Peanut: A Food Crop for Minnesota

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Most of the world's peanut crop (Table 1) is crushed for extraction of edible oil and protein meal. But about half (9 pounds per capita) of the United States crop is consumed as peanut butter and nuts. Peanut is an important crop in a few southern states, which lead the world in peanut yield per acre and in quality of edible nut. Georgia, Texas, Alabama, and North Carolina in 1983 grew 80 percent of the 1,375,000 acres of peanut in the United States. Virginia, Oklahoma, Florida, South Carolina, and New Mexico are other states that grew more than 10,000 acres of peanut.

Table 1. World peanut acreages and yields by continents and leading countries,1982.

Continent and country	Acreage	Pods/acre (pounds)
Asia	28,634,000	1120
India	18,609,000	850
China	6,180,000	1740
Africa	15,355,000	820
North and Central America	1,628,000	2930
United States	1,273,000	3390
South America	1,186,000	1490
Oceania	101,000	1820
Europe	27,000	2420
World	46,932,000	1100

Peanut originated in Bolivia and adjoining countries and was taken to Europe in the sixteenth century. From Europe, it was sent to Africa, India, and China during the sixteenth century. Peanut is called groundnut in a majority of countries, and these two common names are also hybridized to groundpea in a few areas. It is not known when peanut was introduced to the United States, but it was grown primarily as a garden crop until about 1870. Its first use as a field crop was for hog pasture, and this practice was common until about 1930. The first patents for peanut butter were obtained in 1897, and by 1899 several brands were on the market. Penny-in-the-slot peanut machines were introduced in 1901, and peanut candy began to be important. More peanut was needed in World War II for oil, food, and feed, so peanut was designated as a basic commodity in 1941 with authorization for marketing quotas and price supports. The peanut shaker-windrower and combine came into use about 1950 and reduced labor hours per acre. Production increased faster than consumption, but the U.S. Department of Agriculture (USDA) managed the problem with price supports, acreage allotments, and/or poundage quotas. Acreage allotments were eliminated in 1981 so anyone can grow peanut, but only those with quotas tied directly to allotments are eligible for price support. Quota peanut has a higher price support than additional peanut grown by quota growers. A third category, produced by new growers, is sold for export or crushing for oil.

Because of its warm temperature requirement and reputation as a southern crop, peanut has only occasionally been grown in Minnesota. Use of unadapted varieties and inappropriate production practices usually resulted in a low yield of poor quality nuts. Research reported in this bulletin indicates that peanut can be a useful food crop in Minnesota. The research was conducted on silt loam soil at Rosemount and coarse sandy loam at Becker. Both locations have a frost-free season of greater than 120 days (90% probability), but the growing degree-days (base temperature 50°F) are less than 2200 at Becker and less than 2300 at Rosemount. Temperature is the major factor limiting peanut yield in Minnesota as 3000 growing degree-days (base 50°F) have been suggested as minimum for peanut. Various base temperatures for growth have been used; however, 56°F is probably a reasonable base (3). Optimum temperature for peanut growth is about 86°F (5).

THE PEANUT PLANT

Peanut is in the legume family, so its fruit (matured ovary) is a pod. Pods contain from one to five seeds, each covered by a skin (seedcoat). The pod wall or shell is the pericarp. The pericarp is needed to protect the seeds when the crop moves through various markets to the processor or consumer. Consequently, peanut yields and farm prices are on a pod rather than on the seed basis used for soybean, fieldbean, or fieldpea.

The seedcoat encloses two large cotyledons which are attached to and enclose a very small primary axis (heart). The primary axis is composed of root, stem, and the transitional area (hypocotyl) between root and stem. The stem starts at the first node where the two cotyledons (seed leaves) are attached. (Each cotyledon arises from a separate node, but later they appear to be from a single node. The two nodes are considered as a single cotyledonary node in this bulletin.) A node is the cross section of stem where a leaf is attached; an internode is the length of stem between two nodes.

Germination is evident when the radicle (primary root) splits the seedcoat and elongates. Peanut emergence is intermediate between the hypocotyl elongation (soybean, fieldbean) type (epigeal) and the internode elongation (fieldpea) type (hypogeal). The peanut hypocotyl elongates but usually stops before the cotyledons emerge, and only the four-foliolate leaves are visible above ground (Figures 1,2). A peanut leaf has two small stipules at the base of the petiole and two pairs of leaflets (four-foliolate in contrast to the trifoliolate leaves of soybean and fieldbean). Peanut also has a four-foliolate leaf at the second node in contrast to the pair of unifoliolate leaves at the second node of soybean and fieldbean.

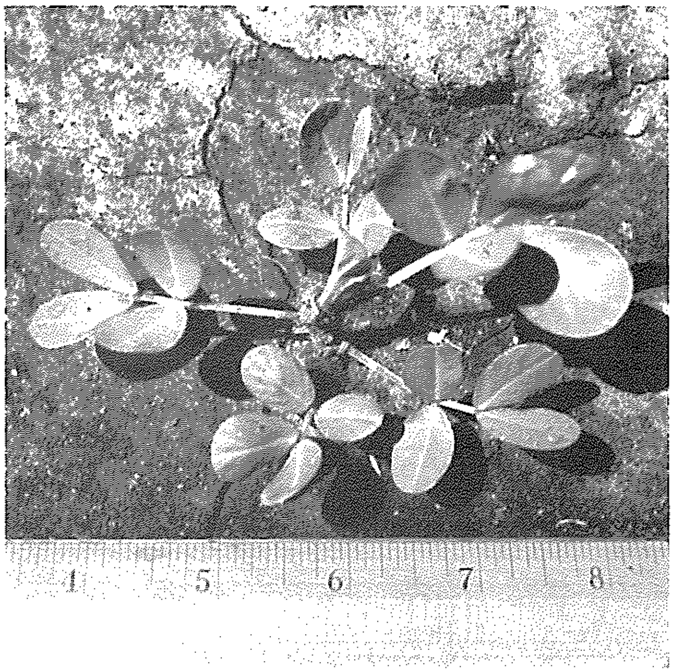

Figure 2. Peanut plant with five four-foliolate leaves. Two are from the branches at the cotyledonary axillary buds, and the other three are from the second, third, and fourth node of the main stem. Little internode elongation occurs during early growth.

In contrast to the strong dominance of the main stem in soybean and fieldbean, peanut has three major stems--main stem and stems from the two cotyledonary axillary buds (Figures 3,4). Additional branching may occur depending on variety and environment.

The yellow flowers are produced from axillary buds and contain both male and female parts (Figure 5). Peanut is a self-fertilized crop except for less than 3 percent natural crossing by insects. Peanut flowers are sessile; the style elongates (Figure 6) but the ovary remains at the stem until after pollination. Then the style and corolla wither, and the ovary elongates outward and downward into the soil about 2 inches deep. The elongating ovarian structure is called a peg but it and the pod at its tip are ovarian tissue (8). There is no ovarian stalk or pedicel in peanut in contrast to most other crops.

