Fundamentals of Seed Production II. Seed Production and Management Principles

Mark Bennett
Ohio State University

- Successful seed production requires the application of good farming practices along with careful management of the crop. This module describes how agronomic practices relate to seed production in general and the special practices necessary for seed production in particular.

Field Selection

- Proper field selection is important for successful production of almost any crop; however, it is particularly important for seed production.

- Seed producers are interested in attaining maximum economic yields, but they must also be concerned about practices that help achieve high quality seed
- Field history must not make it difficult to produce high quality seed
- Example: fields that have produced rye in the recent past should not be used for seed production of wheat or other small grains; fields that produced small seeded legumes should not be used to produce seed of another inseparable legume seed crop

- Fields that have produced inseparable grass seed crops can also be a similar problem although these normally do not remain viable in the soil as long.
- Select fields that do not have weed problems difficult or uneconomical to control
- Weeds compete for nutrients thus reducing yields
- Greatest problem is the danger of weeds becoming a contaminant in the seed crop lowering its value or making it unmarketable. Avoid fields with serious weed problems

- For cross pollinated crops, fields for seed production must also be selected after considering the possibility of genetic contamination by outcrossing
- Minimum isolation distances from other varieties or pollen sources of the same species must be maintained. True for certified and uncertified seed and is a concern for seed producers

Agroclimate & Location

- The variety of crop to be grown for seed must have a suitable agroclimate, adapted to the photoperiodic and temperature conditions prevailing in that location.
- Specific selected locations would be needed to economically grow crop varieties sensitive to photoperiodism (short days vs. long days) and temps.
- Regions with moderate rainfall and RH are more suitable than locations with high rainfall, RH and extreme temps

- Most agronomic crops require a dry sunny period and moderate temps for flowering & pollination.
- Excessive dew and rains affect normal pollination, resulting in poor seed set.
- Extreme temps may cause desiccation of pollen and poor seed set.
- Very hot & dry conditions adversely affect flowering of several crops esp. vegetables, legumes, and fruit crops, which fail to set seed. These require cooler climate with low humidity to flower and pollinate normally.

- Oilseed crops may tolerate hot weather during flowering, but very high temps can result in premature flowering and production of poor quality seeds.
- Extreme cold temps also damage seed quality in the early phases of seed maturation
- Locations with extreme agroclimate (summer heat and cold winters) are generally not suitable for seed production
- Excessive rainfall normally results in higher disease and insect incidence making harvesting and other operations difficult.

- They may also cause delayed maturity and pre-germination of seed in many standing crops.
- A mature seed crop becomes susceptible to shattering, strong winds, heavy rainfall.
- Ample sunshine, moderate rain and climate, and absence of strong winds are ideal for the production of high-quality seed

Field Preparation

- Eliminating weeds or other crops (chemical or tillage methods) and prepare favorable seedbed.
- Modern herbicides aid the elimination of weeds or other
- Many seed producers use herbicides for destroying old seed fields and establishing new ones

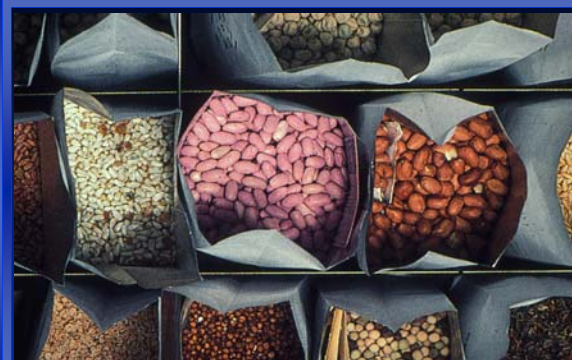
- Permits the seed crop to be established by direct drilling into the old stand
- Most seed crops are planted by conventional methods following the prep of a fine, well-tilled seedbed for maximum seed-soil contact
- Seed-soil contact improved by cultipacking before or after planting, which firms up the soil and ensures max germination and stand establishment

Variety and Seed Selection

- Successful seed production must result in an increase of a variety that is in demand and for which there is a potential or established market
- This presumes that it is an improved variety with desirable agronomic or utilization characteristics

- Example: wheat cvs. should have good yield and milling characteristics and good standability and disease resistance
- Bluegrass should have fine texture, desirable turf type and disease resistance, and should perform well under drought conditions
- No single cv. can have all desirable characteristics, but each should have at least 1 unique feature making it suitable for its intended purpose.

