



James M. Krall, Crops Specialist; Stephen D. Miller, Weed Scientist; Jack T. Cecil, Research Scientist, Plant Sciences; Chris Bastian, Assistant Professor, Agricultural and Applied Economics; and Thomas Foulke, Associate Research Scientist, Agricultural and Applied Economics, all at the University of Wyoming; David D. Baltensperger, Extension Crop Breeding Specialist; Bob M. Harveson, Plant Pathologist; Paul A. Burgener, Research Analyst, Agricultural Economics; Gary W. Hergert, Soil Scientist; Gary L. Hein, Entomologist; and Drew J. Lyon, Dryland Cropping Systems Specialist; all at the University of Nebraska; Thandiwe Nleya, Agronomist; John Rickertsen, Research Associate Plant Science, South Dakota State University; Sue Blodgett, Entomologist, Montana State University

Introduction

Pea (*Pisum sativum*) is an annual cool season grain legume or “pulse crop.” It was first cultivated over 9000 years ago. It is native to the Middle East and has been cultivated in Europe for several thousand years. Field pea is now grown in all climate zones including the tropics, where it is grown under the cooler conditions found at higher elevations. It is a versatile crop. Field pea grain is primarily used as human food, but is also used widely as livestock feed. Field pea seed contains 21 to 25 percent protein. Field pea has high levels of tryptophan and lysine, essential amino acids normally deficient in small grains.

Field pea also may be grown for forage or as a green manure crop. As a forage crop, field pea is commonly grown in mixture with cereal grains to increase the protein concentration of the forage. For more information on green manure utilization, refer to University of Wyoming publication B-1060R, *Austrian Winter Peas for Dryland Green Manure*, available at: <http://www.uwyo.edu/ces/pub/b1060r.pdf>.

Traditionally, U.S. production has been concentrated in the Pacific Northwest, but production is expanding rapidly into the northern Great Plains. Although the USDA National Agricultural Statistics Service currently does not report dry pea production on the High Plains, it is believed that grower interest there has increased in recent years. The initiation of a USDA pulse crop loan rate for dry pea, the development of new varieties, and the potential for pea production under drought and limited irrigation conditions has generated this increased interest.

The purpose of this publication is to provide High Plains producers with information for successful production of pea for grain or forage.

Plant Description and Adaptation

Pea is an annual cool-season legume that grows best when average daily temperatures are 55-65°F. Pea plants range in height from two to five feet. Leaves consist of up to three pairs of leaflets with a terminal tendrils. Tendrils are modified plant parts that coil around objects and help support and elevate the plant.



Figure 1. Normal leaf type pea with blue flowers. Source: Eric Nielsen, University of Nebraska–Lincoln.

There are two main types of field pea. One type has normal leaves consisting of up to three pairs of leaflets with a terminal tendrils (*Figure 1*). Normal leaf types have vine lengths of three to six feet and are usually prostrate at



Figure 2. Semi-leafless type pea with white flowers. Source: Eric Nielsen, University of Nebraska–Lincoln.

maturity, unless planted with a small grain. The other type is semi-leafless, which has modified leaflets reduced to tendrils (Figure 2). This type has more tendrils and shorter vine lengths of two to four feet, which gives semi-leafless types better standability at harvest.

Pea varieties either have indeterminate or determinate flowering habit. Indeterminate peas continually bloom throughout the summer until temperatures and moisture become limiting. Determinate peas are generally dwarf types, have a shorter flowering period and mature earlier. Pea is predominately self-pollinated, resulting in pods about three inches long containing four to nine seeds.

Most major garden, feed, or processing peas belong to the subspecies *P. sativum* spp. *hortense*. This group generally has white flowers and nonpigmented pods and seeds.

Austrian winter pea and maple pea generally have pigmented flowers, pods and seeds, and belong to the subspecies *P. sativum* spp. *arvense*.

Pea is adapted to all soil types. It performs best on well-drained soils with pH of 5.9 to 6.5, but can be grown on soils with a pH of up to 7.5. Pea does not tolerate salinity or waterlogging. If grown under irrigation, excessive irrigation water may promote disease development, leading to crop injury.

Varieties

Field pea varieties are classified based on growth habit or vine length, leaf type, and the color, size and shape of seed as well as season of planting (winter or spring) (Table I). Growers should select pea varieties based on seed cost, intended use or market, and area to which the crop is adapted. Other important factors include yield potential, harvest ease, and disease tolerance.

Both green and yellow pea are used for human consumption — for canning, soup, and as ingredients in food processing (Figure 3). Visual quality is extremely important in the human consumption market. Niche markets have specific requirements in color, seed size, seed shape and cooking characteristics. Pea seed which was originally



Figure 3. USDA pea grades common to the region: a) yellow, b) green, and c) Austrian winter pea. Source: USA Dry Pea and Lentil Council.

Table I. Characteristics of several of the more common varieties by classification. Source: Annual Progress Report 2004, West River Ag Center, South Dakota State University.

Variety	Leaf type	Height (inches)	Lodging (0-9*)	Test Wt (lb/bu)	Seed Size (seeds/lb)
<i>Forage</i>					
Arvika	Normal	31	8	61.0	2990
Forager	Normal	31	8	61.4	2175
<i>Dry Yellow Cotyledon</i>					
Lifter	Normal	20	8	62.0	2300
Admiral	Semi-leafless	18	0	61.6	1990
Carneval	Semi-leafless	19	1	62.9	2245
Delta	Semi-leafless	16	1	63.7	2155
Salute	Semi-leafless	18	1	63.0	2175
<i>Dry Green Cotyledon</i>					
Crusier	Semi-leafless	18	1	62.1	2280
Journey (forage)	Normal	27	8	62.1	2825
Majoret	Semi-leafless	18	0	62.7	2020

*0 = No lodging, 9 = 100% lodging.



intended for human consumption but is of poor quality due to disease, poor weather or damage during harvesting or cleaning can be sold in the livestock feed market. Pea is an excellent protein supplement for all classes of livestock, including poultry and other birds.