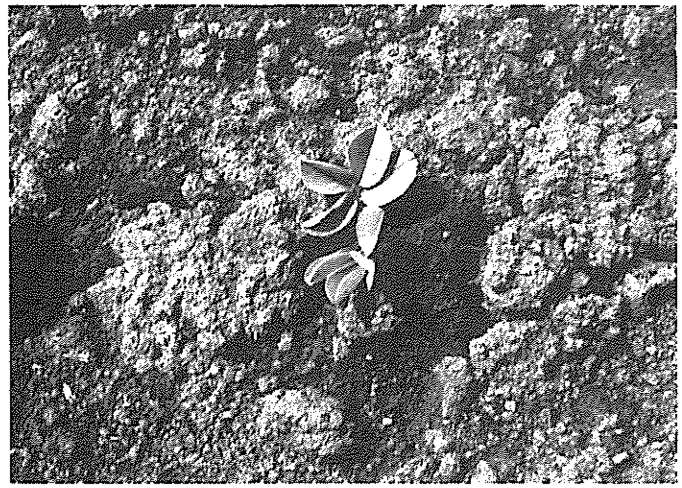

Figure 1. The cotyledons attached to the first node remain below ground. The upper leaf in the photo is the first four-foliolate leaf and is attached to the second node while the lower leaf, the second four-foliolate leaf, is attached to the third node.

Figure 3. Peanut plant showing hypocotyl elongation, cotyledons, two branches from axillary buds at the first node, slight first internode elongation, and several developing four-foliolate leaves.

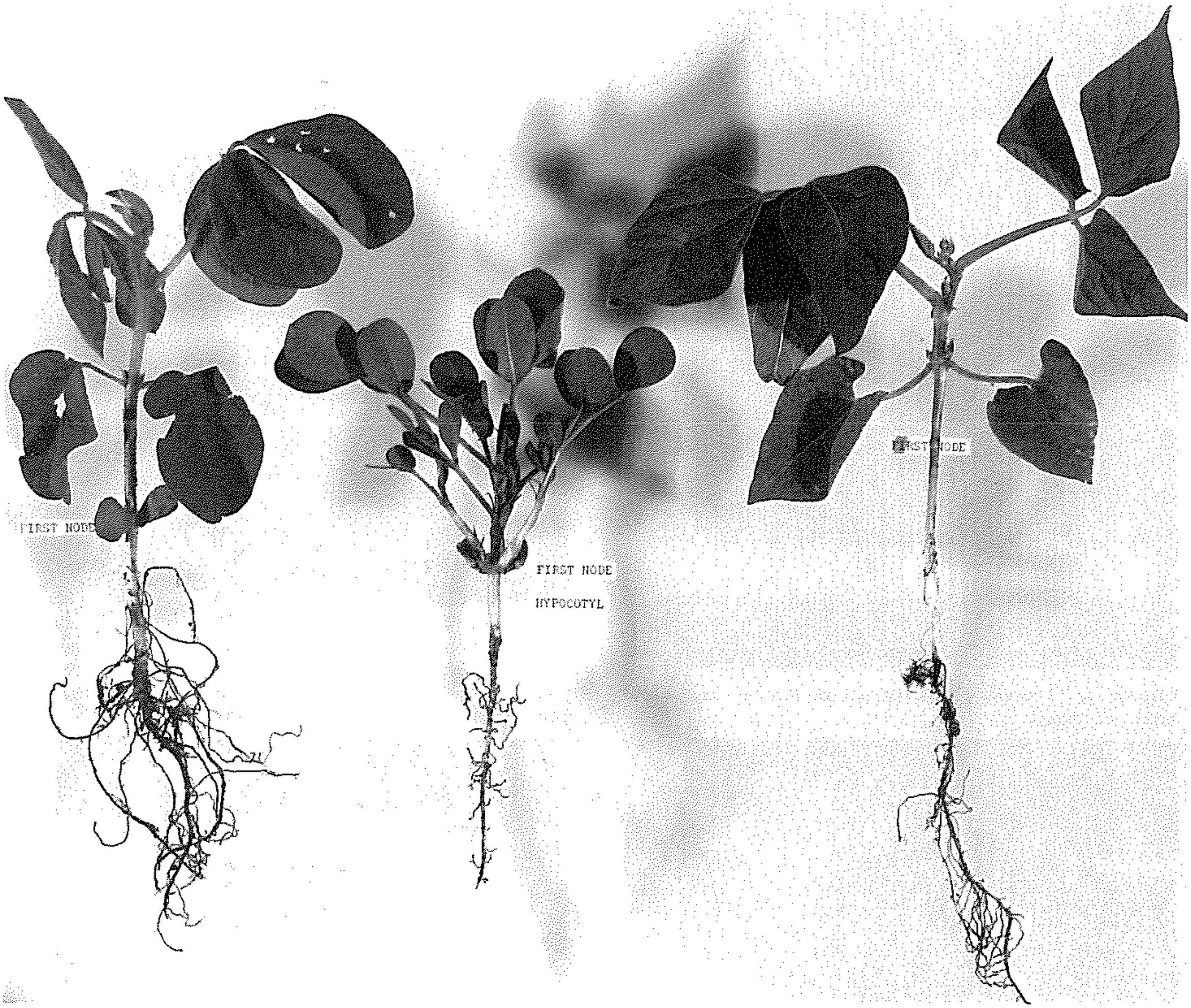

Figure 4. The soybean plant at the left and fieldbean plant at the right of the peanut show the pair of unifoliolate leaves from the second node and two trifoliolate leaves. The cotyledons have already been shed by the fieldbean.

Aerial pegs penetrate the soil 8 to 14 days after fertilization, but pegs from flowers at or just below the soil surface may develop faster because of lack of inhibition by light. The pod shells reach maximum size after 2 or 3 weeks in the soil and maximum dry weight after 5 weeks in the soil. The seeds in the shell develop more slowly, reaching maximum oil percent in 6 to 7 weeks and maximum protein percent in 5 to 8 weeks. Maturity, indicated by maximum levels of protein, oil, dry matter, and shelling percentage, occurs after 7 to 9 weeks in the soil. Brown splotching inside the shell is a sign of maturity and occurs 60 to 80 days after flowering.

Blooming continues over a long time, and pods are in all stages of maturity at harvest (Figures 7,8). The pegs eventually rot (25% after 12 weeks) in the soil, and loose pods are lost during harvesting.

Figure 5. Peanut plant in bloom during the first week of July.

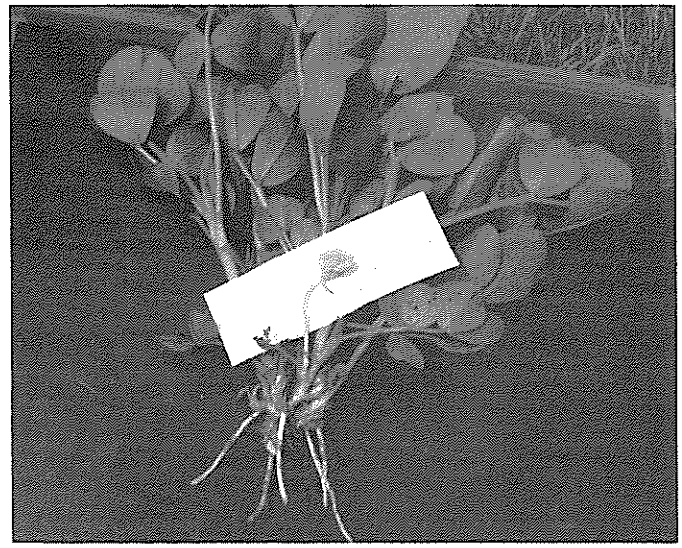

Figure 6. The style has elongated nearly 1 inch, pushing the peanut corolla upward. The ovary at the base of the style will develop a peg. Five pegs from other flowers are elongating downward. (The plant's root is removed.)