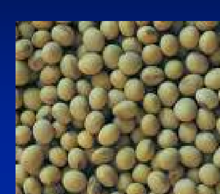
- There is no direct relationship between quality of seed planted and either yield or quality of the crop produced.
- The quality of the seed planted must be adequate to achieve satisfactory plant populations and to permit reasonable yields.
- Generally, seed quality standards are not essentially different for either seed or commercial crop production.



Seeding and Stand Establishment

- Seeding methods for seed production vary greatly among different crops
- Some are similar to seeding methods for commercial crop production; others are very different
- Small-seeded grass and legume crops are almost always seeded at lower rates for seed production than for forage or turf use.
- These tend to have indeterminate flowering patterns that produce higher seed yields in thinner stands.
- Higher seed yields are normally achieved from production in rows rather than in solid stands.

- Seed production of larger-seeded species (small grains, soybeans, edible legumes) normally seeded at similar rates for seed production as for commercial production.
- Some difference between productivity in rows vs. solid stands, but tends to be minimal compared to small seeded grasses and legumes used for forage and turf.



- The time of seeding for seed production is similar to commercial production for most crops.
- The fields for seed production must be planted at a time that permits seedling establishment and allows young plants to undergo floral induction to permit timely seed production
- Timeliness of planting generally permits max seed production of all crops.

Fig. 40. R2 kernels.

- Special seeding techniques often used to permit crop seed to germinate while discouraging weed seed germination
- Important to attain good seed-soil contact for max germ and stand establishment
- This is aided by good seedbed prep and use of cultipackers for a good, firm seedbed.
- Especially important for small-seeded species

Soil Fertility

- No direct relationship between soil fertility and seed quality, but a direct relationship between fertility and yield.
- Generally, if proper fertilization is provided for max yield, good quality seed will be obtained.
- Deficits in minor elements may cause seed quality problems in some crops.
- Calcium and boron deficiencies are known to cause a cotyledonary discoloration in field beans.

- Adequate N, P, K and other essential minerals are crucial for proper growth and development of the seed crop.
- It's necessary to know the nutritional requirements of seed crop to ensure proper nutrition in all growth stages.
- Split applications of N are general advocated to avoid lodging of a crop due to excessive vegetative growth.

- Appl. of N at flowering leads to increase in yield and seed quality of most crops.
- In some early crops N dressings at flowering may tend to delay ripening.
- Grasses and peas are benefited by early apps of N, lettuce crops respond well to N at the time of flowering.

- P & K favor root growth, increased strength of straw, fruiting and seed development
- They hasten plant maturity and increase disease resistance
- K improved photosynthetic efficiency of plants and favors both protein and lipid metabolism in oilseeds.
- Deficiencies of other essential secondary and micronutrients also need to be monitored using soil test measures.

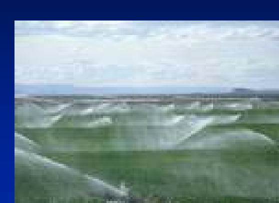
Irrigation

- Availability of H_2O for irrigation in dry areas of the western U.S. makes it possible to produce seed of many species that otherwise would not be possible.
- While dry summers ordinarily provide almost ideal harvesting weather, the crop must be irrigated due to low rainfall levels are inadequate to support production of most noncereal crops
- Available H_2O a major factor in the success of seed production of many species in the western U.S.
- Most other areas depend on groundwater and rainfall to supply crop needs.

- Irrigation may be required before planting and at suitable intervals up to flowering.
- 1 or 2 irrigations may be desirable for many seed crops.
- Frequency of irrigation and amt. of H_2O supplied depend upon the physical texture of the soil, rainfall, and crop requirement.
- Maximum benefits from irrig. can be derived only with adequate crop nutrition in the form of organic manures and fertilization, esp. readily available sources of N &P

- Seed crops sensitive to moisture stress at vegetative, flowering and maturity stages.
- Adequate soil moisture also necessary for uniform seed germination necessary to further crop stand and good seed yields.
- Both excessive moisture conditions and prolonged drought will adversely affect germination, growth and development of the seed crop.