Vine length and leaf type are very important factors in variety selection. Long vine, normal leaf varieties with indeterminate growth habit tend to lodge, especially in high soil moisture conditions. This may present harvesting challenges. On the other hand, long vine varieties tend to perform better than short vine varieties in low moisture or heat stress conditions.

Most new varieties have shorter vines and are semi-leafless. Semi-leafless varieties are less prone to lodging and are generally easier to harvest. Within semi-leafless varieties, producers should choose varieties carefully and base their selections on environmental conditions in their region. Semi-leafless varieties with short vines are better suited to areas with high rainfall and cool summers. In drier regions, producers are better off choosing semi-leafless varieties with longer vines.

Forage pea types are generally normal leaf types. Varieties evaluated within the region include Austrian winter pea, Forager, Arvika, and Journey.

Varieties and experimental lines of pea from the USDA Agricultural Research Service, Canada, Europe, University of Wyoming, and Australia are being evaluated. Grain and forage production results are published annually in the University of Nebraska–Lincoln Extension circular EC-101, *Nebraska Seed Guide*, *University of Wyoming Research and Extension Center Progress Reports*, UNL and UW Web sites at <http://varietytest.unl.edu/> and <http://www.uwyo.edu/plants/key.htm> and the *South Dakota State University West River Ag Center Annual Report*. Results from these grain pea and forage pea trials are summarized in *Tables 2 and 3*.

Table 2. Average grain yields for all varieties and for the highest yielding yellow and green cotyledon varieties across trials in Nebraska, South Dakota, and Wyoming from 1995 to 2004.

	Trial Average	Yellow	Green
	----- cwt/acre -----		
Dryland	14.8*	17.8**	15.5**
Irrigated	19.7***	20.5****	21.2****

*Based on 27 trials; 6 from Nebraska, 18 from South Dakota, and 3 from Wyoming.

**Based on 24 trials; 6 from Nebraska, and 18 from South Dakota.

***Based on 24 trials; 9 from Nebraska, and 15 from Wyoming.

****Based on 16 trials; 9 from Nebraska, and 7 from Wyoming.

Table 3. Average pea, pea/oat, and oat forage yields across trials in Nebraska, South Dakota, and Wyoming from 1994 to 2004.

	Pea	Pea/Oat	Oat
	----- tons/acre at 13% moisture content -----		
Dryland*	1.5	1.7	1.7
Irrigated**	3.3	4.1	3.8

*Based on 6 trials; 2 from Nebraska, 1 from South Dakota, and 3 from Wyoming.

**Based on 7 trials; 2 from Nebraska, and 5 from Wyoming.

Recently the University of Wyoming and the University of Nebraska–Lincoln jointly released a “dun” type spring pea named “Forager” (*Figure 4*). In addition to excellent biomass, production trials reveal that it has good grain production potential; however, as a “dun” pea, it has a greenish/brown seed coat that disqualifies it from the USDA yellow or green grain marketing classes. At this time, attempted sale of this pea into the grain market is not recommended. It will be classified into the miscellaneous class at a discount.

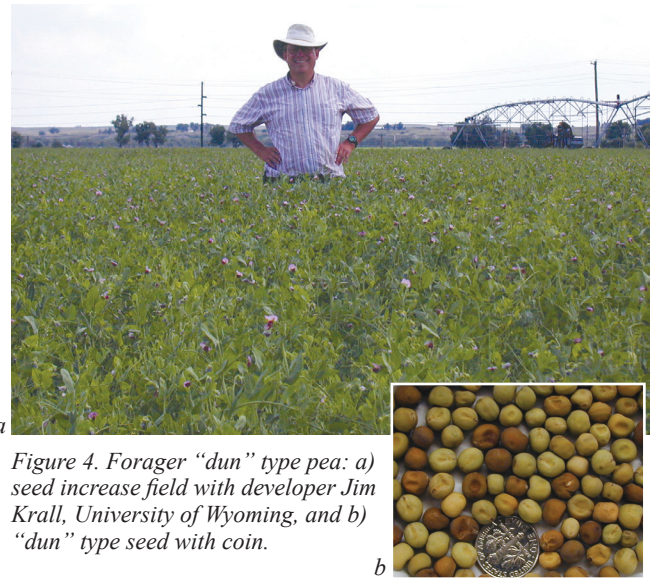


Figure 4. Forager “dun” type pea: a) seed increase field with developer Jim Krall, University of Wyoming, and b) “dun” type seed with coin.

Performance of Grain Pea in Feeding Rations

The universities of Wyoming and Nebraska recently completed confined livestock feeding trials using hogs and cattle. At Wyoming, pea was incorporated at 16 percent of the diet of finishing hogs, at the expense of corn and soybean meal. In comparison to hogs fed a traditional ration of corn and soybean meal, there was no negative effect on finishing hog performance or carcass characteristics (Wolf et al., 2005). In Nebraska trials, it was learned that pea can replace up to 59 percent of the corn dry matter in a beef finishing diet with no significant differences in animal gain or feed efficiency (Fendrick, et al., 2005).