Figure 7. Single peanut plant showing pods attached with pegs and long tap root.

Figure 8. Peanut plants showing typical density of pods in the row.

PEANUT TYPES

Four types of peanut are grown (Table 2). Runner comprises about 75 percent and Valencia less than 1 percent of United States production. Runner and Virginia have large elongated seeds, Spanish has small round seeds, and Valencia is intermediate in size and shape. Most of the Valencia is grown in New Mexico, Spanish in Texas and Oklahoma, and the other types in the southeastern states and Texas.

Virginia type has the largest pods and seeds, and it and Runner supply the large food nuts sold in- and out-of-shell. Spanish supplies small shelled nuts, and Valencia is used for medium size in-the-shell nuts. Runner and Spanish are used for peanut butter. However, all of the types are used for most peanut products that do not require a specific seed size.

Very few of the nearly 4,000 varieties and introductions of peanut available in the world have been tested in Minnesota, but agronomic tests since 1976 show that Valencia and Spanish types are most promising because they initiate pegs from leaf axils on the main stem, and consequently mature some pods sooner than Virginia and Runner types that do not produce pegs on the main stem.

Table 2. Varietal classification of peanut (Arachis hypogaea L.)

Subspecies	Botanical variety	Market type	Agronomic varieties[1]
hypogaea	hypogaea	Runner	Florunner, Sunrunner, GK 7, Sunbelt Runner
hypogaea	hypogaea	Virginia	Florigiant, NC 7, GK 3, NC 6, Early Bunch, NC 8C, Virginia 81 Bunch, NC 2, Avoca
fastigiata	vulgaris	Spanish	Pronto, Starr, Spanco, Tamnut 74, Comet
fastigiata	fastigiata	Valencia	Valencia A, Valencia C, McRan

[1]Ranked within each market type in descending order of 1983 certified seed acreage in the United States.

PEANUT VARIETIES

Previous attempts to raise peanut in Minnesota have usually involved Spanish and occasionally Runner and Virginia varieties. Agronomic research indicates that Valencia varieties are better choices (Tables 3,4). Valencia A, Valencia C, McRan, and to a lesser extent Minnesota X52 produce much cleaner pods than Spanish varieties because of less soil retention. Furthermore, they are easier to shell by hand, are larger-seeded, and have more seeds per pod than Spanish varieties (Figure 9). The Valencia type and Minnesota X52 varieties in Table 2 have red seedcoats whereas the Spanish varieties have light tan seedcoats.

Valencia A and Valencia C were released by the New Mexico Agricultural Experiment Station in 1971 and 1979, respectively. McRan was brought from Morocco in 1967, and its variety protection certificate was issued to the Borden Peanut Company of Portales, New Mexico in 1976. Pronto was released by the Oklahoma Agricultural Experiment Station in 1980, and it has larger seed and greater shelling percentage (100 x weight of seeds ÷ weight of pods) than the standard variety, Early Spanish (Table 4). Delhi seed was obtained from the Agriculture Canada Research Station at Delhi, Ontario.

Other varieties have been tested but none performed as well as the Valencia types and Pronto in Table 3. The numbers of seeds per pod in Table 4 appear low because they are averages and there were many one-seed pods. Valencia varieties commonly have three or four and Spanish varieties two seeds per pod.

Table 3. Yields of peanut varieties at Rosemount and Becker, 1981-83

Variety	Market type	Pod yields/acre (pounds): Rosemount dryland	Becker dryland	Becker irrigated	Average 3 locations
Minnesota X52	Val-Spanish	1580	1320	1820	1570
McRan	Valencia	1540	1210	1700	1480
Valencia C	Valencia	1480	1250	1590	1440
Pronto	Spanish	1450	1210	1420	1360
Valencia A	Valencia	1490	1180	1370	1350
Early Spanish	Spanish	1260	1260	1000	1180
Delhi	Spanish	1200	1130	1100	1140
NC 7[1]	Virginia	540	390	410	450
Florunner[1]	Runner	480	330	390	400
LSD 5%		450	450	450	260

[1]1982 data adjusted to be comparable with 1981-83 data.

Table 4. Characteristics of peanut varieties, 1981-83[1]

Variety	Planting to bloom (days)	Pods/pound (number)	Seeds/pod (number)	Seeds/pound (number)	Shelling (percent)
Minnesota X52	49	480	2.1	1460	68
McRan	48	380	2.5	1510	62
Valencia C	48	390	2.3	1510	61
Pronto	48	550	1.7	1420	69
Valencia A	47	390	2.6	1620	61
Early Spanish	50	650	1.8	1810	65
Delhi	49	660	1.8	1740	66
NC 7	56	--[2]	1.7	--[2]	--[2]
Florunner	55	--[2]	1.9	--[2]	--[2]
LSD 5%		26	0.1	160	4

[1]Averages from Rosemount, Becker irrigated, and Becker dryland.
[2]Immaturity made data on pod and seed size and shelling percent misleading.

GROWING PEANUT IN MINNESOTA

Pod or Seed Planting

Peanut has been called "a crop that plants itself" because the parent plant pushes developing pods into the soil. Planting of pods was a common practice, but seed planting is more amenable to machine planting and results in more uniform stands. Higher yields resulted from seed than from pod planting (Table 5), because pod planting delayed emergence due to slow moisture absorption through the shells.

Table 5. Comparative yields of pod- and seed-planted peanut

Location and year	Pod yields/acre (pounds): pod-planted	seed-planted
Becker irrigated 1976	1510	1940
Becker irrigated 1977	510	540
Becker irrigated 1979	570	940
Becker dryland 1979	670	770
Rosemount dryland 1976	480	620
Rosemount dryland 1977	320	410
Average	680	870

Planting Date

Planting date is an important decision facing peanut growers. Initially, planting in June was favored, but recent research (Tables 6,7) showed that planting in early May gave higher yields, larger seeds, and a higher shelling percentage. Peanut planted in early May required a long time to emerge and developed very slowly after emergence (Table 7). Nonetheless it flowered about July 1 (earlier than later-planted peanut), and the early flowering allowed more pods to reach maturity before frost.

