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Crop Yields as Related to Depth of Plowing

By A. N. Hume, Station Agronomist[1]

Both farmers and research workers have in comparatively recent times showed increasing interest in the effect on crop yields of plowing land. This added interest has been due partly to the introduction of more efficient machinery for seedbed preparation. In order to obtain information on this problem, the experiment reported in this bulletin was carried out over a total period of 20 years at the Central Substation, Highmore, South Dakota. Data and discussion are presented on yields of crops at this Station as related to different depths of plowing and as related to subsoiling only.

The principal contribution of these data is to show that where plowing was used as a means of seedbed preparation, the total yield of rotated crops—corn, spring wheat, and legume—increased consistently with increase in plowing depth for corn up to 8 inches under conditions typical of a considerable area in the northern Great Plains. Much additional investigation is necessary before the fundamental effects upon soil of plowing or not plowing are fully understood. However, the information presented here is of interest to the farmer who wants to increase his crop yields as well as to the research worker.

Other Experiments

Previous experiments at the South Dakota Station on the effect of different depths of plowing on crop yields in a rotation are reported in Bulletin 344 of this Station, issued in June, 1940, and also by A. N. Hume. These experiments were conducted at Brookings over a 25-year period, 1913-37, to determine the result of differential plowing depths on seed and total-plant yields of corn and of three succeeding crops in a 4-year rotation—winter wheat, oats, and a legume (red clover, white sweet clover, or soybeans).

The total-plant yield of corn was found to be the only yield which varied significantly with different depths of plowing in preparation for corn. The largest yields were obtained where the plowing was deepest (12 inches). Seed yields of corn, winter wheat, and oats, however, also increased in general with increased depth of plowing for corn. No significant relationship between yield of legume seed or total plants and differential plowing depths was determined because of other influences due to the location of the plots and indicated by the yields of check plots. Subsoiling with plowing did not seriously affect crop yields.

[1] The experiment with plowing at several depths was inaugurated by the author and J. G. Hutton, Associate Agronomist, who was responsible for the details of the experiment, including the tables of yields which constitute the Appendix of this bulletin. Interpretations are by the author; analyses of variance by Dr. J. E. Grafius, Associate Agronomist; all field work was done by S. W. Sussex, Farm foreman.

In Bulletin 344 nine references were given to studies in the Great Plains bearing directly on the relation of plowing depth to crop yields and quotations from these references were presented. A similar list of those references may be found on page 12 of this publication. These studies were made to determine the effect of differential depths of plowing on only one succeeding crop. They revealed that even for preparation of fallow, plowing deeper than 3 or 4 inches produced some increases in crop yield under Great Plains conditions. Apparently no mechanical differences in machines used for turning soil had any decisive effect on yields of crops.

Plan of Investigation

The purpose of the experiment discussed in this publication was to determine yields of three crops in a rotation—corn (a cultivated or row crop), spring wheat (a small-grain crop), and biennial white sweet clover or soybean substitute (legume crops) on soil plowed for corn only at different depths. It was conducted at the Central Substation at Highmore, Hyde county, during a 20-year period (1913-32) on Williams silt loam, which is one of the extensive soil types in central South Dakota. No additional plowing was used for spring wheat or the legumes but the different depths of plowing for corn affected these two crops also.

Sweet clover was seeded annually when wheat was put in directly with double-disking, harrowing, and drilling on the ground previously in corn. Legume crops in the 3-year rotation of this experiment were harvested first for hay, and later when seed crops were obtainable, a second cutting was taken, this latter cutting being threshed to separate the seed.

In the 18 years 1915-32 sweet clover failed in four seasons to produce any crop whatever. The fact that there was no sweet-clover crop in these years was in no wise due to omission of attempt to seed the crop and make it grow but rather to crop failure. Total yield of sweet clover in the four years indicated was exactly zero from all plots differentially plowed.

In one of the years when sweet clover failed (1926) soybeans were planted for a substitute legume crop. The soybeans in that year produced a weight of seed and a weight of threshed straw, which weights were included in computations of this bulletin as being equivalent to the same weights of sweet clover.

Seed yields of sweet clover failed not only in these four years but also in five other years when sweet clover yielded a hay crop only.

The ground was plowed for corn or otherwise stirred to different depths by three different machines—the moldboard plow, the disk-deep tiller, and the subsoiling machine. The moldboard plow is a type of plow familiar to most farmers and used on many farms throughout the Great Plains. The disk-deep tiller is a machine capable of plowing at greater depths than can the moldboard plow and so it was used to turn the soil at depths of 8 inches and greater. Deep tilling may be considered as plowing. The subsoiling machine consists essentially of a blade with a narrow shoe on the bottom. It was used in this experiment to cut the soil to depths of 6 and 10 inches below plowing and to a depth of 8 inches

alone without turning over the soil. Where subsoiling was done with plowing, the subsoiler blade cut under the bottom of the plowed furrow.

