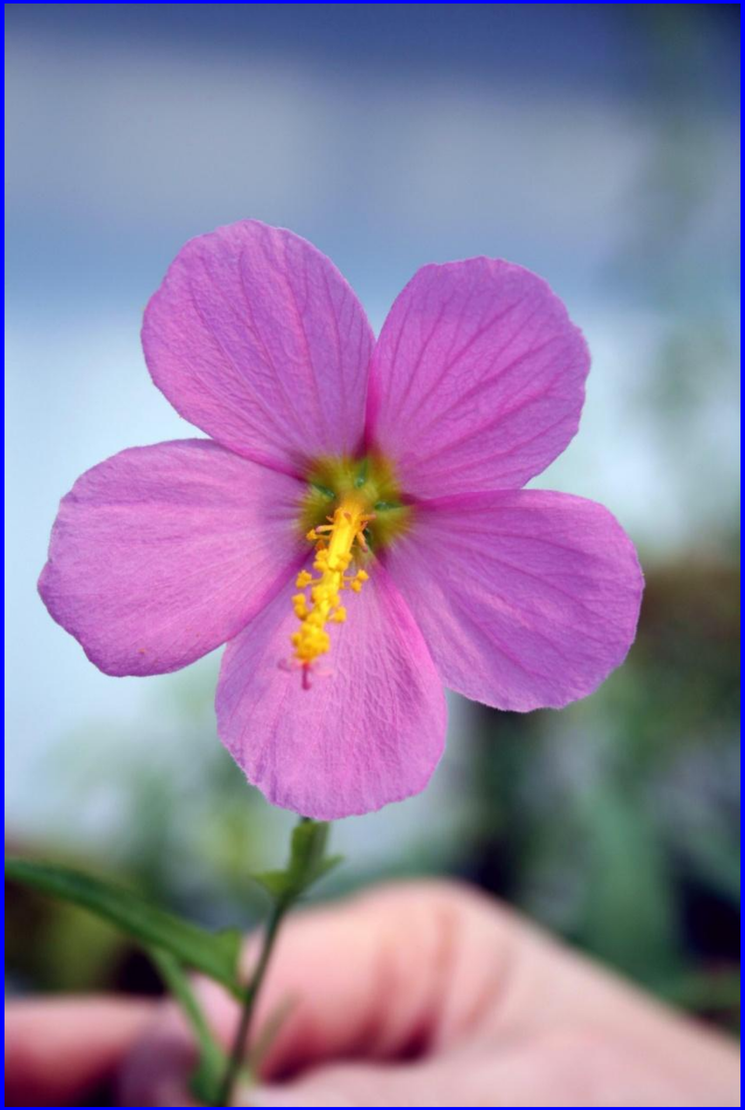
Meet the Plant

Kosteletzkya virginica

- Seashore Mallow
- Malvaceae
- Relative of cotton & okra
- Delaware to Florida and the Gulf of Mexico coast
- Self or cross-pollinated

Seashore Mallow Features

- **Perennial**
- **Grows with saltwater irrigation**
- **Morphology similar to soybean**
- **~18% oil for biodiesel**
- **Residual seed meal ~30% protein**
- **Cellulosic stems for biofuel**
- **Large fleshy roots sequester carbon and contains gums**
- **Grown with traditional farm equipment**



What makes this plant a good candidate for the feedstock list ?

- Uses land and water resources not suitable for traditional crops.
- Requires minimal energy input.
- Grows near coastal population centers.
- Has multiple useful products.

Uses land and water resources not suitable for traditional crops.

- This mallow evolved in the saline, often saturated, soils of the coastal wetlands.

Salt damage from high tides.

- Completes life cycle at coastal ocean salinity.

- Seed production enhanced in the presence of salt.

Requires minimal energy input.