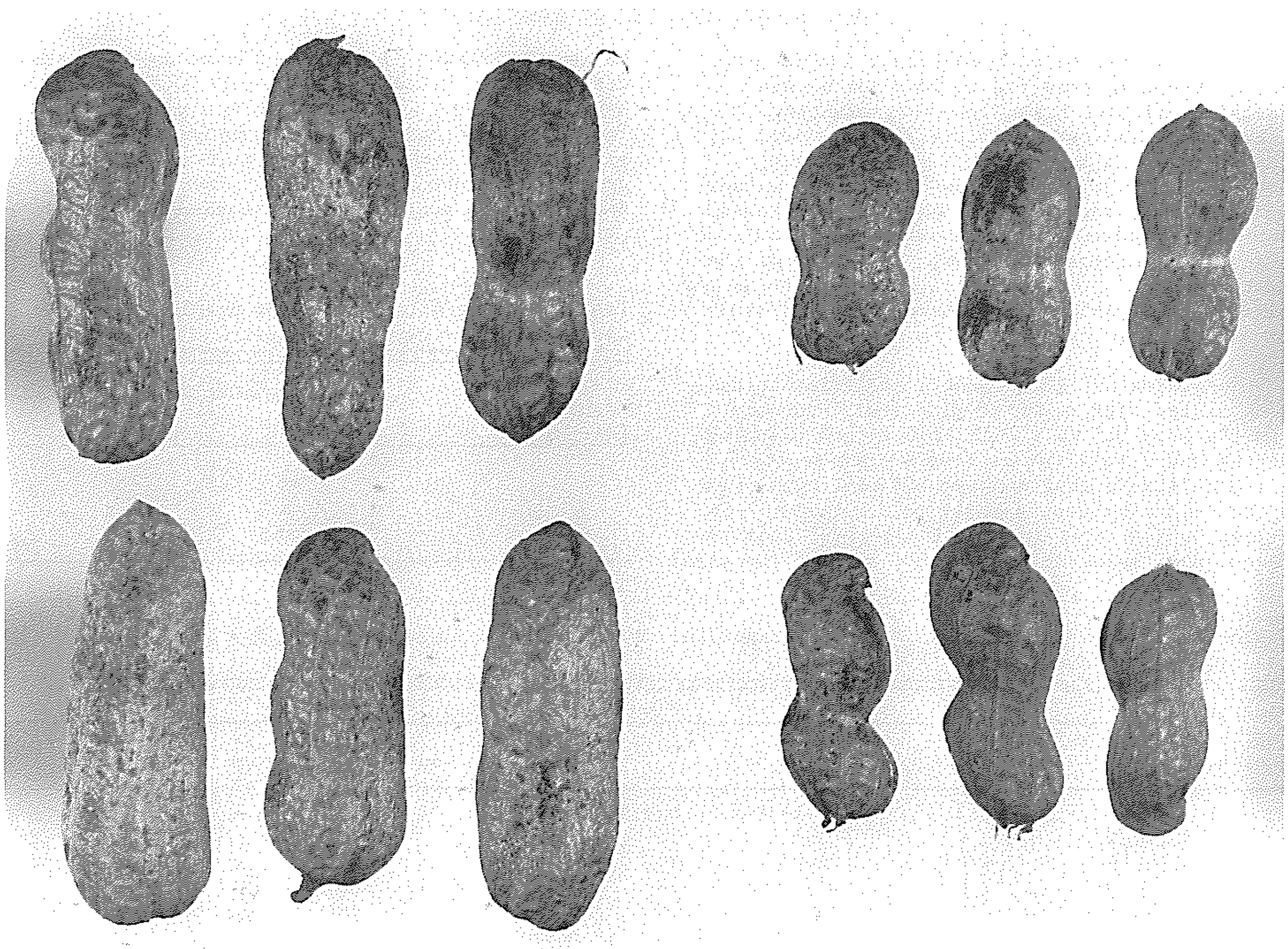

Figure 9. Valencia pods (left) are larger and easier to hand shell than Spanish pods (right).

Table 6. Yields of early-, medium-, and late-planted peanut at Rosemount and Becker, 1981-82[1]

	Pod yields/acre (pounds)			
	Rosemount	Becker		Average
Planting dates	dryland	dryland	irrigated	3 locations
April 29 to May 6	1290	1000	1840	1380
May 14 to May 21	1260	860	1540	1220
June 1 to June 2	1060	590	1170	940
LSD 5%	230	130	210	110

[1]Averages of Valencia A, Valencia C, and Pronto varieties.

Table 7. Characteristics of early-, medium-, and late-planted peanut, 1981-82[1]

		Planting to				
Planting dates	Plants/acre (thousands)	emergence (days)	bloom (days)	Pods/pound (number)	Seeds/pound (number)	Shelling (percent)
April 29 to May 6	70	23	59	430	1330	68
May 14 to May 21	78	17	48	460	1510	65
June 1 to June 2	71	14	41	510	1970	59
LSD 5%	4		1	30	110	2

[1]Average of 3 varieties at 3 locations.

Planting Depth and Preemergence Growth

Peanut should be planted 1 to 2 inches deep; deeper planting resulted in less and slower emergence (Tables 8,9). However, planting 2 to 4 inches deep to reach moisture in sandy soil is satisfactory in late May or June. Emergence varies with seed quality, soil temperature, soil moisture, and soil texture, but slow emergence compared to that of soybean is characteristic of peanut in Minnesota (Table 9). Crusting of the silt loam soil at Rosemount accounted for the low emergence of peanut and soybean planted 3 or 4 inches deep in June (Table 9).

Elongation of the hypocotyl and first internode varies with depth of planting. Hypocotyl lengths were 0.5 to 1 inch from 1-inch planting depths and 2 to 4 inches from 4-inch depths. First internode lengths were 0.5 to 1 inch from 1-inch planting depths and 1 to 2.5 inches from 4-inch depths. The four-foliolate leaf from the second node is usually the first part of the plant to emerge (Figure 1). The two branches from the cotyledonary axillary buds (Figure 3) start growth before emergence and are sometimes nearly 1 inch long when the four-foliolate leaf penetrates the soil suface. The slow but extensive preemergence growth of peanut contrasts with the rapid unbranched stem development of soybean and fieldbean (Figure 4).

Table 8. Time of emergence of Spanish peanut planted at four depths in April

Planting depth (inches)	Days after planting 13	16	22	25	37
	emergence (percent)				
1	26	29	47	59	69
2	29	31	42	52	61
3	3	8	14	18	27
4	0	10	19	21	23

Table 9. Time of emergence of Valencia peanut and soybean planted at 4 depths in May and June at Rosemount and Becker

Planting depth inches	Days after planting: 7	12	15	27	7	12	15	27
	- - -peanut emergence (percent)- - -				- - -soybean emergence (percent)- - -			
			Planted in May at Rosemount					
1	0	0	55	85	0	66	70	78
2	0	0	50	85	0	38	55	68
3	0	0	33	64	0	41	57	76
4	0	0	20	68	0	35	67	82
			Planted in May at Becker					
1	0	0	79	85	0	--	76	87
2	0	0	66	68	0	--	54	58
3	0	0	68	74	0	--	31	39
4	0	0	56	66	0	--	38	50
			Planted in June at Rosemount					
1	0	--	90	94	40	--	98	98
2	0	--	89	93	20	--	80	81
3	0	--	30	48	0	--	8	8
4	0	--	2	6	0	--	3	7
			Planted in June at Becker					
1	52	--	94	96	73	--	96	96
2	90	--	100	100	96	--	96	96
3	83	--	93	95	74	--	81	81
4	37	--	59	60	50	--	66	68

Row Spacing

Row spacings of 30 inches are common for cultivated field crops in Minnesota. Peanut is a short plant; Spanish varieties do not fill 30-inch rows, but other varieties may fill them by midsummer. The higher yield from 18-inch over 30-inch rows (Table 10) may be attributed to more interception of sunlight. Both Valencia and Spanish varieties benefited from 18-inch rows. A row spacing of 18 inches is about minimum for tractor wheels when cultivating, and 22 inches is often better. Some harvesting machinery may not be adapted to narrow rows. However, hand-harvested yields from 18-inch rows were higher than from 30-inch rows except on dryland sand (Table 10) where row spacing had little effect.

