FACTORS AFFECTING VEGETABLE STAND ESTABLISHMENT

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ABSTRACT: Several factors can influence stand establishment in vegetable crop production. Environmental conditions such as soil physical characteristics, temperature and moisture, various cultural practices, and diseases may all be limiting factors in establishing maximum stands and achieving the highest possible yields. Measures taken to increase stands include soil improvements, implementing cultural practices, and use of chemical and biological seed treatments. Combining seed treatments and cultural/tillage practices to minimize environmental constraints can lead to maximum stands and yields in the production of high quality vegetable crops.
Key Words: stand establishment, priming, biological control, environmental stress

FATORES QUE AFETAM O ESTABELECIMENTO DO ESTANDE EM HORTALIÇAS

RESUMO: Diversos fatores podem afetar o estabelecimento das plântulas de hortaliças. Condições de ambiente, tais como as características físicas do solo, temperatura e disponibilidade de água, práticas culturais e doenças podem ser limitantes para a obtenção de estandes adequados e máximo rendimento. Procedimentos destinados a beneficiar o estabelecimento das plântulas incluem o preparo do solo, a técnica cultural adequada e o tratamento químico e biológico das sementes. Para a produção de hortaliças de alta qualidade, a associação do tratamento das sementes com práticas culturais adequadas minimiza os efeitos adversos do ambiente e permite alcançar máximo estande e rendimento.
Descritores: sementes, hortaliças, estande, controle biológico, ambiente, condicionamento fisiológico

INTRODUCTION

Successful vegetable crop production and optimum yields can be accomplished only when maximum stand establishment is achieved. Stand reduction generally results in reduced yields and variable produce quality. Several factors contribute to stand establishment in the production of vegetable crops. Environmental factors (soil, temperature, etc.) as well as pathogens that attack seeds and seedlings contribute to reduced stands (Orzolek, 1991). Understanding both the influence of the seed planted and the soil conditions in which the seed is sown is essential for crop establishment (Hegarty, 1976a). Staggered emergence results in seedlings of various sizes. Plant cultural practices (herbicide and insecticide applications) after emergence may be less effective in fields of nonuniform growth (Bennett et al., 1992). Plants of different sizes within one population may also cause problems in timing sidedress applications (Ford, 1987). Measures to lessen the impact of environmental stresses and various pests are vital in the successful establishment of vegetable crop stands.

SOIL RELATED FACTORS

Soil type, fertility, and tilth all contribute to the success or failture of crop stand establishment (Orzolek, 1991). Soil type dictates whether soil is well drained, has the potential for crusting and its water holding capacity. Soil type also contributes to the rate of soil warming in the spring (Barr, 1998). Soil type is important for direct-seeded crops. Heavy clay soils are more prone to crusting which causes stress on seeds and young vegetable crop seedlings as they emerge through the soil.

Soil tilth refers to the physical condition of the soil and how well it is capable of being transformed into a fine seedbed that will support seedling emergence and root penetration (Donahue et al., 1971). Soil tilth can be improved in a number of ways such as addition of organic matter and waiting for the soil to dry before tilling or plowing. Soil compaction will reduce seedling establishment and contribute to poor stands and reduced vegetable crop yields (TABLE 1). Slow emergence and seedling growth in compacted fields increases the time that the seed is vulnerable to disease, insects and

TABLE 1 - Effect of soil compaction on the yield of vegetables grown on compacted soil (Hagerstown silt loam), Horticulture Research Farm, Russell E. Larson Research Center, 1987-1988, Pennsylvania, USA.

	Yield (lb/20 ft. row)		Compacted yield/
Crop	Compacted soil	Noncompacted soil	noncompacted (%)
Snap bean	3.9	15.5	25
Cucumber	33.4	98.4	34
Cabbage	52.6	153.1	34
Eggplant	4.2	13.3	32
Pepper	48.2	74.0	65
Squash	49.6	166.8	30
Sweet Corn	9.6	21.4	45
Tomato	63.1	144.4	44
Watermelon	185.6	212.2	87

(Adapted from Orzolek, 1991).

competition from weeds (Wolfe et al., 1995). Tillage method (e.g. chisel plowing vs. no-till) alleviated the adverse effects of first year compaction in transplanted cabbage (*Brassica oleracea* L.) and tomatoes (*Lycopersicon esculentum* Mill.), while no-till was the preferred system for direct-seeded sweet corn (*Zea mays* L.) in an Ohio study (TABLE 2).Use of anticrustant materials helps increase stands in heavier, crusted soils (Orzolek, 1991) . Another solution to soil crusting may be to heavily seed crops. The germinating seeds can act together to effectively break up soil crusting when they emerge through the soil surface (Orzolek, 1991). One drawback to seeding at high populations is the added expense of the extra seed and the labor required to thin plantings to a reasonable stand.