Rotational and Cropping System Considerations

Rotations are a planned sequence of crops grown on the same field over successive seasons. All currently available pea varieties should be spring sown with the exception of Austrian winter pea varieties, which can be fall or spring seeded. It is worth noting that the University of Wyoming and the USDA-ARS at Washington State University are developing new pea varieties for fall planting.

Since pea is an early season broadleaf plant, it can be used to add diversity to cropping systems involving grass crops such as wheat, barley, corn or proso millet. The benefits of including pea in these rotations include:

- 1) providing a break in the life cycles of particular plant pathogens, weeds or insects;
- 2) maintaining organic matter and reducing nitrogen fertility costs;
- 3) providing an improved soil physical condition that aids in more efficient use of soil water or soil nutrients throughout the profile; and
- 4) potentially providing a positive yield response for subsequent crops in the rotation.

Crop rotations are effective in suppressing pest problems because they modify the pest complex and management practices, reducing the buildup of crop specific pests. Each crop and crop management system tends to develop its own characteristic pest complex. From the standpoint of pest management, the best crops for a given rotation are those that are botanically unrelated. Crop rotations are most effective on pests that infest the root zone, pests that are relatively immobile, and pests with a narrow host range.

In addition to the previously mentioned benefits in dryland cropping systems, pea offers an opportunity to reduce dependency on summer fallow. Pea is typically planted in early spring, similar to spring small grains, and is harvested in late July, allowing four to eight weeks prior to winter wheat seeding. When used as forage (grazed, silage, or hay), harvest can occur in late June or early July. This generally gives enough time to replenish surface soil moisture prior to planting winter wheat.

Research conducted in Saskatchewan, Canada indicates that pea roots reach a depth of 30-40 inches compared to 60-80 inches for wheat. Pea uses soil moisture in the top 40 inches of the soil profile, leaving soil moisture deeper in the profile as a reserve for the following crop. If soil conditions are too dry for winter wheat seeding after a pea crop, growers may consider dormant seeding winter wheat or planting foxtail or proso millet the following spring prior to returning to winter wheat.

Pea is probably not the crop to be grown just prior to an extended fallow season. It does not leave much surface residue to help protect the ground from wind and water erosion.

Pea production is often successful when grown in rotation with winter wheat and warm-season grasses, such as proso millet or corn. In moist, humid regions the normal practice is to plant pea into stubble. Planting pea in highly

fertile soils or in fallow land with high nitrogen (N) may produce excessive vegetative growth at the expense of seed production and result in lodging.

Broadleaf crops in rotation with pea have to be chosen carefully to avoid certain potential disease problems. For example, pea is susceptible to white mold, caused by *Sclerotinia sclerotiorum*, and should not be grown in close rotation with other crops susceptible to this disease, for example sunflower, dry bean, lentil, chickpea, canola or potato, especially under irrigation. It is also advisable not to plant pea on the same field more than once in four years to minimize risk of disease. Several other disease problems also may affect pea crops in the High Plains (see *Diseases*, page 6).


Seedbed Preparation and Planting

Pea seed must be placed into a firm and moist seedbed. If spring tillage practices are required for seedbed preparation, they should be kept to a minimum and completed as early as possible to conserve soil moisture. Under no-till conditions, avoid excessive amounts of surface residue in order to promote proper seed placement and early warm-up of the soil to seeding depth. As with spring grains, sowing can be early since germination will occur when soil temperature reaches 40°F. Upon germination and seedling emergence, the pea cotyledons and seedcoat remain below the soil surface. The first two leaves are relatively small and seldom emerge completely from the ground. If the young seedling is damaged, regrowth is possible from buds at the base of these two leaves. Thus seedlings can tolerate frost down to 20°F for a short time.

Austrian winter pea can be planted in the spring or fall. Planting into standing stubble with a hoe drill at the same time as winter wheat sowing has proven to be highly successful on the High Plains. For details regarding fall sowing and grazing utilization of pea, refer to University of Wyoming publication B-1128, *Austrian Winter Pea for Dryland Grazing with Lambs*, available at <http://www.uwyo.edu/ces/pubs/b1128.pdf>.

It is imperative that potential production fields have a history of limited weed pressure. Pea crops are at increased risk of infection by soil-borne pathogens when soils are moist at planting (see *Disease* section, page 6). As a legume, pea is capable of fixing atmospheric nitrogen for its own use; however, for nitrogen fixation to occur, a high quality, specific inoculant (*Rhizobium leguminosarum biovar viciae*) must always be used. This will ensure that the correct strain of effective rhizobium is available when the seed germinates. Usually inoculant can be purchased as peat (powder), liquid or granules. Refer to product instructions and consult your supplier as to application requirements and the form of inoculant that best suits your planting practices.

It is essential to plant pea for grain or forage in mid March to early April (early April to early May in South Dakota) when the soil temperature, at a depth of 2-3 inches, is 40°F and rising. Place peas at a depth of 1.5 inches in moist soil regardless of whether sowing into clean-till or no-till fields.



Warm soils are required to promote rapid germination and emergence of seedlings. If planted later than mid April, seed yield and quality may be reduced due to crop exposure to high temperatures during flowering and the early stages of seed pod fill.

Pea are commonly drilled in 6- to 12-inch row spacings. Seeding can be accomplished with either conventional planters/drills or air seeders, each of which must be capable of accommodating and uniformly distributing the large pea seed without plugging or causing damage to the seed. Be aware that high air pressures in air seeders can damage seed due to high speed impact at delivery hose elbows. Air velocity should be set as low as possible without plugging the hose.

