Sunflower Plant Population and Its Arrangement

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Most sunflower is grown for its seed. The three components of seed yield are number of heads per acre, number of seeds per head, and average seed weight. The product of these three components is yield per acre:

yield/acre = heads/acre × seeds/head × weight/seed.

Because most sunflower varieties produce one head per plant, the first component of yield—number of heads per acre—is determined by plant population. Plant population also has a major influence on the other two components. Sunflower adjusts to low populations by increasing seeds per head and weight per seed and to high populations by decreasing seeds per head and weight per seed. So yield, which is the product of the three components, remains relatively constant through a range of populations. But, in high yielding fields of sunflower, adjustments among components of yield are not sufficient and population differences of a few thousand plants per acre may affect yield.

Arrangement of plant population is important, and distributions may range from clumping two or more plants in a group to locating plants singly and at an equal distance from neighboring plants. Arrangement of a population is altered by changing row spacing, by planting seeds singly or in groups, or by changing row direction.

Plant population and its arrangement are important aspects of sunflower production that are directly controlled by the farmer.

PLANT POPULATION

Considering yield per se, the optimum population is the minimum population that produces maximum yield. The yields of this optimum population at six locations in Minnesota appear in boldface in table 1. Yields within the range of the least significant difference (LSD) are not considered significantly different. It is obvious that the optimum population differed among the six locations. The same hybrids and procedures were used at all locations, so the differences among locations can be attributed to soil, temperature, and rainfall. The soils at the first four locations are moisture-retentive silt loams; those at Becker and Grand Rapids are sandy. Lamberton, in southwestern Minnesota, had the highest temperatures and least rainfall in August, and maximum yield was attained at only 15,000 plants per acre. Populations of 25,000 plants per acre were required for maximum yield on sandy soil at Grand Rapids and on silt loam soil at Waseca in contrast to only 10,000 plants per acre on dryland sandy soil at Becker. Cooler temperatures, more rainfall, and a thin clay layer in the subsoil at Grand Rapids contributed to the marked contrast in optimum population between Grand Rapids and Becker.

Disagreement on the optimum plant population is common. Factors other than population may limit yield and lead to an erroneous conclusion that population is not important. For example, populations of 10,000 through 25,000 plants per acre did not differ in yield at Becker because lack of moisture limited yields to 1,000 pounds per acre. But, although yield was not reduced by excess population, seeds per head and weight per seed were reduced to maintain the yield at about 1,000 pounds per acre. With irrigation at Becker, populations of at least 20,000 plants/acre are needed for maximum yield. The 7,000-plant-per-acre population was an equidistant 30-inch × 30-inch plant spacing. The 7,000 plants did not increase seeds per head and weight per seed sufficiently to produce the optimum yield at any location. In contrast to the sensitivity of corn to excess population, sunflower at populations 25 to 150 percent in excess of the optimum population at a location did not suffer reductions in yield.

Plant population also affects sunflower height, lodging, head diameter, and dry-down rate, and these may indirectly affect yield. Both plant height and lodging increased with increasing population (table 2). Increased lodging is sometimes serious, and the risk may discourage the use of high populations that give maximum yields on productive fields.

Table 1. Sunflower yield per acre from five plant populations at six locations in Minnesota

Population/acre (plants)	Crookston 1977-78	Morris 1977-78	Lamberton 1977-78	Waseca 1978	Becker 1977-78	Grand Rapids 1977-78	Average 12 trials
				(pounds/acre)			
7,000	1,775	1,982	1,816	2,058	881	1,373	1,644
10,000	2,181	2,317	2,105	2,418	**1,041**	1,908	1,987
15,000	2,606	2,448	**2,452**	2,727	1,065	2,511	2,278
20,000	**2,941**	**2,841**	2,478	2,993	1,076	2,827	2,513
25,000	3,018	2,799	2,560	**3,243**	1,072	**3,309**	**2,630**
LSD 5%	172	91	150	237	115	178	62

Table 2. Average sunflower plant height, lodging, head diameter, and head moisture percentage at harvest in five plant populations at six locations in Minnesota

Population/acre (plants)	Height (inches)	Lodging (percent)	Head diameter (inches)	Head moisture (percent)
7,000	60	23	11	43
10,000	62	23	10	34
15,000	65	26	8	25
20,000	67	29	8	22
25,000	70	38	7	20
LSD 5%	1	3	0	2