Table 10. Comparison of 18-inch and 30-inch row spacings[1] for peanut[2] at Rosemount and Becker, 1982-83

Row spacing (inches)	Plants/acre[3] June (thousands)	Plants/acre[3] Sept. (thousands)	Pod yields/acre (pounds) Rosemount dryland	Becker dryland	Becker irrigated	Average - 3 locations Pods/acre (pounds)	Pods/pound[4] (number)	Seeds/pound[4] (number)	Shelling[4] (percent)
18	97	88	1580	1210	1870	1550	440	1420	69
30	85	78	1370	1250	1680	1430	420	1370	70
LSD 5%	11	8	190	190	190	110	20	40[5]	1[5]

[1]Planting rates were 105,000 seeds/acre in 1982 and 90,000 seeds/acre in 1983. [2]Averages of Pronto and Valencia C. [3]1982. [4]1983. [5]Difference not significant.

Planting Rate

Varieties and seed lots of peanut differ greatly in number of seeds per pound. Consequently, planting rates should be expressed in seeds per acre rather than in pounds per acre.

Planting rates from 21,000 to 209,000 seeds per acre (seed spacings from 10 inches to 1 inch apart in rows 30 inches apart) showed that close spacing resulted in greater seed mortality than did wide spacing (Tables 11, 12). Peanut yields from planting rates between 42,000 and 105,000 seeds per acre in either 30-inch (Table 11) or in 18-inch (Table 12) row spacings did not differ significantly in yield. However, the highest yields in 30-inch row spacing resulted from 70,000 seeds per acre, and the highest yields in 18-inch row spacings resulted from 105,000 seeds per acre except that 70,000 seeds per acre produced highest yields on dryland sand. Planting rate did not affect pod or seed weight.

A base planting rate of 90,000 seeds per acre is suggested with adjustments for germination below 90 percent, soil texture, and seed price.

Table 11. Comparison of peanut planting rates in 30-inch row spacings at Rosemount and Becker, 1978-82

Seeds/acre (thousands)	Seed spacing (inches)	Plants/acre September[1] (thousands)	Pod yields/acre (pounds) Rosemount 1978 dryland	Becker 1978-82 dryland	Becker 1978-82 irrigated	Averages - 11 trials Pods/acre (pounds)	Pods/pound (number)	Seeds/pound (number)
209	1	176	--	940[2]	1120[2]	1000	500	1010
105	2	91	940	1060	1350	1180	500	1130
70	3	61	--	1110	1500[3]	1270	480	1080
52	4	48	730	1120	1240	1140	480	1080
42	5	36	830	1150	1220	1150	480	1110
21	10	--	370	640[4]	900[4]	730	480	1050
LSD 5%		9	410	300	300	200	50	103

[1]Average of all trials. [2]1979-80. [3]1979-82. [4]1978. Data for rates not included in all trials are adjusted to be comparable with rates included in all trials.

Table 12. Comparison of peanut planting rates in 18-inch row spacings at Rosemount and Becker, 1983.

Seeds/acre (thousands)	Seed spacing (inches)	Plants/acre June (thousands)	Plants/acre Sept. (thousands)	Pod yields/acre (pounds) Rosemount dryland	Becker dryland	Becker irrigated	Averages - 3 locations Pods/acre (pounds)	Pods/pound (number)	Seeds/pound (number)	Shelling (percent)
105	3.3	89	70	1810	1490	2230	1840	450	1370	70
70	5.0	48	50	1670	2170	1850	1900	420	1420	70
52	6.7	42	40	1680	1650	2050	1790	430	1370	70
42	8.3	33	35	1560	1650	1550	1580	440	1420	68
LSD 5%		8	5	760	760	760	440	40	90	3

Ridge Planting, Level Planting, and Hill-up Cultivation

Peanut in the southern states is often produced on level but slightly raised beds of 2 to 4 rows between the tractor wheel tracks. Beds are not used for field crops in Minnesota, but disk hiller cultivators are often used on fine textured soil to form ridges prior to planting corn or soybean seed in the ridge. Higher temperatures in the ridge encourage faster emergence and growth. Comparison of ridge- and level-planted peanut showed that ridge planting resulted in 1 or 2 days earlier blooming but had no other advantages (Table 13, Figure 10). Ridge planting might be better for some harvesting machinery, but a potato digger harvested both plantings equally well on sandy soil.

Row crops such as fieldbean, corn, and sunflower are often hilled up at the last cultivation to cover weeds, reduce lodging, and facilitate operation of bean pullers. This is not a good practice with peanut if axillary branches are buried. A late hill-up cultivation that did not cover branches was compared with level cultivation at three locations (Table 14, Figure 11). Hilling up showed no advantage over level cultivation, and there is the hazard of foliage burial.

Figure 10. Level-planted peanut row (left) and ridge-planted row (right). Seed was planted in the ridge made with a disk hiller cultivator.

Figure 11. Hilled-up Spanish peanut in rows 30 inches apart.

Table 13. Comparison of ridge- and level-planted peanut at Rosemount and Becker, 1981[1]

Planting method	Planting to bloom (days): Rosemount dryland	Becker dryland	Becker irrigated	Average 3 locations	Pod yields/acre (pounds): Rosemount dryland	Becker dryland	Becker irrigated	Averages - 3 locations: Pods/acre (pounds)	Plants/acre (thousands) June	Plants/acre (thousands) Sept.
Ridge	52	47	49	49	1480	860	1290	1210	78	69
Level	53	49	51	51	1430	930	1240	1200	76	69
LSD 5%	1	1	1	1	140	90	140	70	4	3

[1]Averages of Valencia A and Pronto and three dates of planting.

Table 14. Comparison of level and hill-up cultivation of Spanish peanut at Rosemount and Becker, 1978

Cultivation	Pod yields/acre (pounds): Rosemount dryland	Becker dryland	Becker irrigated	Average 3 locations
Level	660	1230	1080	990
Hill-up	770	910	1170	950

Fertilizer, Inoculation, and Irrigation

Peanut, like soybean, responds well to residual soil fertility from previous crops, but its response to fertilizer is often low on soils of medium to high nutrient levels. Adequate levels of phosphorus, potassium, calcium, and magnesium are needed, and soils low in potassium and phosphorus should be fertilized.

Optimum soil pH is 6.0 to 6.4 (4). However, peanut is tolerant of a wide range of soil pH if calcium and micronutrients remain available. On alkaline soil, phosphorus-induced zinc deficiency and chlorosis from unavailability of iron and manganese may occur.

Calcium is of major importance because the underground pods do not transpire water so they do not have access to root-absorbed calcium. Consequently, available calcium should be in the surface 3 inches of soil for absorption by the developing pods. Excessive numbers of empty pods (pops) and black heart (darkened germs) are indicators of calcium deficiency. Gypsum (calcium sulfate) supplies quickly available calcium and is topdressed at early bloom stage over most of the Virginia type peanut and some of the Runner and Spanish peanut in southeastern United States at rates of 500 to 1000 pounds per acre. The calcium levels in many Minnesota soils and the calcium concentration in much of the irrigation water indicate that gypsum may not be needed, but this has not been researched. Gypsum is also a source of sulfur, but only a few areas in Minnesota have sulfur deficient soil.

Boron deficiency causes hollow heart--a sunken cavity between the cotyledons in the seed.