The number of seeds per pound can vary considerably from one variety to the next (*Table 1*). In fact, pea seed size varies dramatically (1400 to 3500 seeds per pound), depending on seed lot, variety and type. Careful attention to drill calibration is important. A good first step is to determine seed size. Accurate sizing can save money in seed cost and add to your peace of mind. A common method is the 1000 seed weight determination (*see box*). Thanks to the diet industry, electronic food scales for weighing small



Determining Seed Size

1. Determine the 1000 seed weight in ounces or grams and then convert to seeds per pound. If using grams, divide the 1000 seed weight value by 28.35 to convert to ounces. Then divide this value into 16,000 to get seeds per pound.
2. Choose a desired seeding rate (7-8 plants per square foot or 304,920 to 348,480 plants per acre is recommended) and determine the likely plant survival (percent seedling vigor or percent germination, from seed tag).
3. Divide seeds per pound into your seeding rate in plants per acre to get pounds of seed per acre, assuming 100 percent survival.
4. To get a more accurate seeding rate, adjust it for likely plant survival. Using the number provided on the seed tag, subtract percent germination from 100 to get percent non-germinable seed. Pounds of seed per acre should be increased to make up for the weight of the non-germinable seed. To accomplish this, increase the seeding rate by the percent non-germinable seed.

Here is an example with a population of 348,480 plants per acre (8 plants per square foot), a 1000 seed wt of 230 g and 85% germination. 1000 seed wt in oz = $230/28.35 = 8.11$ oz. Seeds per lb = $16,000/8.11 = 1973$. Seed per acre, assuming 100% survival = $348,480/1973 = 176.6$. Percent non-germinable seed = $100 - 85 = 15$. Pounds of non-germinable seed = $176.6 \times 0.15 = 26.5$. Adjusted seeding rate = $176.6 + 26.5 = 203.1$ lb per acre.

amounts of seed are readily available and inexpensive. (We found one at a local pharmacy.)

Some seed lots, if not cleaned properly, may contain a high percentage of impurities (greater than 1-2 percent). Avoid using these lots for sowing. Large impurities like stem and pod pieces can interfere with proper drill function. If this is not possible, increase the seeding rate in pounds using the same approach as that used for the non-germinable seed adjustment.

Because pea seed size and weight can vary dramatically, refer to drill chart settings **only as guidelines**. Check seed delivery rates by 1) collecting and weighing seed from seed tubes over a given area before deciding on final settings or 2) counting seeds per running foot of row, remembering to adjust for row spacing. Number of seeds per foot of drill row is a function of the adjusted seeding rate (plant per square foot) and row width. Using the above lot, the same population per square foot and a 7-inch row spacing as an example:

- 1) the number of non-germinable seed per square foot = $8 \times 0.15 = 1.2$;
- 2) adjusted seeds per square foot = $8 + 1.2 = 9.2$;
- 3) area per running foot of row = $7/12 = 0.58$ square feet; and
- 4) number of seeds per running foot of row = $9.2 \times 0.58 = 5.3$.

Check several drill rows over a running distance of at least 10 feet. Time spent on setting the drill will help avoid costly over- or undersowing.

Pea for hay or green chop is often sown with cereal. The cereal provides dry matter and supports pea vines through harvest. The pea component, with protein levels similar to alfalfa, can increase and balance the protein content of the mixture when the cereal is harvested at the late-milk to soft dough stage. The pea is generally seeded at 75-100 percent of the recommended rate and the cereal rate is reduced to 25 percent of normal. A more precise approach is to target a plant establishment ratio of three cereal plants to one pea plant. At this proportion, dry matter should be maintained while protein composition of the forage should increase by about 2 percent.

Fertilizer Management

In the High Plains fertilizer requirements for pea production are based on limited research data; however, based on available information, guidelines have been established for nitrogen, phosphorus, zinc and sulfur fertilization.

Soil testing is the best way to determine soil fertility status and sampling and testing guidelines are available for individual states. Tests for pH, organic matter, phosphorus (P), potassium, sulfur (S) plus zinc and iron are suggested. If previous crops have received nitrogen, or yields have been limited due to drought or hail, a residual nitrate-N test should be taken to a 30-inch depth.

Phosphorus is required for pea development and N fixation. Soil P levels are often low in the High Plains,



Table 4. Soil P levels with corresponding broadcast and band application rates.

Soil Test P – ppm in 0- to 8-inch depth			P Application rate - lbs/acre	
Bray 1 P (for acid soils)	Olsen P (for alkaline soils)	AB-DTPA P	Broadcast	Banded
0-5	0-3	0-2	60	30
6-11	4-7	3-4	40	20
12-16	8-11	5-6	20	10
>16	>11	>6	0	0

especially on calcareous soils. If soil P is below 5-10 ppm (sodium bicarbonate test), P₂O₅ should be broadcast or band applied at a rate of 40 or 20 lbs/ac, respectively.

Table 4 provides suggested guidelines based on different soil P extractants.

Pea may respond to S on deficient soils; however, if S has been applied to other crops (10-15 lbs S/ac) in rotation with pea, it is likely that crop response, if any, will be minimal.

If properly inoculated, pea will fix its own N. Therefore, only in rare instances (< 20 lbs residual N/ac in top 30 inches) will any additional N fertilization (20-30 lbs N/ac) be recommended. Research indicates that small amounts of N (i.e., 20 lbs/ac of 10-50-0 or 11-52-0) can be safely placed with the seed. However, it is recommended that N and S be band applied (2 inches below and to the side of seed placement) or broadcast applied. Excessive amounts of N can reduce N fixation and delay maturity.

Special attention to N fertilization is important when growing pea/cereal mixtures. Pea biological N-fixation will not meet the N needs of the cereal crop. Review soil tests and fertilize with N for the cereal crop or yields will be reduced.