Table 3. Head moisture percentages at harvest of sunflower populations with and without preharvest desiccant spray at Morris

	1978		1979		
Population/acre (plants)	Paraquat	No spray	Paraquat	Sodium chlorate	None
	(percent)				
7,000	53	71	—	—	—
10,000	41	59	27	29	34
15,000	27	43	—	—	—
20,000	24	37	20	24	29
25,000	21	32	—	—	—
LSD 5%	2	5	5	5	5

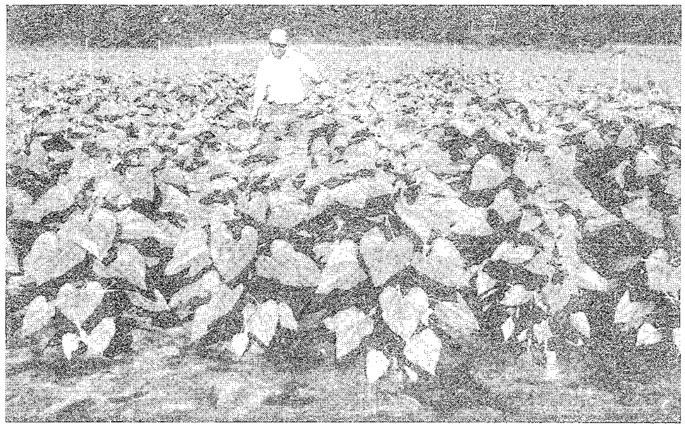
Table 4. Average test weight per bushel, oil percentage, and large seed percentage of seed harvested from five plant populations at six locations in Minnesota

	Test weight/bushel			
Population/acre (plants)	Oilseed (pounds)	Nonoilseed (pounds)	Oil[1] (percent)	Large seed[2] (percent)
7,000	31.5	22.9	37.5	81
10,000	32.3	23.5	39.7	70
15,000	32.7	24.4	41.4	50
20,000	32.8	25.0	42.2	36
25,000	33.4	25.4	42.4	24
LSD 5%	0.2	0.2	0.5	3

[1]10 percent moisture basis. [2]Held on a 20/64 round-hole sieve.

Head diameter and head moisture percentage decreased with increasing population (table 2). The lower head moisture of high populations is evident soon after physiological maturity, and this early drying advantage persists throughout the dry-down period. Early dryness permits early harvest and results in less exposure to damage from birdfeeding and weather. Early dryness is of major importance both in southern Minnesota, where the crop may mature in early September, and in northern Minnesota, where snow may prevent harvest until spring. Preharvest desiccant sprays shortened the drying period, but they did not change the relationship between plant population and head moisture percentage (table 3). Increasing plant population reduced head moisture percentage with or without preharvest desiccant spray.

Large heads resulting from low plant populations often bend their stalks so that the heads face down, whereas heads in medium or high populations usually hold their faces vertically to the ground. Hybrids also differ greatly in head position, and some hybrids have vertical head faces while others have inverted faces. The inverted face position may be a disadvantage in harvesting or if spray contact with the face is important in insect control. On the other hand, inverted faces may reduce birdfeeding.



The taller plants at the right of agronomist D. L. Rabas are in a 20,000-plant-per-acre population; the shorter plants at the left are in a 7,000 population.

Plant population also affects the quality of the seed produced. Both test weight and oil percentage increased with increasing population (table 4). Seed from oilseed hybrids at all populations greatly exceeded the 27-pound-per-bushel minimum test weight required for Grade 1 oilseed sunflower. But 15,000 or more plants per acre were needed to produce the 24-pound-per-bushel minimum required for large nonoilseed sunflower. Price premiums or discounts may be given for oilseed sunflower above or

A large head from a 7,000-plant-per-acre population and a smaller head from a 20,000 population are compared by Brown County Extension Director L. G. Peichel. The heads face the ground in the 7,000-plant-per-acre population.