Sandy soils in Minnesota's central sand plain are low in nitrogen. Irrigation of these sandy soils and rainfall result in large losses of nitrogen by leaching. Nitrogen fertilizer on irrigated sandy soil increased peanut yields, pod weights and seed weights (Table 15). However, peanut does not need nitrogen fertilizer if the proper strain of nitrogen fixing bacteria is present in the soil. Peanut is in the same inoculation group as adzuki, tepary bean, and cowpea so it is unlikely that many Minnesota soils have the correct bacteria. Consequently, cultures of living bacteria (available in commercial products) may be mixed with peanut seed just before planting. Or, an alternative to seed inoculation is placement of granular inoculant in the peanut row through a planter attachment. Without inoculation, peanut yields may be limited by the amount of available nitrogen in the soil. Residual nitrogen left by preceding crops and nitrification from soil humus during the summer may supply enough nitrogen for peanut on fine-textured soils. Trials on irrigated and dryland sand showed that foliage yellowing was prevented by either inoculation or nitrogen fertilizer (Table 16). However, yield was not increased on dryland sand because water shortage rather than nitrogen shortage limited yield. On irrigated sand, either inoculation or 150 pounds of nitrogen per acre was needed to prevent large reductions in yield. Inoculation is recommended for peanut in all Minnesota soils because inoculation enables the peanut to use nitrogen from the air instead of fertilizer and soil nitrogen.

Peanut in Minnesota is a drought-tolerant crop, but irrigation usually increases yields on sandy soil (Table 17). However, lack of irrigation expenses and lower land values may give dryland production an economic advantage over irrigated production.

Table 15. Response of peanut varieties to N fertilizer at Becker with 8 inches of irrigation, 1981

Variety	N/acre[1] (pounds)	Pods/acre (pounds)	Pods/pound (number)	Seeds/pound (number)	Shelling (percent)
Delhi	0	990	600	1680	67
Delhi	150	1020	570	1510	69
Valencia C	0	1510	380	1420	69
Valencia C	150	2280	360	1330	68
McRan	0	1190	400	1460	67
McRan	150	1900	360	1330	66
Average	0	1230	440	1510	68
Average	150	1730	410	1370	68

[1]30 pounds/acre May 16, June 11, June 27, June 30, July 12. Heavy rains in June (5.5 inches June 14) made repeated applications necessary because of probable leaching loss.

Table 16. Response of Valencia and Spanish peanut to inoculation with rhizobia and N fertilizer at Becker, 1982

Variety	Treatment	Foliage color[1] in August		Pods/acre (pounds)	
		dryland	irrigated[2]	dryland	irrigated[2]
Valencia C	Untreated	2	2.6	350	1010
	Inoculation	1	1.0	390	1350
	50 lb. N/acre June 2	1	2.4	410	1230
	150 lb. N/acre (50-June 2, July 1, July 28)	1	1.3	380	1390
Pronto	Untreated	2	2.8	800	850
	Inoculation	1	1.0	590	1410
	50 lb. N/acre June 2	1	2.3	800	860
	150 lb. N/acre (50-June 2, July 1, July 28)	1	1.0	590	1390
LSD 5%				170	120
Average	Untreated	2	2.7	570	930
	Inoculation	1	1.0	490	1380
	50 lb. N/acre June 2	1	2.4	610	1050
	150 lb. N/acre (50-June 2, July 1, July 28)	1	1.2	480	1390
LSD 5%				140	250

[1]1 green to 3 yellow green. [2]10 inches between July 1 and August 26.

Table 17. Average yields of irrigated and dryland peanut from various trials at Becker, 1978-83

Year and trial	Pod yields/acre (pounds) irrigated	dryland
1978 Planting rate	1130	1070
1979 Planting rate	640	740
1980 Planting rate	1790	1440
1981 Planting rate	1510	990
1981 Variety	1380	1010
1981 Planting date early	1420	1030
1981 Planting date medium	1360	960
1981 Planting date late	1030	690
1982 Planting date early	2260	980
1982 Planting date medium	1720	770
1982 Planting date late	1310	480
1982 Variety	1090	990
1982 Row spacing	2040	980
1982 Nitrogen	1190	540
1982 Planting rate	1380	1120
1983 Planting rate	1920	1740
1983 Variety	1500	1480
Average	1450	1000

Pests--Weeds, Insects, Diseases, Nematodes, and Birds

Peanut grows slowly. The foliage canopy is less than that of soybean and it takes nearly 3 months to achieve complete ground cover. Consequently, both cultivation and herbicides are essential unless the grower plans to pull weeds by hand. Many effective herbicides are available for preplant incorporated, preemergence, cracking stage, and/or postemergence applications (9). Herbicides and rates of active ingredient in pounds per acre are: Preplant incorporated herbicides include benefin (Balan) at 1.1 to 1.5 pounds, metolachlor (Dual) at 1.5 to 3.0 pounds, pendimethalin (Prowl) at 0.75 to 1.0 pounds, or vernolate (Vernam) at 2.0 to 2.6 pounds. Preemergence herbicides include alachlor (Lasso) at 3.0 to 4.0 pounds or metolachlor (Dual) at 1.5 to 3.0 pounds. Cracking stage herbicides include alachlor at 3.0 pounds, naptalam (Dyanap) at 2.0 to 3.0 pounds, chloramben (Amiben) at 2.0 to 3.0 pounds, metolachlor at 1.5 pounds to 3.0 pounds, or dinoseb (Premerge) at 1.5 pounds. Postemergence herbicides include acifluorfen (Blazer) at 0.25 to 0.5 pounds, bentazon (Basagran) at 0.75 to 1.0 pounds, dinoseb at 0.5 to 1.0 pounds, naptalam at 1.0 to 2.0 pounds, or 2,4-DB (Butoxone, Butyrac 200) at 0.2 to 0.4 pounds.

Both tank mixtures of complementary herbicides and separate treatments of herbicides are commonly used to control mixed populations of weeds and to keep weeds controlled until harvest. Treatments at the soil cracking stage are more common in peanut than in other crops because peanut remains in this stage for about 2 weeks. The roots grow extensively during the cracking stage while little or no peanut foliage is above ground and exposed to the herbicide.

Trifluralin (Treflan) at 0.5 to 1.0 pounds per acre preplant incorporated has given excellent control of weeds without injuring peanut in research trials at Becker and Rosemount but its label restricts use to Texas and Oklahoma. Current herbicide labels should be checked before using any herbicides on peanut in Minnesota.

Injury from insects and diseases has rarely occurred in Minnesota research plots. Potato leafhopper was controlled in a few trials. Leaf spot disease has been observed in August. New insect and disease problems may appear with continued production of peanut in Minnesota. Peanut diseases, insects, and nematodes are controlled by crop rotation and/or chemicals in the southern states.

Peanut drying in the windrow is subject to feeding by migrating birds. Several hundred pounds of research plot material were eaten in a single October day at Becker.

Harvesting, Drying, and Storage

Optimum harvest time is when most pods have a veined surface, seed coats are colored, and 75 percent of the pods show darkening on the inner surface of the hull. Peanut does not reach this stage in Minnesota so immature pods are removed in the threshing, drying, and cleaning operations. Harvesting in Minnesota should start after the first killing frost if soil moisture is at a level suitable for cultivation. Wet soil sticks to the pods. In hard, dry soil, digger blades may not maintain an even depth.

Commercial harvesting often starts with clipping and coultering. If plant growth is too great for efficient harvesting, a rotary mower removes up to one-half of the top growth. Branches of prostrate growing varieties may overlap between rows and a coulter makes the vertical cut between rows where separation is desired.