- H_2O applied by surface, sprinkler, drip, overhead, or subsurface irrig.
- Systems have merits and drawbacks with choice method depending on circumstances
- Sprinkler has several advantages, but tends to favor foliage diseases; should be used with discretion.
- Subsurface irrig. may be used to overcome troublesome diseases
- Irrig. should be stopped 2-3 wks. before seed maturity to ensure drier conditions for harvesting.



Weed Control

- Especially important for high quality seed production
- Weeds reduce yields (compete for space, nutrients, moisture and sunlight)
- Reduce seed quality by contaminating the crop with weed seeds that must be removed
- Make a seedlot unmarketable by contamination with noxious weed seeds

- Weed control begins with field selection and continues with field prep.
- Field selection based on freedom from hard to control perennial weeds.
- Weeds that can be controlled are controlled by chemical and cultural methods.
- Tillage and field prep usually complete control of remaining perennial weeds and annual weeds.

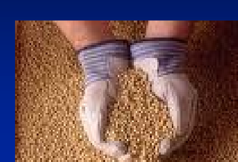
- Weed control in established stands aided by planting in rows that can be cultivated in early spring.
- Supplemented by use of selective herbicides or removal of weeds that are missed or remain uncontrolled by other methods.
- All seed producers understand the necessity of roguing by either manual or chemical means.

- Manual roguing : hand removal of weeds throughout the field
- Chemical roguing: chemical desiccation of weeds prior to seed production to prevent their occurrence in the harvested seed; may be followed by burning desiccated plants (e.g., dodder plants in alfalfa seed fields) to kill or remove immature seeds that may have formed.
- Job is slow and tedious, but often mean the difference between success and failure in producing high quality, marketable seed free of either troublesome or noxious weed seeds.

Disease Control

- Important in successful production of crops, especially for the production of high quality seed
- Seedborne diseases may be caused by bacteria, viruses or fungi; infected seed can be a source of inoculum to infest the next generation

- Production of disease-free seed is accomplished using disease-free plant stock and producing seed in isolated, disease-free areas.
- Chemical foliar sprays help, but usually don't provide adequate control to prevent diseases from becoming seedborne when they are the sole source of disease control.
- Areas in Idaho and Calif. have developed for the production of high quality, disease-free seed under disease-free conditions.



- Systemic seedborne diseases such as loose smut in wheat, passed on to following crop generations, must be controlled scrupulously
- Non-systemic disease may also leave spores on seed coats and carried to following seasons.

- Fungicide treated seed effectively checks the seedling and seedborne diseases.
- Applying appropriate fungicides (and insecticides) in proper quantities at the right time can effectively control most seed crop pests.
- Adoption of appropriate schedules of plant protection and roguing of diseased plants and earheads will further check the spread of disease (and insects)..

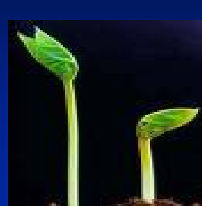
Insect Control

- Not normally as great a problem for seed production as disease, but can be deterrents to high quality seed production.
- Generally cause problems by sucking, chewing and general defoliation
- Some may become seedborne after adults lay eggs in the developing seed.
- After larvae hatch, adults emerge through seedcoat, leaving a hole and empty seed incapable of germination and must be removed during conditioning

- Insects controlled by insecticides and in storage by cleanliness and sanitation of bins.
- Protection may also be provided by treating the seed with insecticide
- Harvested lots already infested may be controlled by fumigation
- Seedlots with uncontrolled infestations tend to heat and increase in moisture level leading to rapid deterioration

Planting

- For maximum seed yields, establish good stands
- Use production practices that rely on sound soil management and methods to place the seed into the soil at the proper depth and minimum seed damage and maximum seed-soil contact.
- Factors: soil type, soil prep, time of planting, seeding depth row width and plant population



Soil Preparation

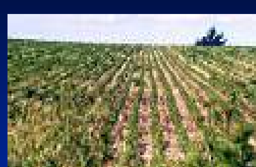
- Soils become compacted over time during ground prep, planting, cultivar and harvest.
- Integrity of soil and its fertility must be monitored, replenished and maintained (various tillage methods to prepare soil for planting and other cultural practices.
- Fine, firm seedbed ensures good seed-soil contact promoting rapid seed imbibition and seedling establishment

- Excessive tillage can be detrimental to soil since it destroys structure, reduces organic matter and causes soil erosion.
- Gov't. programs dictate new minimum-till or no-till practices that influence seed production of some crops
- Care must be taken to use new soil prep methods that encourage soil warming in the plant zone.