Spring pea does not respond to zinc unless soil test levels are very low (< 0.6 ppm DTPA or 0.3 AB-DTPA). At these soil test levels the zinc recommendation would be 5 lbs/ac broadcast or 2.5 lbs/ac banded from a soluble (sulfate) source.

Weed Control

Pea is a poor competitor with weeds, especially during the first four to six weeks after planting. Because of slow early season growth, it needs to be kept free of weeds until the canopy begins to cover the soil. Weeds that emerge early in the season and weeds that grow above the crop canopy will cause the greatest seed yield loss. For example, common lambsquarters or kochia will cause more competition with pea than green foxtail.

A number of factors should be considered when planning and developing a weed management program for pea. Accurate weed identification needs to be the first step in developing a program. In addition, factors such as field selection, cover crop, preplant tillage, crop rotation, seeding rate, row spacing, cultivar selection, herbicide and cultivation all need to be integrated into the weed management program.

The use of a fall planted cover crop can reduce weed emergence the following spring. The cover crop can be killed with glyphosate and pea can be planted directly into

it. Because spring tillage is reduced or eliminated, summer annual weed problems tend to be lower. Pea competitiveness with weeds can be improved by planting high quality seed with even, rapid emergence, maintaining pea seedling densities of seven to eight plants per square foot and drilling peas in narrow rows.

Preemergence or early postemergence tillage with a rotary hoe or harrow can reduce populations of shallow emerging annual weeds. Postemergence tillage with a rotary hoe or light harrow needs to be timed to control emerging weeds in small peas (one to two inches tall). Pea stand reductions are likely to occur with this treatment.

Herbicide performance has generally been best when herbicides are applied before or after planting but before weed emergence. Postemergence herbicides should be applied to small weeds and pea (2- to 4-inch height) to maximize weed control and minimize crop injury or weed competition. Herbicide selection should be influenced by expected weed species, chemical expense, incorporation requirement and rotational restrictions. Consult the South Dakota State University *Weed Control in Pulse Crops* (FS 525-PC) or the *Montana, Utah, and Wyoming Weed Management Handbook* for a complete list of herbicides labeled for field pea.

Pea is susceptible to several persistent herbicides used in corn and wheat production systems, including Ally, Amber, Finesse, atrazine, Curtail and Stinger. Care should be taken with herbicide selection and use in crops preceding pea in the crop rotation system.

Diseases

Several pathogenic fungi, occurring singly or as a complex, infect pea seeds and roots from planting until



Figure 5. A complex of the fungal root rots on a pea root.



maturity (Figure 5). They cause seed rot, damping-off, seedling blight, root rot and wilt diseases, which are not easy to differentiate. The pathogens responsible for these diseases include *Fusarium solani* f. sp. *pisi* (root rot), *Fusarium oxysporum* f. sp. *pisi* (wilt), *Rhizoctonia solani* (damping-off, stem and root rot), and *Pythium* spp. (seed rot and seedling blight). All diseases tend to be more severe in warm, wet soils, with the exception of certain *Pythium* species that cause seed rots and pre-emergent damping-off. These diseases tend to be more problematic in cool soils, particularly from *P. ultimum*, which is the most regularly isolated species from rotted seeds. If a seed treatment is not used, it is not unusual to observe poor emergence under these types of soil conditions. Maxim 4FS, LSP, Apron XL-XS and Allegiance are fungicides currently labeled for use as seed treatments.

Bacterial blight, caused by *Pseudomonas syringae* pv. *pisi*, is commonly found throughout the High Plains, but incidence and damage is generally low (Figure 6). It can be destructive during periods of cool, damp weather, particularly if the crop was previously damaged by hailstorms. The pathogen is often seedborne, which directly infects young seedlings. The bacterium can also live on various weed species and other plants and can spread to neighboring, healthy plants through wounds and rain splashes during storms.



Figure 6. Bacterial blight on pea leaves.

Three species of *Ascochyta* have been described causing diseases in pea. They are:

- 1) *Ascochyta pisi*, which causes leaf and pod spots that are slightly sunken, tan and delineated by a distinct dark border;
- 2) *Mycosphaerella pinodes* (perfect stage of *A. pinodes*), which attacks all aboveground plant parts and is contrasted with *A. pisi* by producing lesions on plants beginning as irregular dark flecks that progress to concentric ring patterns in alternating shades of tan and brown; and
- 3) *Ascochyta pinodella*, now known as *Phoma medicaginis* var. *pinodella*, which causes lesions indistinguishable from those of *M. pinodes*, except they occur more commonly as a foot rot on stem bases and subsurface portions of the plants rather than on stems or leaves.

These three *Ascochyta* diseases are widespread throughout the temperate areas of Europe, North America and New Zealand where high volume acres of pea is grown. They are restricted to infecting field and garden pea (*Pisum*), field bean (*Phaseolus*), fava bean and wild vetches (*Vicia*), grass pea and wild pea species (*Lathyrus*), but not lentil (*Lens*) or chickpea (*Cicer*). These latter two crops have their own distinct *Ascochyta* diseases, thus, pea pathogens would not potentially carry over to subsequent chickpea production.

Insects

Insects have not commonly caused severe damage to pea in the region; however, several insects have the potential for damaging pea. Insects such as cutworms, pea aphids, grasshoppers and lygus bugs are commonly seen throughout the region on other crops, but only occasionally are found in damaging numbers. Pea leaf weevil and pea weevil are not commonly found and may not be noticeable until pea has been grown a few years in an area. Because of the sporadic nature of insect damage to pea, scouting is critical to identifying problems before severe damage occurs.