Proper seeding depth is important in stand establishment of direct-seeded vegetable crops. Deeply planted seeds have a difficult time breaking through the ground. Shallow planting may expose seeds to excessive temperatures, and uneven moisture (Barr, 1998). Proper seeding depth is important for allowing adequate moisture for the seed to germinate without exposing it to unnecessary environmental stresses. Soil fertility also has been shown to have an effect on seedling emergence. Fertilizers added to seedbeds can prevent germination or kill seeds and seedlings after germination occurs, especially in dry soils (Hegarty, 1976b). This holds true particularly when fertilizer is spread unevenly and inadequately incorporated into the soil. Strong solutions of fertilizer salts in the soil and in contact

TABLE 2 - Soil compaction (imposed in spring, 1989) and tillage effects on yield of cabbage, tomato, and sweet corn grown at the Waterman Research Farm, Columbus, OH, USA. Soil type was Miami silt loam.

	1989		1990	
Compaction level	Chisel	No-till	Chisel	No-till
	Cabbage (transplanted) tons/ acre			
Control	30	21	18	16
10 ton/axle	17	3	14	18
17 ton/axle	22	11	23	15
	Tomato (transplanted) tons/acre			
Control	22	25	13	9
10 ton/axle	20	18	13	13
17 ton/axle	21	21	10	15
	Sweet corn (direct-seeded) 60 ear crates/acre			
Control	170	170	274	306
10 ton/axle	110	100	226	306
17 ton/axle	90	110	339	322

with the seed can inhibit germination. Nitrogen fertilizers can be applied to crops after establishment in the field without a negative effect on final yield (Precheur, 1998). Environmental stresses such as soil moisture levels and soil temperatures also effect seedling establishment. Both of these factors together have a greater effect on the seed then either factor by itself (Wagenvoort et al., 1981).

Many cultural practices for vegetable crops may also influence soil related factors and thereby contribute to successful stand establishment in the field. Use of row covers, plastic mulches and plastic tunnels are techniques which enable growers to establish seeded crops under less-than-optimal conditions (Orzolek, 1996). Use of plastics can improve stands and yields by maintaining favorable soil moisture and temperature needed for seed germination and seedling growth. Many direct-seeded crops [e.g. snap beans (*Phaseolus vulgaris* L.), squash (*Cucurbita* sp.), melons (*Cucumis melo* L.), cucumbers (*Cucumis sativus* L.), and and sweet corn] can be sown directly into the plastic laid in the field (Orzolek,1996). Use of drip irrigation in plasticulture systems is recommended to maintain adequate moisture levels at germination and throughout the growing season.

Precision farming methods use seed placement, cultivar selection, time of planting and other inputs to optimize crop management on small areas of a field (Barr, 1998). The Global Positioning System is a space-based satellite system that enables growers to seed fields to a depth where highest emergence rates could occur using site-specific crop needs. Precision farming is used in many aspects of field crop production but the possibilities for use with high-value vegetable crops have not been fully researched (Barr, 1998).

SEED QUALITY ASESSMENTS AND ENHANCEMENTS FOR IMPROVED STAND ESTABLISHMENT

The quality of the seed planted will effect the germination, seedling establishment, and yield of vegetable crops (Orzolek, 1991). Poor quality seed will lead to reduced stands and are more susceptible to attacks from pathogens and insects. Proper seed storage is crucial for all seeds. Seed quality should be checked prior to planting with appropriate seed quality tests, such as standard germination, accelerated aging, cold tests and conductivity. Recent results with a saturated salt accelerated aging test (SSAA) using impatiens (*Impatiens wallerana* Hook.) seed lots was effective in assessing seed vigor (Jianhua and McDonald, 1997). The SSAA test was also better than the standard AA test at accurately assessing the vigor of sh2 sweet corn cultivars (Bennett et al., 1998) and may be especially useful for most small-seeded vegetable species.