- No-till planting
- Long-lived Perennial
- Saline water suppresses weeds
- Stored carbon reserves close canopy quickly when regrowth begins
- Deep root system taps water deep in the soil profile

Products from Seashore Mallow

Biodiesel -

Oil from the seeds

Sodium Accumulation in Seeds

Seed	Na	K	Ca
Seashore Mallow	15	1248	205
Great Northern	19	1196	144
Soybean	5	1677	226
Barley, pearled	3	160	16

(Islam, et al. 1982) (data are reported in mg per 100 g)

Oil Comparison

	% Oil
Soybean	18-20
Seashore Mallow	15-20
Cottonseed	18

Fatty Acid Composition (%) of Three Seed Crop Oils

Fatty acid	*Seashore Mallow*	*Cottonseed*	*Soybean*
14:0	0.1	1.4	0.1
16:0	24.1	23.1	9.8
16:1	0.6	2.0	0.4
18:0	1.0	1.1	2.4
Malvalic	1.8	1.5	-
18:1	13.7	22.1	28.9
18:2	55.2	47.8	50.7
18:3	0.8	-	0.5
Sterculic	0.5	0.5	-
20:0	0.9	1.3	0.9
22:0	0.9	-	-
24:1	1.9	-	-

Table 4 – Biodiesel properties of *Kosteletzkya virginica*

Indices	*K. virginica*[a]	Criterion of biodiesel[b]			Petroleum[b]
		EN14214 in EU	ASTMD6751 in USA	GB/T20828 in China	
Density (15 °C) (g/ml)	0.879 (20 °C)	0.860–0.900	0.870–0.890	0.818	0.830
Water content (%) (v/v)	nd	<500	<500	77	
Acidity (mg/100 ml)	11				
Flash point (closed cup) (°C)	>90	>120	>100	63	60
Cold filter plugging point (°C)	−5.0			−1.0	
Rust class of steel (50 °C, 3 h)	1	1	3	≤1	2
Ash content (%)(v/v)	nd	<0.02	<0.02		
Sulfur content (%)	0.0003	<10.0000	<0.0010	0.0385	<0.2000
Kinematic viscosity (20 °C) (mm²/s)	6.577	3.50–5.00	1.90–6.00	4.24	2.00–4.00
Machine impurity (mg kg⁻¹)	nd	<24		85	
Cetane No. (real measure)	56	>51.0	>45.0	61.0	≥49.0

nd: content is too low to detect.

[a] Indices were measured by China Petroleum & Chemical Corporation.

[b] Data from www.biodiesel.org.au, and Jia and Xu (2006).

Additional Products

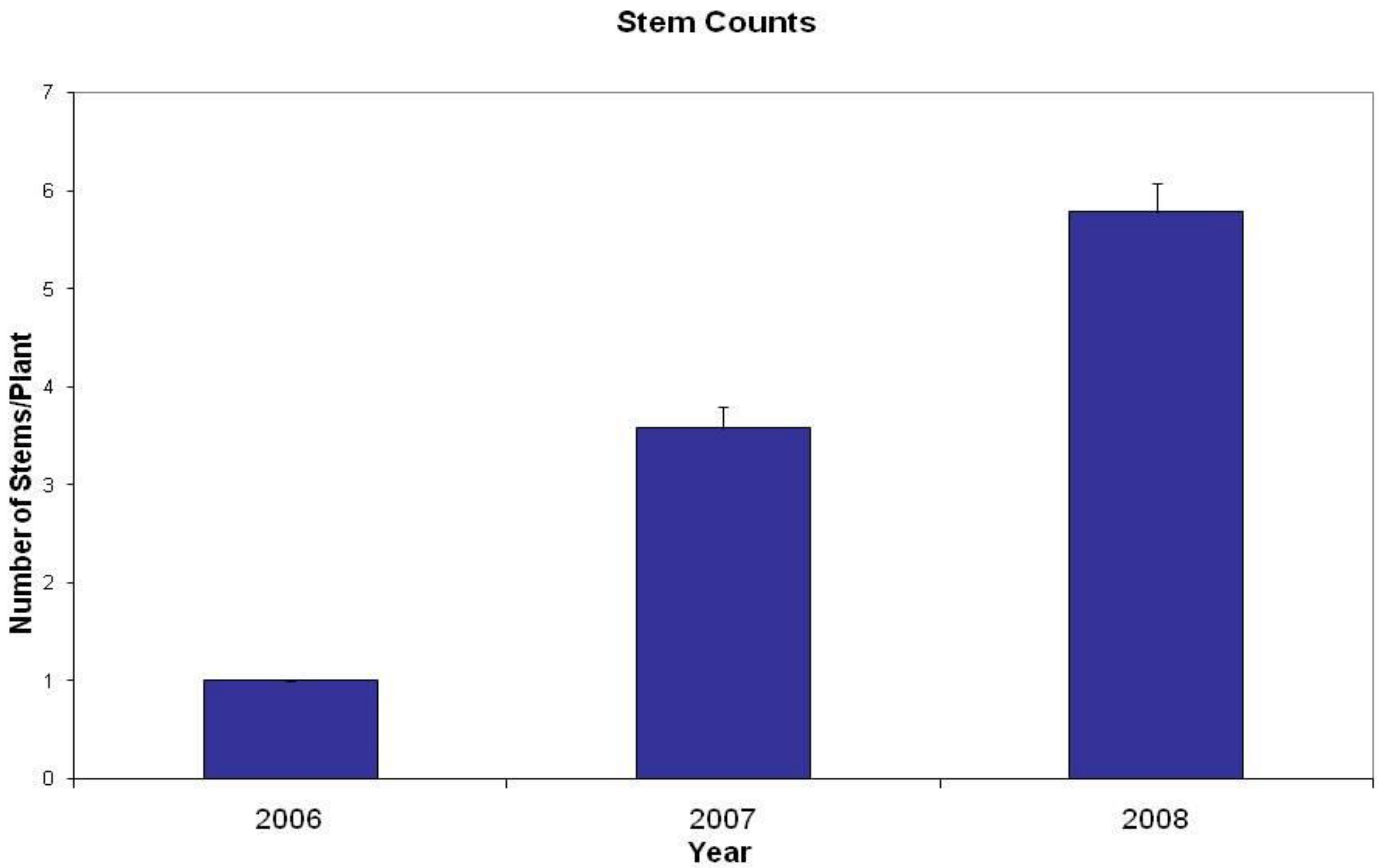
- Feed from mash remaining after oil extraction
- Slow release organic fertilizer