Early Season Insects

Cutworms. Climbing cutworms such as the army, dingy, and darksided feed on above ground plant parts at night. Army and dingy cutworms, which overwinter as larvae, are present early in the crop season and may injure seedling pea plants. Darksided cutworms, which overwinter as eggs and hatch early in the spring, are more likely to be a problem later in the spring. Other species of cutworms can be found damaging pea. During the day, cutworms retreat to the soil and may be found by scraping the soil, especially at the base of the plant. Visiting a field in the evening, at night, or early in the morning with a flashlight can reveal the presence of feeding cutworms. Damaging populations have been encountered in pea plantings, especially when there is moderate to heavy plant residue on the soil surface. Cutworm damage is likely to show up as poor or missing plant stand, and is likely to be most severe early in the season when plants are small and damage can accumulate quickly. Pea must be monitored carefully at emergence to prevent this early season stand loss.

Pea Leaf Weevil. The pea leaf weevil (*Sitona lineata*) is a pest of seedling pea plants. The adult is gray-brown and about 1/5 inch, with a short, blunt beak. It has three light, inconspicuous stripes that run lengthwise down the back. The grub-like larvae is legless, curved and white in color with a dark brown head. It will reach 1/4 inch in length.

Adults overwinter in alfalfa fields, roadsides or other areas where they are protected by crop residue and debris. They emerge in spring and seek their preferred hosts: pea and vetch. They also have been noted to feed on alfalfa and clover. Adults are more likely to be found in low-lying fields with heavy soils and only partially incorporated residues. In these areas more injury is likely to occur to the subsequent pea crop. Damage is also more severe on field edges adjacent to grassland, pasture, riparian areas or other similar refuges. Adult feeding results in scalloped leaf edges that can coalesce and cause significant injury



to seedling alfalfa. Larvae feed through the summer on nitrogen-fixing nodules on roots, but this does not cause economic damage.

Pea leaf weevil can be very damaging to the growing point of seedling pea plants, and when more than 25 percent of the leaves are notched or there are more than 0.2-1 weevil per plant, treatment is justified. For 2- to 4-leaf plants, treatment is justified if 25 percent of the plants have feeding injury and insects are present. Once the six-leaf stage is reached, more defoliation can be tolerated. Variety trials conducted in Washington indicate that semi-leafless pea is more susceptible to pea leaf weevil than conventional pea.

Pea Aphid. Pea aphids are small (1/6 inch) green insects that can be found in most legumes. Pea aphids damage pea directly by sucking plant juices, resulting in stunted, less vigorous plants that produce fewer and smaller seeds. Heavy populations or prolonged feeding by pea aphid may cause severe stunting, yellowing, wilting, and ultimately death of the plants. Aphids are known to be a vector of pea enation mosaic, pea streak, pea seedborne mosaic, alfalfa mosaic, bean yellow mosaic, and pea leaf roll. The importance of aphid-vectored viral diseases varies with environmental factors that influence viral infection and outbreaks.

Conditions that increase the risk of pea aphid outbreaks in pea include: 1) abundant regrowth of nearby perennial host plants (alfalfa) in the fall; 2) a late killing fall frost, allowing for greater production of overwintering forms; 3) mild January and February temperatures; 4) stresses on perennial host plants (alfalfa) in spring that results in early movement of aphids to pea; and 5) pea aphids migrating to pea fields from nearby alfalfa fields that were recently cut.

Younger plants are more susceptible to aphid feeding damage and impact of virus infection is apt to be more severe. Therefore, early planting allows plants to become well established before aphids move from alfalfa into pea fields. A sweep net should be used to sample for aphids in pea. If an average of 30 to 40 aphids per sweep is found and few, if any, natural enemies are present, insecticide treatment is justified. Aphid populations are very susceptible to parasites and predators; therefore, if natural enemies such as ladybird beetles are present, resample in two days. If numbers are the same or decreased, treatment may not be needed.

Late Season Insects

Grasshoppers. Both adult and immature grasshoppers are generalized defoliating pests that typically cause the most damage when the adult stage is reached in mid-summer. Pea is not a preferred host for grasshoppers, but grasshoppers can cause damage to field pea, especially to pea in the flower to pod-filling stages. Grasshopper movement into pea fields from surrounding areas will result in damage on field edges before the whole field is colonized. As with many crops, grasshopper control is advised whenever 20 or more adults per square yard are found in field margins or 8 to 14 adults per square yard are occurring in the crop.

Lygus Bug. The lygus bug or “tarnished plant bug” has the potential of being a serious insect pest in field pea. Lygus adults are slightly less than 1/4 inch in length and about half as wide. Body color ranges from pale green to light brown. It has a distinct light colored triangular shaped marking near the center of its back where the wings join. Adults survive the winter protected in ground litter, crop residues and buildings. Adults feed and lay eggs in the spring on a variety of hosts. Eggs hatch into nymphs in about 10 days and reach maturity in a month. Nymphs are brighter green in color, smaller than adults and have wing pads that become more pronounced in later nymphal stages. Smaller first and second instar nymphs somewhat resemble pea aphids; however, they are much more active than pea aphids. Later instars have distinct black markings on the abdominal segments.

Lygus bugs feed preferentially near the growing point of the plant or the developing reproductive tissue, resulting in aborted, shriveled and/or damaged seed. One sign of damage is “chalk spot,” a chalky white spot on the dried seed, which has been documented in lentils. This damage severely affects the appearance of the seed, lowering the grade and marketability. Pea harvested at high moisture are susceptible to bruising as they are harvested or handled roughly, causing damage similar to chalk spot.