Time of Planting

- Best time for planting varies with the crop and its geographical location.
- Early planting often recommended because it allows crop to become quickly established, create a ground cover and provide max light interception.
- Early planting and rapid establishment minimize weed competition and increases the period of vegetative growth.

- There is risk associated with early planting
- Freezes can occur that damage seed or seedling and require replanting
- Low soil temps can delay seedling emergence and reduce plant population
- Proper tillage practices minimize early planting problems by enhancing drainage and reducing difficulties related to wet, cold soils.



- Risks associated with late plantings include increased weed competition, loss of germination and vigor due to frost, or delayed harvest and reduced yields.
- Eradication of weeds from seed fields is paramount because weed seeds may be difficult to remove from the crop seed at harvest or during conditioning.

Seeding Depth

- Maximum yields require that seedlings emerge from the soil as rapidly as possible so that photosynthesis can be initiated and biomass produced
- Optimum seedling depth varies according to crop and environmental conditions at planting
- Planting 1 to 1-1/2 the seed's diameter is usual idea for most crops except that sufficient soil moisture is not always available to initiate germination
- Most plantings require at least a minimum of soil coverage.

- Deeper planting in the soil minimizes the problems associated with decreased soil moisture but increases likelihood that the seedling will not be able to sufficiently elongate to penetrate the soil surface.
- Deeper plantings also results in cooler soil temps that may retard seedling growth

Row Width

- Decisions on optimum row widths have been historically established.
- Rows that are 76 cm (30 in) common for many agronomic crops because it permits cultivation by tractors.
- Trend today is to narrower row widths to maximize leaf area and eliminate interrow competition for nutrients between seed crop and weeds.

- If row is too wide, crop is unable to rapidly shade the interrow area to capture sunlight and weeds quickly become established.
- If row is too narrow, interrow crop competition results in poorer yields, difficulties in disease and insect control and greater likelihood of lodging
- Planting decisions require that optimum row widths for the seed crop be determined.
- Most current studies suggest that row widths can be narrowed further and seed quality will still be retained while enhancing yields.

Plant Population

- Optimum for seed production is determined by the crop produced, soil fertility, soil type, and the availability of moisture.
- Objective is to determine the upper limit of the plant population that will contribute to increased seed yield without a reduction due to competition among plants for light, water and nutrients.
- Planting pattern can be modified to take advantage of crop architecture at differing stags during the development of the crop.

- The seed crop, soil type, geographic area, soil moisture and fertility are all important in determining the proper tillage and planting practices and greatly affect seed yield and quality
- Availability of equipment and ideal plant pop is most important.
- Seed producers must be aware of the array of equipment available and the principles on which it was designed and operates

Tillage

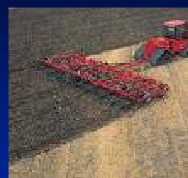
- Defined as those mechanical, soil-stirring actions conducted for the purpose of enhancing crop growth
- Main objectives:
  - Production of a suitable “tilth” or soil structure
  - The control of soil moisture
  - Destruction of weeds
  - Burying or clearing of rubbish and the incorporation of fertilizers
  - Destruction or control of pests
- Tillage systems are divided into primary and secondary tillage operations

Primary Tillage

- Often modifies the soil to the greatest extent
- Typically, it works the soil to a depth of 15 cm (6 in) or more and leaves it with a rough appearance
- Objective is to loosen and fracture the soil and to mix either crop residues or fertilizers into the soil
- Equipment used include moldboard, disk and chisel plows and subsoilers

Secondary Tillage

- Objective of taking the rough soil remaining from a primary operation and smoothing it further for uniform planting, optimum weed control and chemical incorporation
- Most often practiced in the spring immediately prior to planting
- Common implements include field cultivators, harrows, and packers



Planting

- Three main objectives:
  - Maintain spacing of seed rows
  - Control quantity of seed planted per unit area
  - Ensuring a uniform depth of planting
- # of plants/hectare for maximum yields can be increased with increasing fertility

- Uniformity in row spacing is important to permit subsequent cultivation by equipment to eradicate weeds.
- Row spacing important during roguing and detasseling operations as well as harvesting to ensure the ease of passage of harvest equipment
- Planting equipment and setup has a major impact on quality of seed produced

- To achieve the row spacing, population and planting depth objectives, most planters provide an orderly sequence in a planting operation.
- They open a furrow in the soil, meter the # of seeds, place seed in the furrow, cover it and firm the seedbed.
- Various implements in a planter complete these tasks.