Amino acid	mg/g N	Amino acid	mg/g N
Asp	598+	Val	199*
Thr	224	Ile	175
Ser	321	Leu	357
Glu	1045+	Tyr	187
Pro	230	Phe	283
Gly	336	Tot.arom-AAs	470
Ala	261	His	172
Cys	166	Lys	278
Met	93	Arg	657+
Tot.S- AAs	259	Try	258

*limiting amino acid, + also the most abundant AAs in cottonseed

Stems for Bio-based Products

Single stem first year, multiple stems subsequent years



Stem Counts
Number of Stems/Plant
0
1
2
3
4
5
6
7
2006
2007
2008
Year

Grows near population centers.

- Coastal fields where sea-level rise is flooding fields with saline water (east coast U.S.)
- Coastal deserts that could be irrigated with saline water (Pakistan)
- Soils where either riverine or well irrigation water is contaminated by salt water intrusion and salt-wedge movement upstream (coasts where sea level rise or water use depletes resources)

Phragmites

An example of an agricultural field in Delaware becoming influenced by tidal encroachment and *Phragmites* colonization.

- New coastal soils claimed from the sea (China coast)

- Inland arable fields degraded during irrigation (CA)

- Dry lands with brackish aquifers (Egypt)

- Saline soil with seasonal rainfall (Thailand)

- Non-saline upland soils, especially light droughty soils where irrigation is not available.