Table 5. Sunflower yield, seed quality, and lodging from four plant populations at Waseca

Population/acre (plants)	Yield/acre 1971-74	1979	1980	Oil[1]	Large seed[2]	Lodging (score)[3]
	----------(pounds)	----------		(percent)		
20,000	3,161	1,946	2,969	41.0	25	3.2
25,000	3,360	2,212	3,453	41.4	20	3.7
30,000	3,640	2,109	3,331	41.9	13	4.3
35,000	4,115	2,390	3,614	42.2	9	5.7
LSD 5%	220	200	228	0.4	5	0.5

[1]1979-80; 10% moisture basis. [2]1979-80; nonoilseed; held on a 20/64 round-hole sieve. [3]1979-80; 1 = erect, 9 = flat.

below 40 percent oil. On the average, it took 15,000 or more plants per acre to produce seed of over 40 percent oil at a 10 percent moisture level.

Large grade nonoilseed sunflower must contain at least 30 percent large seed, but processor-grower contracts often specify 40 percent. On the average, populations over 15,000 plants per acre did not produce 40 percent large seed. However, percentage of large seed also varied with hybrid and location. A maximum population of 10,000 plants per acre at Becker compares with maximum populations of 15,000 plants per acre at Morris and Lamberton and 20,000 plants per acre at Crookston, Grand Rapids, and Waseca to produce 40 percent large seed. It is often difficult to produce Grade 1 seed of large nonoilseed sunflower because of the opposite responses of test weight and seed size to changes in plant populations. This conflict is particularly difficult to resolve with some hybrids and at some locations.

Sunflower hybrids and varieties tested did not respond differently in yield or other characteristics to changing populations in these trials. Even nonoilseed and oilseed hybrids gave maximum yields at the same populations. Nonetheless, recommended populations for nonoilseed hybrids are less than those for oilseed hybrids because of the market requirements for large seed of nonoilseed sunflower. The state average yields in both Minnesota and North Dakota for 1978 to 1980 averaged about 60 pounds/acre more for oilseed than for nonoilseed sunflower. Yet nonoilseed and oilseed hybrids as groups did not differ in yield when grown in variety trials at the same populations. Perhaps the yield advantage of oilseed hybrids is a result of the common use of lower plant populations for nonoilseed sunflower.

The price paid for large, nonoilseed sunflower often compensates for lower yield and slower drying. Consequently, recommendations of 13,000 to 16,000 plants per acre for nonoilseed and 17,000 to 22,000 plants per acre for oilseed sunflower are common.

The soil, weather, and management at Waseca have resulted in unusually high yields of sunflower. Corn yields at Waseca are also much higher than those at other Minnesota Agricultural Experiment Stations. In this favorable environment, sunflower yields were significantly higher at 35,000 plants per acre than at lower populations (table 5). Sunflower diseases and sunflower moth were usually prevalent in these trials but did not cause major losses except in 1979, when premature ripening caused serious damage. Increasing plant population increased both yield and percentage of oil in the seed but decreased seed size. Even 20,000 plants per acre were too many to produce nonoilseed of satisfactory size for the large seed food market.

Despite the yield advantage of high populations, the risk of increased lodging (table 5) usually makes it inadvisable to exceed 25,000 plants per acre in favorable environments.

Plant population is determined initially by the planting rate, which must be greater than the population desired. Seed weight, germination percentage, and expected survival are used to calculate the planting rate for a desired population:

$$\text{planting rate/acre, lb.} = \frac{\text{plants/acre} \times 10{,}000}{\text{seeds/lb.} \times \text{germination \%} \times \text{survival \%}}.$$

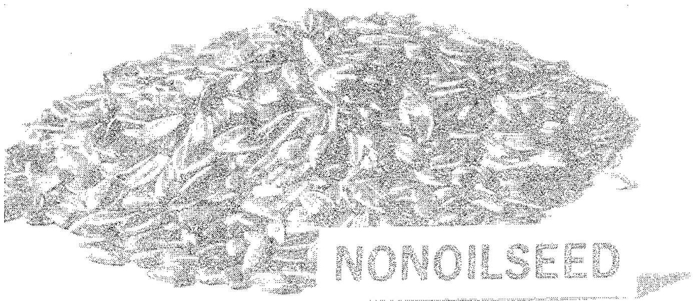
The number of seeds per pound and the germination percentage are usually shown on the bag, but the survival percentage must be predicted for each field. Use of medium size seed, planting depths of 1 to 3 inches, sandy soil, and good seedbeds contribute to high survival. Harrowing at the four- to six-leaf stage for annual weed control can be expected to destroy up to 5 percent of the plants. Post-emergence harrowing at other stages causes greater loss. The seed requirements in table 6 are not adjusted for germination deficiency or plant mortality.