- Shovel openers, shoes or runners, and wheel openers open the furrow. Important because the depth of the furrow determines the depth at which seed is planted.
- Seed metering devices include finger pickups, plates, fluted feeds, air pressure and vacuum
- Placing of seed in furrow by seed tubes and power drop devices
- After placement the seed is covered using either knife or disk coverers and firmed and packed by press wheels.
- A firm, tight seedbed provides excellent soil and moisture contact with the seed and improved conditions for seed germination.

Types of Planters

- 5 general types:
  - Row crop
  - Grain drills
  - Air seeders
  - Broadcast seeders
  - Specialized planters such as vegetable seeders and transplanters

Row-crop planters

- Generally used for crops requiring precise row and plant spacing such as corn, sorghum, soybean and cotton
- Drop seeds in a row at a given distance apart to achieve a desired plant population and enable interrow cultivation
- Planting units placed on a toolbar
- Planters are built compactly and can be as closely spaced as 38 cm (15 in) apart to provide 38cm row widths

Lima Bean (*P. lunatus* L.)

- Diverse seed types
  - large white
  - light green
  - speckled seed coats
  - small-seeded 'baby limas'
- Vine vs. bush types
- Seed yields of ~3000 lbs/A

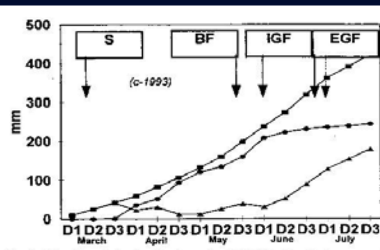


Fig. 1. The climate during the 3 yr of a field irrigation timing experiment on Solara pea. S = sowing date, BF = beginning of flowering, IGF = initiation of seed-filling (broken line with arrow head for WI treatment and solid line with arrow head for NI treatment), EGF = end of seed-filling (broken line with arrow head for WI treatment and solid line with arrow head for NI treatment). D1, D2, and D3 are the first, second, and 10-d period of each month, respectively.

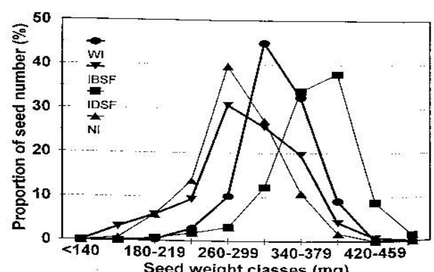


Fig. 2. Within-lot variability of single seed weight of Solara pea for water stress imposed at different stages of plant development (data for 1992 only). WI, irrigated as-needed throughout growing season; IBSF, irrigated from flowering to beginning of seed fill; IDSF, irrigated during seed fill only; NI, non-irrigated.

Table 1. Early season yield of ripe butterbeans that grew over different colored mulches in 1997 and ripened during a 1-wk period ending 6 August.

Characteristic	Mulch color: Black	Red	Green	White	Significance
	Seed yield per plant				
Seed wt. (g)	12.88 b†	21.51 a	8.93 b	14.57 b	0.021
Seed (no)	53.44 b	84.92 a	37.02 b	57.08 b	0.019
Pod wt. (g)	11.64 b	19.84 a	7.82 b	13.22 ab	0.028
Pods (no)	24.03 b	37.71 a	17.08 b	25.48 b	0.017

† Values are means for three replicates of nine plants each, expressed on a per plant basis. Within each row, means followed by the same letter do not differ significantly at $P = 0.05$.

Table 2. Early season yield of ripe butterbeans that grew over different colored mulches in 2001 and ripened during a 2-wk period ending 25 August.

Characteristic	Mulch color: Black	Red	Green	White	Significance
	Seed yield per plant				
Seed wt. (g)	65.6 c†	125.1 a	72.4 c	97.0 b	<0.0001
Seed (no.)	211.9 c	385.2 a	234.6 c	316.9 b	0.0005
Pod wt. (g)	37.7 c	66.2 a	44.2 c	55.4 b	0.0005
	Weight/seed and seed/pod wt. ratio				
Weight (mg)/seed	310 a	325 a	309 a	306 a	NS
Seed/pod (wt. ratio)	1.74 bc	1.89 a	1.64 c	1.75 bc	<0.0001

† Values are means for 18 plants (six plants per each of three replicates per color). Within each row, means followed by the same letter do not differ significantly at $P = 0.05$.