Lygus bugs may move from nearby alfalfa or canola fields, especially after alfalfa hay is cut. In this situation, monitoring is important and should be focused on the field edge near the source of migrating lygus. When pea is in bloom and pods have begun to form, sweep nets can be used to detect lygus presence. In Idaho, the threshold for lygus bugs in field pea is 7-10 lygus per 25 sweeps (U.I. Bulletin No. 664).

Pea Weevil. Adults are small, 1/16-inch and gray-brown flecked with light and dark irregular patches. The tip of the abdomen protrudes beyond the wing covers. Adult pea weevils overwinter and emerge about the time that pea blooms. Adults feed on flowers, leaves or pods, congregating on pea flowers at early bloom. They begin to mate following a pollen meal. Females lay one or two eggs on the outside of the pea pod. Larvae hatch within one to two weeks and burrow into the pod. Larvae are C-shaped and legless with a brown head and creamy white body. Only one larva develops within a seed. Larvae emerge from threshed pea seed and pupate as much as one month after harvest. There is one generation per year.

Weevil-infested seed can result in decreased seed weight, yield reduction and dockage at point of sale. A sweep net should be used to sample for adults. One weevil in 25 sweeps (180 degrees) can result in 10 percent infestation at harvest; the threshold is two adults per 25 sweeps. Although pea weevil resistance is available, currently no resistant varieties are available in the United States. Destroying crop residues, preventing shattering at harvest, eliminating volunteer plants and planting noninfested seed can reduce infestation. Also, early planting and harvest is desirable.



Harvesting Grain Pea

A growing season of 85 to 110 days, depending on variety, seeding date, precipitation and heat units is required for field pea. Base the decision to harvest on crop maturity and seed moisture. The crop is at physiological maturity when all pods are yellow to tan in color. The older, bottom pods mature first. It is important to monitor several representative areas of the fields and check maturity of the bottom, middle, and top pods. Hot, dry weather brings on rapid maturity, so check fields more often under these conditions. Under ideal conditions, determinate varieties should be harvested when the bottom seeds rattle in the tan to brown pods, the middle and top pods are yellow to tan, and the seeds are firm and shrunken.

Under moist conditions, or with indeterminate varieties such as Austrian winter pea, the top pods will be less mature and fully expanded; however, harvest should occur before significant shattering of lower pods.

Pea is harvested by direct combining, or swathing and combining. At this time, paraquat is the only labeled desiccant for pea in the High Plains.

During hotter years, most determinate field pea varieties can be direct combined; however, with indeterminate varieties, or under cool, moist conditions, swathing is advisable. Swathing is done when most of the pods and vines have turned yellow to tan in color. Up to one-third of the vines or pods may still be light green, but these will mature with limited seed shrinkage in the swath. Most seeds will be difficult to dent with the thumbnail at this stage.

Swath when most of the field is ready, even though plants in scattered low areas remain green. The yield and quality of the majority of the pea crop should not be jeopardized by delaying harvest to allow plants in low field areas to mature.

Continuous monitoring of cracked seed and damaged seed coats is necessary to ensure proper combine settings. General guidelines for combine settings include:

- 1) a reel speed equivalent to ground speed (< 5 mph);
- 2) a cylinder speed of 250-600 rpm;
- 3) a concave setting of 1/4-5/8 inches in front and 1/2 inch in rear;
- 4) high air flow;
- 5) a chaffer sieve setting of 5/8-3/4 inch; and
- 6) a cleaning sieve setting of 3/8-1/2 inch.

To minimize the incidence of earthtag during combining, combines can be modified with a perforated clean elevator door trap and scrapers attached to every fourth or fifth paddle in the clean grain elevator. Close the unloading auger slides on the combine hopper to prevent plugging the auger in the clean grain tank. Slowing the combine engine when unloading will reduce seed cracking. A very mature crop can be pulled and combined, using special equipment such as a Rake-up or Sund pick-up. This harvest method requires a weed-free crop with dry, brittle stems.

After harvest, careful handling of pea seed is an important consideration. Often quality is lost when removing the pea from storage. Alternative seed handling equipment such as brush augers or belt conveyors should be considered. Seed stored at a 16 percent or lower moisture content should be safe; however, in-bin temperatures need to be monitored, especially as outside temperatures fluctuate. If necessary, aeration can be used to cool and dry the seed. Grain driers should not be operated at temperatures over 113°F. High temperatures and rapid cooling will cause stress cracking of the seed and reduced germination.

Small grain pea forage mixtures should be harvested based on the maturity stage of the small grain. These mixtures should be harvested at the late boot stage (few heads showing) for lactating dairy cows and the soft dough stage for heifers, dry cows, and beef cattle. Harvesting at late boot will generally result in forage that is about 125 to 130 relative feed quality (RFQ). Harvesting at the soft dough stage will increase tonnage and result in a forage that is about 100 to 110 RFQ, which is adequate for heifers, dry cows and beef cattle. Small grain pea forage mixtures are most commonly ensiled, but they also make excellent pasture and can be made into dry hay, although drying is more difficult than with perennial forages.

Markets and Economics

World dry pea exports in 2001 totaled 3.5 million metric tons with U.S. exports representing 3 percent of the export market (Johnson, 2005). The United States exports nearly 60 percent of its dry pea production, and thus, the market is highly dependent on exports (Johnson, 2005). The major destinations for exported dry pea are: Canada, Mexico and other Latin American countries.