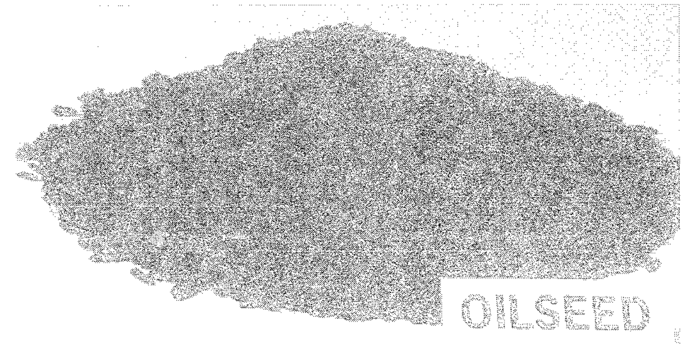
Sunflower seed for planting is usually sold by size grade. The sizes for oilseed commonly range from 2 (largest) to 5 (smallest). Number of seeds per pound is not standardized but can range from 3,000 to over 11,000. Nonoilseed varieties are sometimes available in two or three sizes. One way of reducing seed cost per acre is to use the smallest *good* seed grade. Research with both oilseed and nonoilseed varieties showed that crops produced from large, medium, or small seed did not differ in yield, oil

Table 6. Amount of seed required to plant an acre of sunflower

Weight per 100 seeds (grams)	15.1	11.3	9.1	7.6	6.5	5.7	5.0	4.5	4.1
Number of seeds per pound	3,000	4,000	5,000	6,000	7,000	8,000	9,000	10,000	11,000
Population desired	Seed required per acre (pounds)[1]								
10,000	3.3	2.5	2.0	1.7	1.4	1.3	1.1	1.0	0.9
15,000	5.0	3.8	3.0	2.5	2.1	1.9	1.7	1.5	1.4
20,000	6.7	5.0	4.0	3.3	2.9	2.5	2.2	2.0	1.8
25,000	8.3	6.3	5.0	4.2	3.6	3.1	2.8	2.5	2.3
30,000	10.0	7.5	6.0	5.0	4.3	3.8	3.3	3.0	2.7

[1]Increase for less than 100 percent germination by using this formula: $\frac{\text{pounds/acre} \times 100}{\text{percent germination}}$. Increase by 5 to 20 percent to allow for seed and young plant mortality.





Seed cost per acre is usually more for nonoilseed than for oilseed sunflower. Both piles of seed weigh 1 pound, but there are 3,700 seeds in the nonoilseed pile (left) and 11,000 seeds in the oilseed pile (right).

percentage, or test weight.[1] In this research, seed harvested from seed fields was cleaned and then sieved into size grades. The smallest grade averaged less than 9,000 seeds per pound (similar to some grade 4 seed lots). A "trash" grade of small, lightweight seed comprising 2 percent of the ungraded seed lots produced plants of low seedling vigor and 22 percent lower yield than did plants from the other grades. North Dakota research showed that very small (11,700 seeds per pound; size 5) seed gave 83 percent compared with 89 percent emergence for large (5,700 seeds per pound; size 2) seed, but yields did not differ.[2] In another study, small and large seed emerged equally well when planted up to 2.5 inches deep, but emergence of large seed was greater than that of small at 3 and 4.5 inches.[3]

ARRANGEMENT OF THE POPULATION

Row Direction

Sunflower is phototropic from emergence to flowering. The head and leaves face east in the morning and west in the evening. About a day before the ray flowers open, phototropic movement ceases and most heads face the east. Other common field crops of Minnesota do not have this directionally-oriented morphology of the mature stem, so only shape, slope, and drainage of the field are considered in choosing row direction. However, the phototropic growth of sunflower makes consideration of other factors advisable.

Sunflower grown at Rosemount, Minnesota, in east-west, in north-south, and in 16 other magnetic compass row directions did not differ in yield, oil percentage, large seed percentage, seed weight, or test weight. But lodging was significantly greater in east-west than in north-south rows.