The next operation usually involves a digger-shaker-windrower. Sharp digger blades are set to clip taproots just below the pod zone (Figure 12). The loosened plants flow over the digger blade and on to the shaker. Soil and trash fall through the openings in the shaker, and the peanut plants move over the shaker and drop to the ground in a windrow. Windrow inverting attachments were commercialized about 20 years ago in Texas and New Mexico. These orient the plants as they leave the shaker so that the pods are primarily at the top of the windrow (Figure 13). The exposure to sun and wind reduces drying time.

Figure 12. A two-row peanut digger-shaker-inverter showing blades that resemble plowshares and the shaking elevator which removes soil from the plants. (Courtesy Lilliston Corporation).

The windrowed peanut may be combine-harvested wet (35 to 50 percent moisture), semidry (18 to 25 percent moisture), or dry (8 to 10 percent moisture). Windrowed peanut may reach the semidry condition (seeds rattle in pods) 1 to 3 days after digging. Drying in the windrow to a moisture level of 8 to 10 percent requires 5 to 10 days of good drying weather. Peanut that has been in the windrow several days is more subject to weather damage than when freshly dug. Consequently, combining of wet or preferably semidry peanut followed by artificial drying may result in better quality peanut. Artificial drying of wet

Figure 13. The inverting windrower catches the plants as they leave the shaker. Additional soil is sifted from the plants before the inverting rods form a windrow of plants with pods on top. (Courtesy Lilliston Corporation).

or semidry peanut should start immediately after combining to prevent mold growth and possible aflatoxin formation. Unheated air may be used to dry peanut when relative humidity is below 65 percent.

In addition to removal of water, drying causes physical and biochemical changes which can be harmful or beneficial to peanut flavor and quality. Peanut seed should not be heated above 95°F, and rate of drying should not exceed 0.5 percent per hour. Hulls dry before the seed, but moisture moves from seeds into the hulls until a moisture balance is achieved. Hulls are more hygroscopic than seed so water moves from seed to hulls even when hulls have a higher moisture percentage than that of the seed. At a relative humidity of 65 percent, research calculations indicate that peanut seed of 7 to 8 percent moisture and hulls at 11 to 16 percent moisture are in equilibrium (10). Experience has confirmed that at a relative humidity of 65 to 70 percent, dry peanut maintains a moisture of about 7 percent.

Potato diggers (Figures 14,15), fieldbean harvesting blades, plowshares, and similar devices can be adapted by noncommercial growers to dig peanut. However, the simplest method is to firmly grasp the plant at ground level, pull it up, and pound the attached pods on the ground to remove soil. Moisture in the pods must be reduced from 50 percent when pulled to 10 percent or less for storage. The pods can be separated from the plants immediately after pulling or later after drying in a windrow, in small stacks, in a building, or in a crop drier. Pods and plants can be separated by hand or through a threshing machine.

Figure 14. This potato digger used to harvest peanut plots simulates the digger-shaker portion of commercial peanut harvesting. The potato digger did an effective job when operated at one-half the depth used for potato. The addition of a windrow inverter at the rear would make the operation similar to that of modern commercial peanut production.

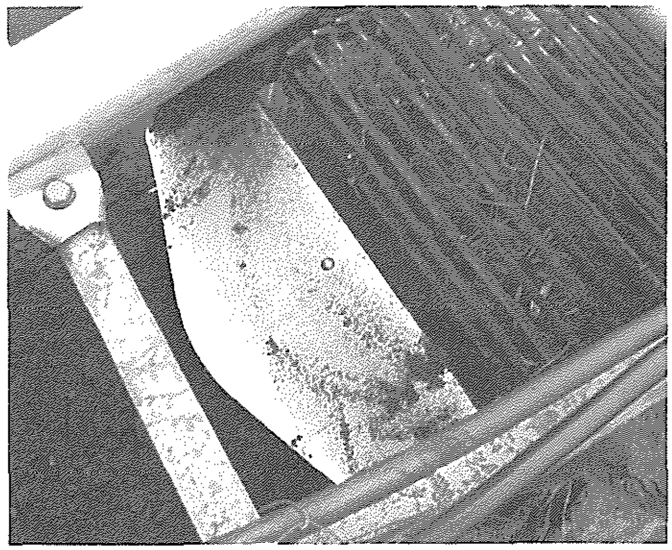

Figure 15. Close-up of the potato digger blade and conveyer rods which shake soil from the plants.

Slow, uninterrupted drying with unheated air and storage in a dry, cool area will provide good quality peanut until the next crop is available.

Peanut is semiperishable but dry pods may be stored for several years under good storage conditions of low temperature and low relative humidity. Unshelled peanut should retain edible quality for 6 months at 70°F, for 9 months at 45°F, for 2 or 3 years at refrigerator temperature, and for many years if frozen. Shelling reduces storage life by about 35 percent.

Seed Production, Viability, and Treatment

Varietal purity can be maintained for many generations by avoiding accidental mixing of varieties in planters, combines, cleaners, treaters, etc. Natural cross-pollination is usually very low although it has ranged from 0.2 to 6.2 percent in peanut breeding nurseries. Field isolation requirements range from 20 to 100 feet depending on the state and seed class (foundation, registered, or certified).

Viability of peanut grown in Minnesota has been good. Germination rates of seed harvested from research plots were usually 90 percent or higher. Seed retained viability longer when stored in the pod than when shelled. Low humidity and cool temperatures favor retention of viability. Seed of 5 percent moisture loses viability more slowly than seed of 8 percent moisture, but relative humidity must be less than 50 percent to maintain such a low moisture level.

In a 3-year storage trial of Early Spanish variety harvested at Rosemount, shelled seed treated with captan and untreated seed maintained satisfactory viability for 3 years frozen and for 1 year in a heated office. Unshelled seed maintained viability for about 22 months in the office. All seed stored for over 12 months molded severely on germination blotters even when germination was satisfactory.

Fungicide seed treatments protect live seed from seed-rotting fungi in the soil. The peanut seed coat provides natural protection, but it is usually scratched or broken in machine shelling. Most seed sold to growers is already treated. Treatment also improves emergence of hand-shelled seed. Seed treatment fungicides used include captan (Orthocide), thiram (Arasan), folcid (Difolatan), maneb (Dithane)-captan, Botran-captan, Vitavax-captan, captan-maneb-PCNB-terrazole, and captan-thiram-PCNB(4).

Crop Comparisons

Peanut if grown commercially in Minnesota would be an alternative to soybean or fieldbean. Comparative yields of peanut, soybean, and sunflower planted in the same trials are shown in Table 18. On silt loam soil at Rosemount and on irrigated sand, soybean greatly outyielded peanut. However, peanut outyielded soybean in two of five comparisons on dryland sand and also outyielded sunflower in two comparisons. These results indicate that peanut has most potential as an economic crop on dryland sandy soil.

Yields and market prices are based on peanut pods, soybean seed, and sunflower achenes so business and scientific analyses of crop comparisons may differ because the plant parts differ.

Peanut foliage has shown unusually high tolerance to hail. Hail in June that decimated corn and soybean did not injure peanut; however, effect of hail on flowering peanut in July has not been observed in Minnesota.