Table 4. Protein concentrations in butterbean seed that developed and ripened over different colored mulches in 2001.

	Mulch color			
Seed Protein	Black	Red	Green	White
mg/g of seed	304 a†	298 a	307 a	293 a
g/plant	19.9 c	37.2 a	22.2 c	28.4 b

† Within each row, values followed by the same letter do not differ significantly at $P = 0.05$.

Cultural practices and seedling establishment

- Site selection
- Soil structure, characteristics
- Planter technology
- Sowing depth

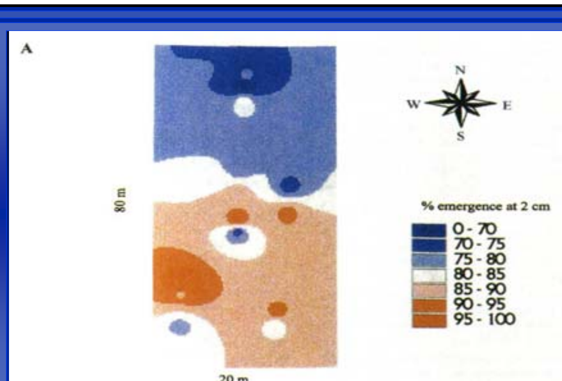
Variable sowing depths

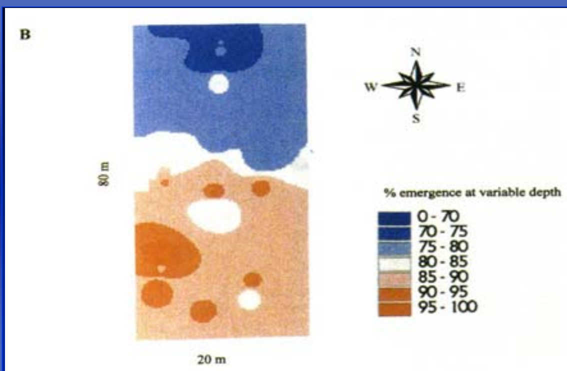
- Soil type, % OM, soil moisture, potential for crusting among key factors
- Many parts of N. America, other sweet corn growing regions deal with variable soils in a given field
- Field mapping, planter technology and site-specific seeding rates & depths useful for sweet corn seedling establishment

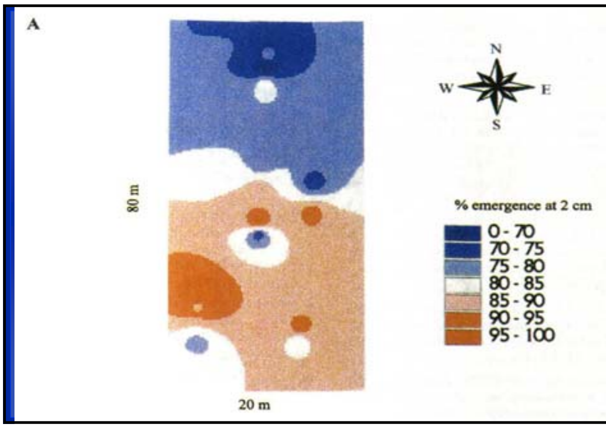
- 'Skyline' (sh_2) planted in early May (Columbus, OH) at 2, 4, and 6 cm. (0.8, 1.6, 2.4 inches)
- Field with transition from Crosby silt loam to Kokomo silty clay loan (darker soil with high OM & soil moisture
- Soil temps, moisture and compaction measured

(Barr, Bennett & Cardina, 2000)

- Field data and calculated heat units for each planting depth compared to actual 'Skyline' emergence data
- ArcView™ software used to map emergence scenarios over entire research field
- Compared emergence results for 2 cm (0.8 in.) depth only vs. variable planting depth (2 or 4 cm.) depending on field data/emergence for each of the 162 microsites







- Significant variability within the 20 x80 m research 'field' with respect to soil moisture, temp., nutrient levels and compaction
- ArcView was useful for analysis of sweet corn emergence
- Mapping factors related to seedling establishment may guide seeding and plant population targets

(Barr et al., 2000)

NC ORGANICS