Harvesting losses are sometimes slightly greater when combines approach east-west rows from the west. Some growers with combine pans 9 or 10 inches wide (suitable for all row spacings, in contrast with wider pans for specific row spacings) found that losses were reduced by driving diagonally across the rows. But diagonal travel is usually precluded by the practice of hilling-up (which reduces lodging) at the last cultivation.

North-south rows are slightly preferable to east-west, but this advantage is not an important consideration for commercial production. Seed production fields that require examination of heads to detect pollen production should be planted in north-south rows for efficient roguing. For research or demonstration plots, east-west rows with plot labels on the east end permit easy evaluation because all heads face the viewer.

Rows at the ends of the field are usually planted at right angles to the main rows. The advantage of planting end rows first is that the inner row serves as a mark to raise and lower the planter, which helps prevent gaps or excess population. But if the soil is so loose that machinery tires will move the seed, end rows should be planted last. A greater rate of planting for end rows will offset loss of stand from machinery tires when the main rows are cultivated.

Row Spacing

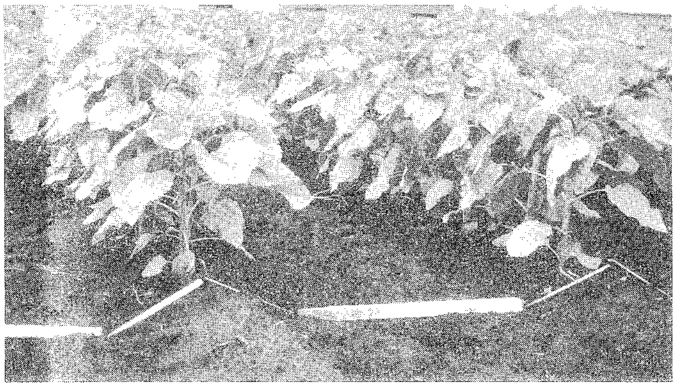
The space between rows is largely determined by the machinery available and by the needs of all crops grown by the individual farmer. Most sunflower is grown in rows 30 inches apart, but sunflower growers who also raise sugarbeet, soybean, or field bean may use 22-inch or other narrow spacings. Some growers who raise corn or potato in wide rows may use 38-inch or other wide spacings. Small

Harvesting north-south rows. The heads are leaning toward the east.

[1] R. G. Robinson, 1974. Sunflower performance relative to size and weight of achenes planted. *Crop Sci.* 14:616-618.

[2] A. A. Schneiter and B. K. Johnson. 1979. Size of sunflower planting seed in relation to stand establishment and yield performance. *Proc. Sunflower Forum* 3:2.

[3] B. J. Radford. 1977. Influence of size of achenes and depth of sowing on growth and yield of dryland oilseed sunflower on the Darling Downs. *Austr. J. Exp. Agric. Anim. Husb.* 17:489-494.




Sunflower at the left was hilled at the last cultivation; that at the right was not.

grain farmers in parts of central North Dakota and Canada who do not have row crop planters sow sunflower in widely spaced rows for intertillage or in noncultivated rows 6 to 18 inches apart.

At optimum populations, sunflower should produce highest yields when row spacing and plant spacing in the row are equal. This equidistant spacing produces an earlier and more complete soil cover than other spacings. As a result, more sunlight is intercepted by the foliage. The greater interception increases photosynthesis per acre and reduces evaporation of water from the soil. The more complete soil cover also intercepts more rainfall and may reduce runoff and soil erosion. Equidistant plant spacing in 30-inch rows results in an inadequate population of 7,000 sunflower plants per acre. The 40-year trend in corn, soybean, and grain sorghum production has been to reduce row spacing in order to gain a greater uniformity of plant distribution.

Sunflower grown in rows 22, 30, or 38 inches apart did not differ in seed yield, oil percentage, large seed percentage, seed weight, seed test weight, height, or flowering date.[4] Results were consistent among five populations and ten trials at Waseca, Lamberton, Morris, and Grand Rapids. The height and phototropic growth habit of sunflower may be responsible for the fact that yield was unaffected by row spacing. However, stalk lodging increased as row spacing increased and plant spacing in the rows decreased. The increased lodging that resulted from close spacing of plants in wide rows is in agreement with the increased lodging from high populations. At equal populations, plants are closer together in wide than in narrow rows down to the 22-inch spacing (table 7). But plants are closer together (less equidistant) in 12-inch than in 22-inch row spacings at populations below 25,000. At populations above 25,000, plants in 12-inch row spacings are farther apart (more equidistant) than are those in 22-inch row spacings.