Table 18. Comparative yields of peanut, soybean, and sunflower planted in the same trials

Location	Planting (date)	Row spacing (inches)	Yield/acre (pounds)		
			Peanut[1]	Soybean[2]	Sunflower[3]
Rosemount dryland	May 3, 1982	30	1190	2700	--
	May 21, 1982	30	940	2630	--
	June 1, 1982	30	730	2440	--
	April 30, 1983	30	1570	3040	--
	April 30, 1983	18	1870	2390	--
Becker dryland	April 29, 1982	30	980	1390	720
	May 19, 1982	30	770	1040	450
	June 2, 1982	30	480	1050	--
	May 2, 1983	30	1550	770	--
	May 2, 1983	18	1410	540	--
Becker irrigated	April 29, 1982	30	2260	3680	--
	May 19, 1982	30	1720	2750	--
	June 2, 1982	30	1310	2710	--
	May 17, 1983	30	1400	2210	--
	May 17, 1983	18	1600	2640	--

[1]Average of all varieties in trial. [2]Evans variety. [3]USDA 894 hybrid.

AFLATOXIN

Fungi of many kinds are in continuous contact with the peanut pod. Aspergillus flavus Link ex Fries and Aspergillus parasiticus Speare are of great concern because they may produce aflatoxin. Aflatoxin is toxic to humans and farm animals and is a carcinogen. Peanut seed is generally resistant to these fungi during its growth in the soil and is most often infected while drying in the windrow. However, immature pods can be infected during the 4 to 6 weeks prior to harvest if severe drought stress or insect damage weakens the plants. Overmature pods can also be infected in the soil, but overmaturity is unusual in Minnesota.

Aflatoxin is most likely to be produced at peanut moisture levels of 12 to 30 percent. Consequently, harvested peanut should be dried to the "safe" 10 percent moisture level without interruption but at rates not exceeding those recommended for good quality peanut. Aflatoxin did not develop at relative humidities below 84 percent, and this limiting humidity is in equilibrium with seed moisture of over 10 percent (2). The minimum growth temperature for A. flavus is about 45°F (7), and the minimum temperature for aflatoxin production in unshelled peanut shortly after digging was 63°F for one variety and 59°F for another (2). Mold development is favored by pod moistures between 14 and 35 percent and air temperatures of 80°F to 100°F (4). Cool September and October weather in Minnesota should reduce the aflatoxin hazard if good drying practices are followed.

Aflatoxin tests are required on shelled peanut sold for human consumption, and peanut testing higher than about 20 parts per billion is rejected.

FOOD VALUE

Peanut is a tasty and nutritious food. The seeds are commonly reported to contain about 26 percent protein and nearly 50 percent oil. Peanut protein is not as well balanced nutritionally as that of soybean, but is better than that of some common grain and pulse crops. Peanut oil may be hydrolyzed into about 80 percent unsaturated and 20 percent saturated fatty acids. Oleic acid (monounsaturated) comprises about 50 percent and linoleic acid (polyunsaturated) about 30 percent of the fatty acids in peanut oil. The fatty acid composition of polyunsaturated vegetable oils such as sunflower, corn, and soybean is 20 to 30 percent oleic and 50 to 70 percent linoleic. The high oleic concentration in peanut oil imparts stability against odor absorption and longer shelf life to peanut products. Refined peanut oil has an iodine number of about 90 and a smoke point of about 440°F. It is free of peanut odor and flavor.

The chemical composition of peanut is affected by genetic factors of type and variety and by environmental factors of weather, soil, and farming practices. The nutritional composition of Delhi Spanish and Valencia C peanut in Table 19 indicates that peanut is equivalent to fieldbean in protein percentage but much higher in fat (oil). Fieldbean contains about 1 percent oil. Consequently, peanut provides about 580 calories per 100 grams of seed compared with only 340 calories for fieldbean. Peanut is higher in methionine and cystine (sulfur-containing amino acids) than fieldbean so it is sometimes considered a better-quality protein source.

The seedcoat (skin) comprised only 3.3 percent of the seed so its removal had little effect on peanut composition (Table 19).

About half of the edible peanut (excluding that crushed for oil and exported) in the United States is used for peanut butter. Peanut butter differs from whole peanut in that the heart (primary axis) and skin are usually removed because the former imparts a bitter flavor and the latter appears as dark spots in the butter. Consequently, common peanut butter consists of at least 90 percent peanut cotyledons, additional oil, sweeteners, emulsifiers, salt, etc. Runner varieties provide over 90 percent of the peanut used for peanut butter. The peanut heart by-product (about 3 percent of the seed) is a common constituent of birdfeed.

Blanched peanut with only seedcoats removed or with both seedcoats and hearts removed is available. Defatted peanut has 50 to 80 percent of the oil and many calories removed. The flavor tends to remain with the oil so some oil is left and salt, sugar, and spices may be added to enhance flavor.

Peanut flakes result from blanching, cooking, grinding, and drying. The flavor is destroyed leaving a tasteless product that has nearly the same nutritive value as the original peanut but which can be blended into other foods without altering their taste. Partially defatted and defatted flakes can also be made.

Peanut flours with protein levels between 45 and 60 percent are being developed.

Peanut meal, a by-product of oil extraction, is used as a protein concentrate for livestock. Peanut hulls are used for fuel in shelling plants and are a high-fiber filler in livestock feed.

Table 19. Average nutritional composition of peanut varieties produced at Rosemount and Becker, 1980

Nutrient	Whole seed Delhi (percent)	Whole seed Valencia C (percent)	Blanched seed[1] Delhi (percent)	Blanched seed[1] Valencia C (percent)	Seedcoat Average (percent)
Protein	21.6	21.3	22.2	22.1	14.2
Carbohydrate[2]	23.2	26.7	18.5	22.9	73.1
Fat	44.9	42.1	49.2	45.0	1.9
Fiber	3.9	3.3	3.0	3.4	16.9
Ash	2.3	2.1	2.1	2.1	2.8
Water	8.0	8.0	8.0	8.0	8.0

[1]Seedcoats removed. [2]Fiber plus nitrogen free extract.

PREPARATION FOR EATING

Raw peanut is edible, but roasting improves the texture, flavor, and aroma. Pods can be cleaned just before roasting by placing them in a colander and rinsing them with water. Peanut can be roasted in-the-shell by placing the pods in an oven at about 300°F for about 30 minutes. Oven temperature and time can be varied to suit individual taste. The roasted pods can be shelled by hand and the nuts consumed either hot or cold.

The seedcoats (skins) are good food (Table 19), but much peanut is processed to remove skins and sold in blanched form. For those who wish to blanch peanut at home, USDA personnel (1) suggested the following procedure: Immerse raw, shelled peanut in 1 percent sodium hydroxide for 8 seconds and then dip in 1 percent hydrochloric acid to prevent the red color of the skins from staining the seeds. Rinse the loose seedcoats out of the peanut with water. Dry and roast the seeds.

Boiled peanut is considered a delicacy by some peanut growers. Freshly dug, "green," or not fully mature peanut pods are boiled in brine (0.5 pound salt per gallon of water) for 35 minutes or until tender (6). Boiled peanut is hand shelled and eaten hot or cold. It will keep for several days in a refrigerator.

CONCLUSION

Minnesotans who want a lifestyle of self-sufficient food production will find that peanut is a valuable addition to their crop choices. Other groups who are concerned about the precarious dependence of most Americans on distant food supplies should encourage locally-grown peanut. However, production of peanut in Minnesota is economically inefficient considering the present costs and reliability of the food distribution system in the United States. Research to develop varieties that require fewer heat units is needed if the area of commercial peanut production is to be extended northward.

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