The following procedures were used:

1. Moldboard plowing at 7 inches (check plots).
2. Subsoiling to a depth of 8 inches without plowing.
3. Moldboard plowing at 4 inches.
4. Moldboard plowing at 6 inches, subsoiling 6 inches below furrow.
5. Moldboard plowing at 6 inches, subsoiling 10 inches below furrow.
6. Turning the soil with a disk-deep tiller at 8, 10, and 12 inches.

The land utilized for this experiment was divided into three series of plots, and two of these series were then divided into 10 plots each. The third series contained 11 plots.[2] The plots in each series were plowed at different depths. These three series were numbered 1201-1210, 1211-1220, and 1221-31. These numbers are used in the tables of the Appendix.

Three check plots in each acre were plowed to a depth of 7 inches (the depth of the surface soil). Six plots were plowed to depths of 4, 6, 8, 10, and 12 inches (two plots were plowed 6 inches and subsoiled). The remaining plot was subsoiled without plowing.

Yields of corn, spring wheat, and legumes are recorded for the different plots in the tables of the Appendix. They are the basis for computations and conclusions presented in this bulletin.

The yield data secured from the field plots in this experiment were analyzed statistically. This analysis makes it possible to observe whether yields from certain plots were significantly higher or lower than other yields. Such information substantiates some conclusions and renders some additional hypotheses tenable.

It is the hypothesis of the writer that differences in yields between field plots in this experiment are directly attributable to differences in depth of plowing based on the statistical analysis, long-time observations of the growing crops in the field, and on the similarity of outcome of this experiment with the one at Brookings reported in Bulletin 344.

Best Seed Yields Followed Deep Plowing For Corn

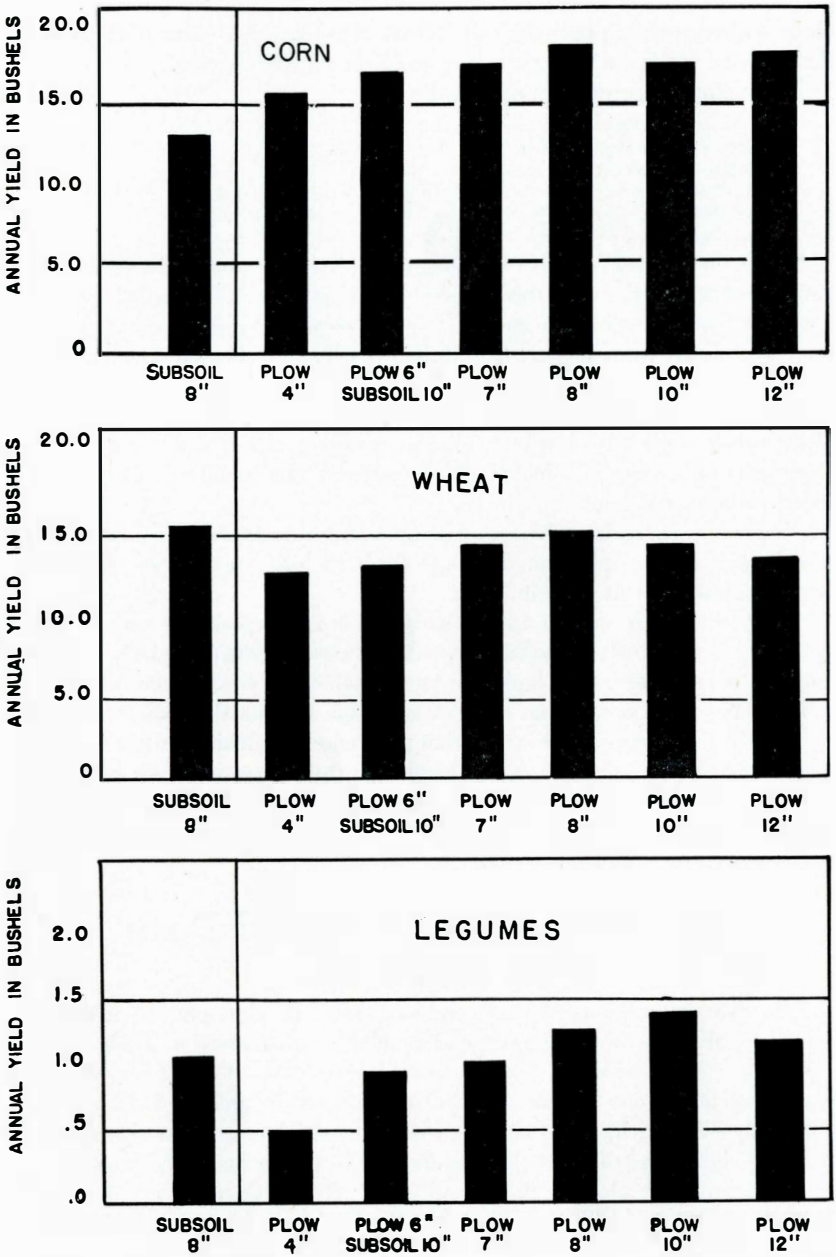
The average amounts of seed produced from the plots plowed at different depths are abstracted from the Appendix tables and assembled in Table 1.