The basal stem rot disease caused by *Sclerotinia sclerotiorum* (Lib) de Bary spreads by root contact. Wide, equidistant spacings between plants delay this contact. Spacings in excess of 12 inches may reduce losses. However, plant spacing does not control spread of the asco-

Table 7. Plant spacings for five populations in various row spacings

Population/ acre (plants)	Row spacing 12 inches	22 inches	30 inches	38 inches	Other[1] (number)
	plant spacing (inches)				
10,000	52.3	28.5	20.9	16.5	627
15,000	34.8	19.0	13.9	11.0	418
20,000	26.1	14.3	10.5	8.3	314
25,000	20.9	11.4	8.4	6.6	251
30,000	17.4	9.5	7.0	5.5	209

[1]For plant spacing in any row spacing, divide the number given by the row spacing in inches.

spores that cause head rot, nor does spacing help if the soil is uniformly infested with sclerotia.

Wide row spacings are sometimes used in western, dryland farming areas as a substitute for fallow. Sunflower row spacings of 90 and 30 inches at a population of 10,000 plants per acre were compared on dryland sand at Becker.[5] Some moisture in the middle of the 90-inch spaces might be retained till flowering, in contrast to depletion of moisture in the 30-inch spaces by seedling growth. Sunflower plants in the 90-inch row spacing were 9 inches taller and lodged more than those in 30-inch rows. Despite the 60-inch difference in row spacing, yields did not differ significantly; they were about 1,100 pounds per acre.

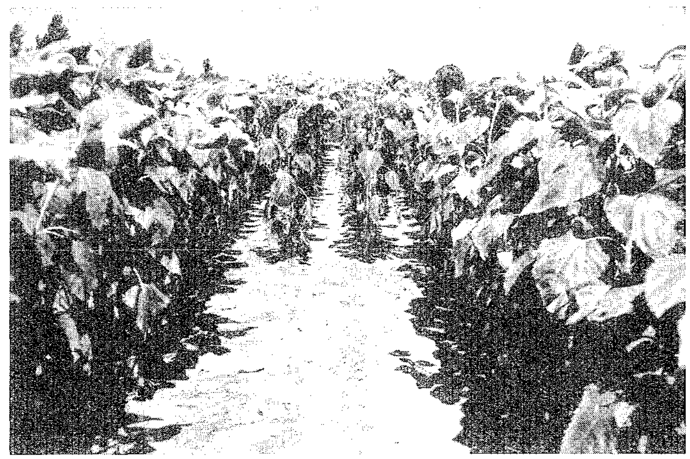
Experimental sowings with a grain drill in noncultivated rows 6 or 12 inches apart during the 1950s at Crookston and Rosemount and in southwestern Minnesota usually resulted in weedy stands and low yields. Plant populations were two to four times those used in cultivated rows. When herbicides were used and gave weed control, sunflower lodged. Even at these high rates of seeding, dilution of the seed with cracked corn was needed for even distribution through the fluted feed mechanism of grain drills. However, better drills for sunflower seed are now available. When sunflower became established as a cultivated crop in Minnesota, research work on solid-seeding was terminated.

The potential gain from noncultivated, narrow-row sunflower does not warrant the risk of poor weed control

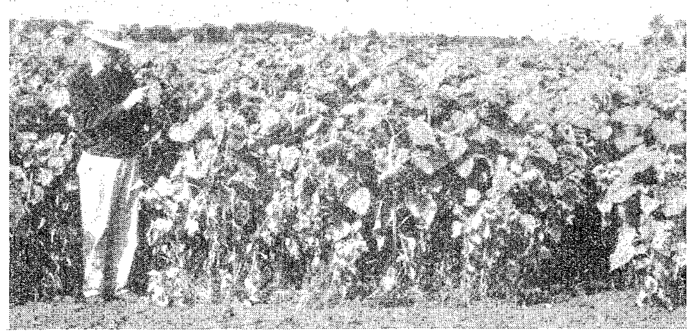
[4]R. G. Robinson, D. L. Rabas, L. H. Smith, D. D. Warnes, J. H. Ford, and W. E. Lueschen. 1976. Sunflower population, row width, and row direction. *Minn. Agric. Exp. Stn. Misc. Rep.* 141:1-24.