One of the primary reasons for the growth in dry pea production is the existence of a USDA marketing loan program for dry pea. As part of the Farm Security and Rural Investment Act of 2002 (applicable from 2002 to 2007), the marketing loan program allows producers the flexibility to store their crop at harvest time when prices are low. This also helps farmer's cash flow and evens out commodity marketing throughout the year. The marketing loan program can also be viewed as a price support mechanism since producers participating in the program can opt to accept a loan deficiency payment (LDP) when market prices fall below the loan repayment rate (FSA, 2003). For 2004, most producers eligible for the marketing loan program chose to accept loan deficiency payments. The average LDP for dry pea was \$2.37 per cwt (USDA, 2004). It is important to note that assistance through the marketing loan program is only available when the crop is harvested for grain or seed and is not available if the peas are grazed.

High Plain's dry pea production is not reported by USDA. Trials in Nebraska and eastern Wyoming have produced yields averaging about 15 cwt per acre for dryland pea and about 20 cwt per acre for irrigated pea (Table 2). Some producers in the region, however, reported significantly higher yields for irrigated green pea. Most dry pea from the High Plains is sold on the spot market.

Table 5. Estimated per acre net returns (including fixed and variable costs) for irrigated pea production in western Nebraska and eastern Wyoming.

Price (\$ per cwt)	Pea Yield (cwt per acre)				
	18	19	20	21	22
\$6.00	-\$139.31	-\$133.31	-\$127.31	-\$121.31	-\$115.31
\$7.00	-\$121.31	-\$114.31	-\$107.31	-\$100.31	-\$93.31
\$8.00	-\$103.31	-\$95.31	-\$87.31	-\$79.31	-\$71.31
\$9.00	-\$85.31	-\$76.31	-\$67.31	-\$58.31	-\$49.31

Table 6. Estimated per acre net returns (including fixed and variable costs) for dryland pea production in western Nebraska and eastern Wyoming.

Price (\$ per cwt)	Pea Yield (cwt per acre)				
	13	14	15	16	17
\$6.00	-\$42.93	-\$36.93	-\$30.93	-\$24.93	-\$18.93
\$7.00	-\$29.93	-\$22.93	-\$15.93	-\$8.93	-\$1.93
\$8.00	-\$16.93	-\$8.93	-\$0.93	\$7.07	\$15.07
\$9.00	-\$3.93	\$5.07	\$14.07	\$23.07	\$32.07

Estimated returns for dry pea in the High Plains are shown in *Tables 5 and 6* for a range of yields and prices. *Table 7* shows the estimated costs. Fixed costs can vary widely by producer, so producers wishing to estimate returns over only variable costs can add fixed costs from *Table 7* to the applicable values in *Tables 5 and 6*. For example, returns over variable costs for yields of 18 cwt and a price of \$6 as reported in *Table 4* would be -\$17.86 per acre as opposed to -\$139.31.

Table 7. Estimated per acre costs for High Plains pea production.

	Irrigated	Dryland
Variable costs	\$125.86	\$63.79
Fixed costs	\$121.45	\$57.14
Total costs	\$247.31	\$120.93

Source: Bergener et al., 2005

The tables show that from a total cost perspective, irrigated pea production is not particularly feasible in the region due to the higher costs associated with irrigated production. Dryland pea production is economically viable at prices over \$8 per hundredweight with yields over 16 cwt per acre. Grower's prices for 2003 and 2004 are presented in *Table 8*. As previously mentioned, large crops in these years have led to a softening of prices.

Table 8. Grower's prices for dry peas, 2003-2004.

	2003		2004		Chg. prev. year	
	Oct.	Nov.	Oct.	Nov.	Oct.	Nov.
	--cents per pound--				--percent--	
Green peas, whole	8.09	8.84	7.09	7.30	-12.4	-17.4
Yellow peas, whole	6.75	7.53	6.25	7.08	-7.4	-6.0

Source: USDA-ERS Vegetables and Melon Outlook, December 2004.

Factors to Consider

The dry pea market can be characterized as a low volume niche market that is highly dependent on the export market. As such, prices can be volatile. When growing an alternative crop such as dry pea, it is important to consider risk management options such as crop insurance. For those counties where the crop has been established, crop insurance products may be available, but in many counties in western Nebraska and southeastern Wyoming most producers do not have the actual production history or an agent who is offering crop insurance for dry pea (Johnson, 2005). In the absence of Risk Management Agency (RMA) actuarial tables for a crop within a county or area, a producer must file a request for actuarial change from the RMA before crop insurance can be purchased (Johnson, 2005). The process of requesting an actuarial change may result in the producer receiving a custom insurance agreement that may be relatively more expensive than other insurance products offered in that county or area.

As with any new enterprise, it is important to consider a number of issues, and dry pea is no exception. Given the niche market properties of dry pea, one of your first considerations is to determine the market outlet in your area (Bastian, 1999). Where do you have to go, and who will buy your dry pea? Dry pea also can be used in livestock rations for cattle, swine, sheep and poultry (Schatz et al., 2002). Thus, if you have a livestock enterprise you may want to investigate marketing dry pea through your livestock. From a planning standpoint, you will want to consider all of the production, management, and financial resources needed to add dry pea as an enterprise to your operation. Consider your market access and plan on less than top yields the first year or two you grow them.

Small grain/pea forage mixtures are usually not economically competitive with perennial forage crops (i.e., alfalfa) due to higher establishment costs; however, there are three situations where this practice should be used:

- 1) when alfalfa or other perennial forages are established using a companion crop (a nurse crop), the mixture may be removed as forage to allow better establishment and more vigorous growth of the alfalfa;
- 2) to provide an emergency source of forage when perennial forages are in short supply; and
- 3) as a short-term dryland pasture fallow replacement crop.



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