4.19.2003


4. 18. 2003


4. 19. 2003


4. 16. 2003

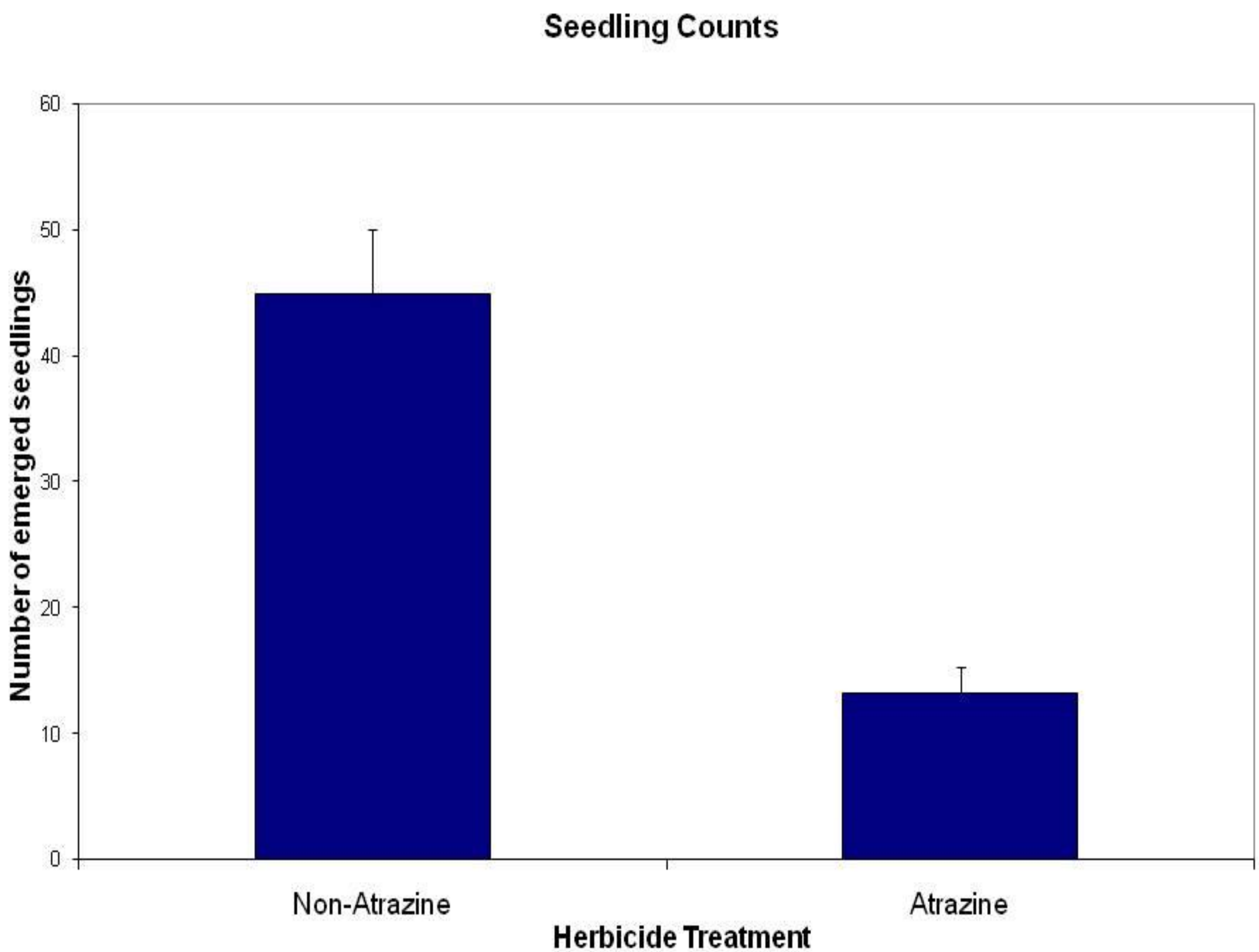
Carbon Sequestration

Larger roots penetrate at least 60 cm in sandy loam soil after the first year's growth.

Planting Seashore Mallow in a no-till setting on the Freeman farm in Sussex County, Delaware.

Planting in tilled sandy loam on the same farm.

The effect of Atrazine applied to second year plants before emergence. *K. virginica* growth was not impacted. From left to right: control (no treatment), 1 lb atrazine per acre, 2 lb atrazine per acre, and 4 lb atrazine per acre.


Seedling Counts
Number of emerged seedlings
60
50
40
30
20
10
0
Non-Atrazine
Atrazine
Herbicide Treatment

Application of macro-algae to *K. virginica*

Treatment	**Nitrogen content (mg g^{-1})**
Macro-algae	26.72
K. virginica control (no treatment)	11.29
K. virginica fertilized with macro-algae	24.33