[5]R. G. Robinson, J. H. Ford, W. E. Lueschen, D. L. Rabas, L. J. Smith, D. D. Warnes, and J. V. Wiersma. 1980. Response of sunflower to plant population. *Agron. J.* 72:869-871.

and harvesting problems if the crop lodges. A corn or soybean header may do a fair job of salvaging lodged plants in 30-inch rows but not in a solid-seeded field. Noncultivated, narrow-row sunflower usually fails to produce a crop on dryland, sandy soil. On silt loam or clay soils, where a plant population of 20,000 is suggested for cultivated rows, a final plant population of 23,000 to 25,000 is suggested for noncultivated rows 12 inches apart. A planting rate of at least 30,000 seeds per acre may be expected to produce an initial stand of 27,000 plants per acre. In addition to a preplant incorporated application of herbicide, postemergence use of a coil spring harrow, rotary hoe, or weeder is usually necessary and will reduce the stand to 25,000 plants or less. The final population should be slightly higher than that suggested for cultivated rows; the higher population should result in a faster dry-down. A more even distribution of plants is possible in 12-inch than in 30-inch rows and may be expected to reduce lodging. But this advantage is counterbalanced by preventing hilling-up to reduce lodging.



Sunflower in the foreground is in 90-inch and that in the rear is in 30-inch row spacing. The mesh bags over the heads prevent birdfeeding.



Sunflower planted with a grain drill in rows 6 inches apart. Row spacings of 12 or 14 inches obtained by using alternate furrow openers on the drill are preferred over 6- or 7-inch spacings.

Plant Spacing in the Row

Plants too far apart and too close together are common in fields of adequate average population. Unevenness is assumed to be undesirable, but the lack of response to increased uniformity from close row spacing suggests that moderately uneven stands of sunflower may not affect yield. The effects of uniform and nonuniform plant spacings within an overall population of 20,000 plants per acre in rows 30 inches apart were measured at Waseca, Lamberton, Morris, Crookston, and Grand Rapids in 1979 and 1980.[6]

The distributions tested included uniformly spaced, clumped, and widely spaced plants: a) uniform single—plants 10.5 inches apart, b) uniform double—two-plant groups 21 inches apart, c) 5-5-5—five plants 5.25 inches apart, 31.5-inch space, five plants 5.25 inches apart, 31.5-inch space, etc., d) 7-1-7—seven plants 3.5 inches apart, 31.5-inch space, one plant, 31.5-inch space, seven plants 3.5 inches apart, 31.5-inch space, one plant, etc.

Plant distribution significantly affected sunflower yield in four of the nine trials and at three of the five locations (table 8). Yields were greater from uniform than from uneven plant spacings, and the uniform, single-plant spacing gave the highest average yield. Both oilseed and nonoilseed hybrids responded the same to the plant distributions except at Waseca in 1979. In that trial, uniform spacing of single plants resulted in the highest yields of USDA 924 but not of USDA 894. The latter hybrid was injured severely by premature ripening, which may have overshadowed the effect of plant distribution.

The central plants in the five- and seven-plant groups were in populations of 40,000 and 60,000 plants per acre, respectively, and the single plants alternated with the seven-plant groups were at a population of less than 7,000 plants per acre. Despite this wide range in plant population within the overall population of 20,000 plants per acre, yield was decreased by an average of only 10 percent by uneven plant distributions. The greatest yield reduction from nonuniform spacing within a single trial amounted to 31 percent. The nonuniform spacings in these trials are not extreme and are similar to those found intermittently and randomly in most sunflower fields. Consequently, these

[6]R. G. Robinson, J. H. Ford, W. E. Lueschen, D. L. Rabas, D. D. Warnes, and J. V. Wiersma. 1982. Response of sunflower to uniformity of plant spacing. *Agron. J.* 74:363-365.