Presowing seed treatments can be used to increase germination, lead to more uniform stands and higher yields. Coatings are applied to seed for a number of reasons; improve physical properties of the seed for ease of handling, reduce pesticide dusts used on seeds, better protection against disease and enables biological controls to be added to the surface of the seed (Bennett et al., 1992). Seed coatings include pelleted, film coated or encrusted seed treatments. Pelleting and encrusting techniques involve coating the seed with a layer of material that increases seed weight, size, shape and plant ability. This process can also include the addition of pesticides, biologicals and dyes. Film coating adds a thin coating that does not change the physical properties of the seed, but adds pesticides, colorants or dyes and/or biologicals for seed protection (Tryon, 1994). The main objective of seed treatments is to control disease organisms and other pests which attack the seed. Disease protection on high quality seed will lead to optimum germination and field establishment. Seeds with reduced vigor or those of low quality are not improved with the use of coatings.

Seed priming, or osmoconditioning, treatments consist of using sugars, salts, polyethylene glycol or mannitol as soaking solutions that provide a moisturization period for the seed which does not allow radicle emergence (Bennett et al., 1992) but promotes rapid and uniform germination once the seeds are planted in the field. For most vegetable species, priming increases vigor and yields resulting in greater profits that help justify the additional cost of these seed treatments (Warren & Bennett, 1997). Priming is only effective on high quality seed and does not transform poor quality seed into healthy, high germinable seed (Cantliffe, 1989). An osmoticum used in priming should be nontoxic and economical while regulating water potential (Taylor & Harman, 1990).

Solid-matrix priming involves the use of a solid medium plus water as the delivery system to the seed. This procedure allows the seed to imbibe water without radicle emergence (Taylor & Harman, 1990). Solid materials used must have good water holding capacity and be easily removed from the seeds after priming. Vermiculite or calcined clay are often used as the solid medium (Khan, 1992).

Seed rotting pathogens such as Pythium sp., Rhizoctonia solani and Fusarium sp. can attack seeds once they are in the soil. Biological seed treatments involve the use of microorganisms to protect the seed against many soilborne diseases such as pre-emergence damping-off (Bennett, 1997). Biologicals such as the beneficial bacterium Pseudomonas aureofaciens AB 254 have the potential to control diseases much like traditional chemical seed treatments (TABLE 3) such as metalaxyl and thiram (Warren, 1997). Beneficial microorganisms can also protect seeds against insect damage as well as several diseases. Biological seed treatments control pathogens by using beneficial fungi, bacteria or both

TABLE 3 - Percent final seedling emergence of 'OH8245' tomato seeds following application of various seed treatments when sown in soilless mix inoculated with Pythium ultimum. (Warren, 1997).

Seed treatment	Final seedling emergence (%)
Untreated	56
Metalaxyl	80
Bioprimed[z] with AB 254[y]	77
Bio-osmoprimed[x] with AB 254	73

[z]Biopriming combines preplant seed hydration on moist paper towels with application of beneficial microorganism(s).
[y]AB 254 = Pseudomonas aureofaciens AB 254
[x]Bio-osmopriming combines seed priming in aerated salt solution (KNO^3) with application of beneficial microorganism(s).

(Warren, 1997). Successful biological seed treatments demand treatment preparations that are specific for the disease, prolific in growth and have a good shelf life (Taylor & Harman, 1990). The environment for the seed treatment must be favorable for the biological control agents to grow rapidly. Biopriming, which combines preplant seed hydration with biological treatments is also effective when used on vegetable crops that are susceptible to imbibitional chilling injury such as sweet corn and lima bean (*Phaseolus lunatus* L.) (Callan et al., 1991; Bennett, 1997). Bio-osmopriming is a technique that combines seed priming and application of bacterial coating to the seed surface in one step (Warren, 1997). Because seeds can fail to germinate due to a number of reasons, both biological and physiological seed treatments used in combination seem to provide the best seed protection (Bennett et al., 1992).

CONCLUSION

Optimal stand establishment in vegetable crops can be obtained when appropriate cultural practices and seed treatments are used in combination. Poor stands result in reduced yields, but this can be overcome when healthy, vigorous seed is protected from disease by the use of chemical and biological seed treatments. Biologicals are a viable option or adjunct to traditional chemical disease control applied to seeds, particularly at present when chemical use is being examined due to environmental issues. Protecting the seed and seedlings from disease pathogens and using effective cultural practices will lead to increased plant stands and final yields. Many new vegetable cultivars being grown are selected for their high yield potential when grown under optimum conditions (Khan, 1992). Measures to counteract the soil and environmental constraints on seeds, and the use of appropriate seed treatments to aid in seedling emergence and disease management are essential for modern vegetable crop production.

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