Coast Day

SEED YIELDS

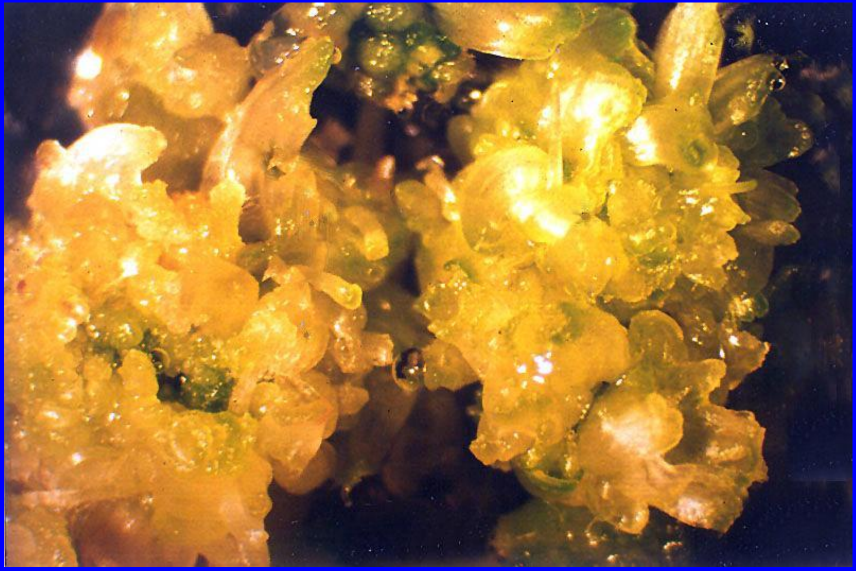
	Bushels per acre		
	Soybeans (2003-2004)		Seashore Mallow
DE	36	42	~ 34
GA	33	30	
IA	32	49	
SC	28	27	

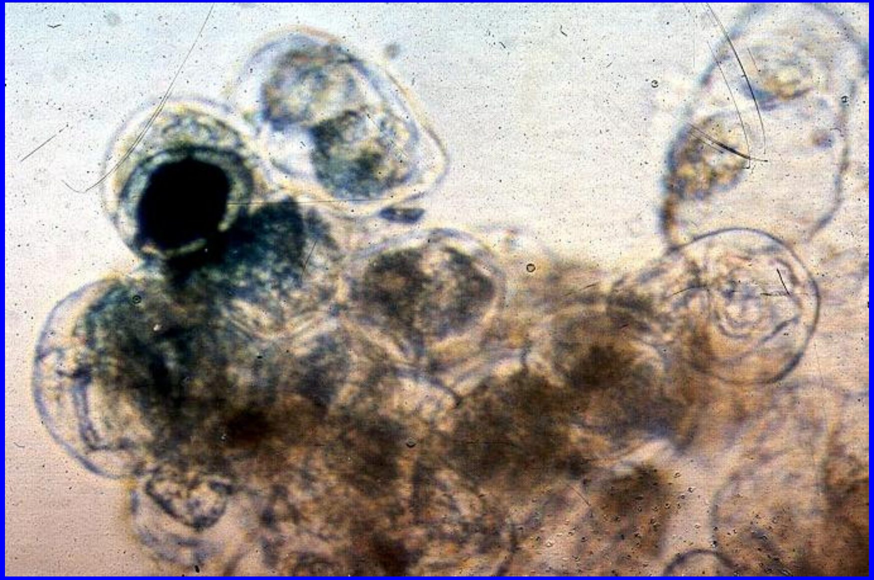
Table 3 – Oil content and relative contents of fatty acids in the seeds of *Kosteletzkya virginica*

Item	YC	TT1	TT2	NJ1	NJ2	Mean ± S.E.	CV (%)
Oil content	18.600	18.860	17.620	16.160	16.440	17.536 ± 0.547	3.119
Myristic acid (C14:0)	0.188	0.122	0.144	0.187	0.079	0.144 ± 0.021	14.583
Palmitic acid (C16:0)	24.603	27.588	25.572	27.313	29.019	26.819 ± 0.779	2.905
Palmitoleic acid (C16:1)	0.435	0.306	0.360	0.467	0.199	0.353 ± 0.048	13.597
Steartic acid (C18:0)	2.015	0.899	1.780	2.514	0.916	1.625 ± 0.316	19.446
Oleic acid (C18:1)	16.279	15.045	14.423	23.621	20.637	18.001 ± 1.775	9.861
Linoleic acid (C18:2)	48.953	52.493	50.874	37.531	41.210	46.412 ± 2.827	6.091
Linolenic acid (C18:3)	4.413	2.543	3.531	5.537	5.003	4.205 ± 0.532	12.652
Arachidic acid (C20:0)	1.637	0.547	2.018	1.484	1.565	1.450 ± 0.245	16.897
Arachidonic acid (C20:1)	1.478	0.456	1.297	1.346	1.372	1.190 ± 0.186	15.630
Saturated acid	28.422	28.316	29.515	31.498	31.579	29.866 ± 0.714	2.391
Unsaturated acid	71.558	71.684	70.485	68.502	68.421	70.134 ± 0.712	1.015

Note: S.E.: standard error of the mean; CV: coefficient of variation (%).

Genetic improvement



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