Table 8. Sunflower yields from four distributions of 20,000 plants per acre at five locations in Minnesota

Distribution (plants)	Crookston 1979-80	Morris 1979-80	Lamberton 1980	Waseca 1979-80	Grand Rapids 1979-80	Average 9 trials
	(pounds/acre)					
Uniform single	2,046	2,650	2,982	2,394	2,468	2,455
Uniform double	2,067	2,322	2,466	2,334	2,488	2,321
5-5-5	2,065	2,101	2,377	2,306	2.377	2,231
7-1-7	2,004	2,045	2,466	2,292	2,279	2,190
LSD 5%	169	201	385	205	139	71

Table 9. Average lodging, head moisture percentage at harvest, test weight per bushel, oil percentage, and large seed percentage of sunflower grown in four distributions of 20,000 plants per acre at five locations in Minnesota, 1979-80

Distribution (plants)	Lodging (score)[1]	Head moisture (percent)	Test weight/bushel Oilseed (pounds)	Test weight/bushel Nonoilseed (pounds)	Oil (percent)	Large seed (percent)[2]
Uniform single	1.9	43.3	33.0	27.0	46.6	40
Uniform double	2.3	46.6	33.0	26.8	46.3	43
5-5-5................	2.7	44.4	32.8	26.9	46.1	41
7-1-7................	3.1	46.2	32.9	26.7	45.8	44
LSD 5%	0.4	1.7	0.3	0.3	0.5	4

[1] 1 = erect, 9 = flat. [2] Held on a 20/64 round-hole sieve.

data support continued efforts to improve germination retention and grading of sunflower seed and continued improvement of planting techniques and equipment.

The major effect of plant distribution was on lodging except at Crookston, where no lodging occurred. Lodging differences among distributions were highly significant in five of the nine trials. Plants spaced singly and uniformly lodged least, and plants in the 7-1-7 arrangement lodged most (table 9). The clumps of high plant population in the uneven spacings probably accounted for the increased lodging in nonuniform plant distributions. The yield advantage from uniform spacing (table 8) might have been greater with combine harvest because of relatively higher harvesting losses from lodged plants.

Plants uniformly spaced in pairs did not support each other; they lodged more and yielded less than uniformly spaced, single plants (tables 8 and 9). Paired plants may give more emergence through crusted soil than single plants, but this possibility was not evaluated.

Head moisture differences among plant distributions were highly significant on the average and in three of eight trials. Plants spaced singly and uniformly had lower head moisture percentages than did the 7-1-7 arrangement in all trials. The single plant (7,000 plants per acre) in the 7-1-7 distribution and the central plants (40,000 plants per acre) in the 5-5-5 distribution may account for the relatively high and low moisture percentages of heads from their respective plant distributions.

The nonuniform plant distributions were uneven in height from preheading to maturity. The center plants of the groups of five and seven plants were 4 to 7 inches taller than the single plants. Average plant heights among the distributions did not differ noticeably.

Plant distribution did not, on the average, significantly affect test weight per bushel of seed, but it did affect large seed percentage in three trials. The 7-1-7 distribution had the largest seed on the average and the single plant in that distribution probably contributed many of the large seeds because of its distance from the other plants. Although differences were not large, seed from uniformly spaced, single plants had the highest oil percentage. Differences were significant in two trials and on the average.

SUMMARY

Plant population has a major influence on sunflower performance. Optimum sunflower population varies considerably among fields; grower experience and objectives are major considerations. Excess population hastens drying of heads and increases oil percentage and lodging, but it may not affect yield. Lodging is a major deterrent to the use of high populations for maximum yield. The risk of lodging is lessened by reducing row spacing to about 22 inches, by orienting rows in a north-south direction, by distributing seed evenly when planting, and by hilling-up the rows at the last cultivation. Row spacing per se had no effect on sunflower yield.

A general recommendation for oilseed production on silt loam and clay soils in central and northern Minnesota is 20,000 plants per acre. Populations of 15,000 plants per acre are adequate for southwestern Minnesota and for sandy soils. Populations of 20,000 to 25,000 plants per acre are suggested for southeastern Minnesota and for irrigated soils. For nonoilseed markets that require large seed, populations of 15,000 plants per acre are adequate for most hybrids. For especially large-seeded hybrids, populations of 20,000 plants per acre on some fields will produce the desired amount of large seed. Populations as low as 10,000 plants per acre are necessary to meet market requirements for large, nonoilseed sunflower on droughty, sandy soils in southern and central Minnesota.

High winds caused severe root lodging in the high population plot (left), whereas the medium population (right) is erect except for a few plants along the road.

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