The average seed yields for corn cover a period of 20 years; for wheat, 19 years (except for one plot used 18 years); and for legume seed, 18 years. As previously stated yields of legume seed were actually harvested in nine of the 18 seasons—eight crops of sweet clover and one substitute crop of soybeans.

Subsoiling with plowing did not affect the seed yields enough to disturb the general trend of yields at varying depths. It should not be overlooked that two plots each plowed 6 inches were subsoiled below such plowing.

Corn yields. Maximum seed yields of ear corn, 17.72 bushels an acre, were obtained when land was plowed to a depth of 8 inches (Table 1). Yields in-

[2] Plots 1229 and 1231 were plowed 12 inches and their average yield is given in the Appendix as the yield from 12-inch plowing.



Seed yields of ear corn, spring wheat, and a legume (sweet clover or soybean substitute) in rotation at the Central Substation, Highmore, Hyde county, over a 20-year period (1913-32) as related to depth of plowing for corn. (The bar for 7-inch plowing is based on the average yields of three check plots. Only one of the two plots subsoiled under plowing is presented because subsoiling showed no effect great enough to disturb the general trend of variations in yields with variations in plowing depths.) The low average yields of legume seed are due partly to the failure of sweet clover to produce a seed crop in nine seasons.

TABLE 1. SEED YIELDS PER ACRE OF EAR CORN, SPRING WHEAT, AND LEGUMES (SWEET CLOVER OR SOYBEAN SUBSTITUTE) FROM PLOTS PLOWED TO DIFFERENT DEPTHS AT THE CENTRAL SUBSTATION, HIGHMORE, DURING A 20-YEAR PERIOD (1913-32)

Depths	Corn	Wheat	Legume†
	bu.	*bu.*	*bu.*
7-inch plowing (check plot)	15.25	14.40	0.82
4-inch plowing	14.82	13.19	0.58
6-inch plowing with 6-inch subsoiling	16.05	13.64	0.75
6-inch plowing with 10-inch subsoiling	16.98	14.12	0.94
7-inch plowing (check plot)	17.19	14.74	1.01
8-inch subsoiling alone	15.18	15.21	1.01
7-inch plowing (check plot)	15.80	13.47	0.89
8-inch plowing	17.72	15.14	1.20
10-inch plowing	17.31	14.35	1.26
12-inch plowing	17.50	13.97	1.12
Average of check plots	16.08	14.20	0.91
Least significant difference	2.11	0.78	0.42

ANALYSIS OF VARIANCE OF SEED YIELDS‡

Crop	Source of variation	Degrees of freedom	Mean square
Corn	Total	158	
	Depths	7	25.8*
	Years	19	1,643.2**
	Error	132	11.0
Wheat	Total	150	
	Depths	7	76.2**
	Years	18	431.8**
	Error	125	1.4
Sweet Clover	Total	143	
	Depths	7	.9*
	Years	17	13.6**
	Error	119	.4

* Significant difference

** Highly significant difference.

† The average yields of legume seed were arrived at by dividing the total production of the years when seed was produced (8 of sweet-clover seed and 1 of soybean seed) by 18, the number of years a legume was planted. Sweet clover failed to produce seed in 9 years and in 1 year soybeans were substituted.

‡ There was one missing plot in the wheat yields and one missing plot in the corn yields and degrees of freedom were subtracted accordingly.

creased steadily with deeper plowing from a minimum of 14.82 bushels an acre with the shallowest plowing, 4 inches, but plowing deeper than 8 inches did not increase yields further. Plowing 4 inches deeper than the shallowest plowing gave an increase of 2.9 bushels per acre in seed yield.

As shown on page 6 the second highest yield was obtained with deep tilling 12 inches. Subsoiling without plowing gave about the same yield as did 4-inch plowing.

Spring-wheat yields. Plowing 8 inches for corn was also found to be the best plowing depth for production of spring-wheat seed in a 3-year rotation (Table 1). At a depth of 8 inches, seed yields were 15.14 bushels an acre, about 2 bushels an acre higher than the minimum yield, which was obtained with shallowest

plowing. Average yields of wheat seed increased regularly with depth of plowing to 8 inches and then decreased.

When land for corn was subsoiled to an 8-inch depth without plowing, seed yields of spring wheat were slightly higher than the maximum with plowing. However, this advantage was more than offset by the lower yields of corn and legumes when land for corn was subsoiled but not plowed.

Legume-seed yields (sweet clover or soybean substitute). Sweet clover produced seed crops in 8 of 18 seasons, and soybeans, seeded in 1926 as a legume substitute, produced seed in this year.

Highest yields of legume seed (1.26 bushels per acre) were produced following 10-inch plowing for corn, and lowest yields, slightly more than a half-bushel, with shallowest plowing (Table 1). Yields from plots which were plowed at 10 inches were .68 bushel per acre higher than yields from plots with the shallowest plowing.

Subsoiling land for corn without plowing resulted in a yield of legume seed in the rotation equal to that obtained with 7-inch plowing for corn, about 1 bushel per acre.

Highest Total-Plant Weights Followed Deep Plowing For Corn

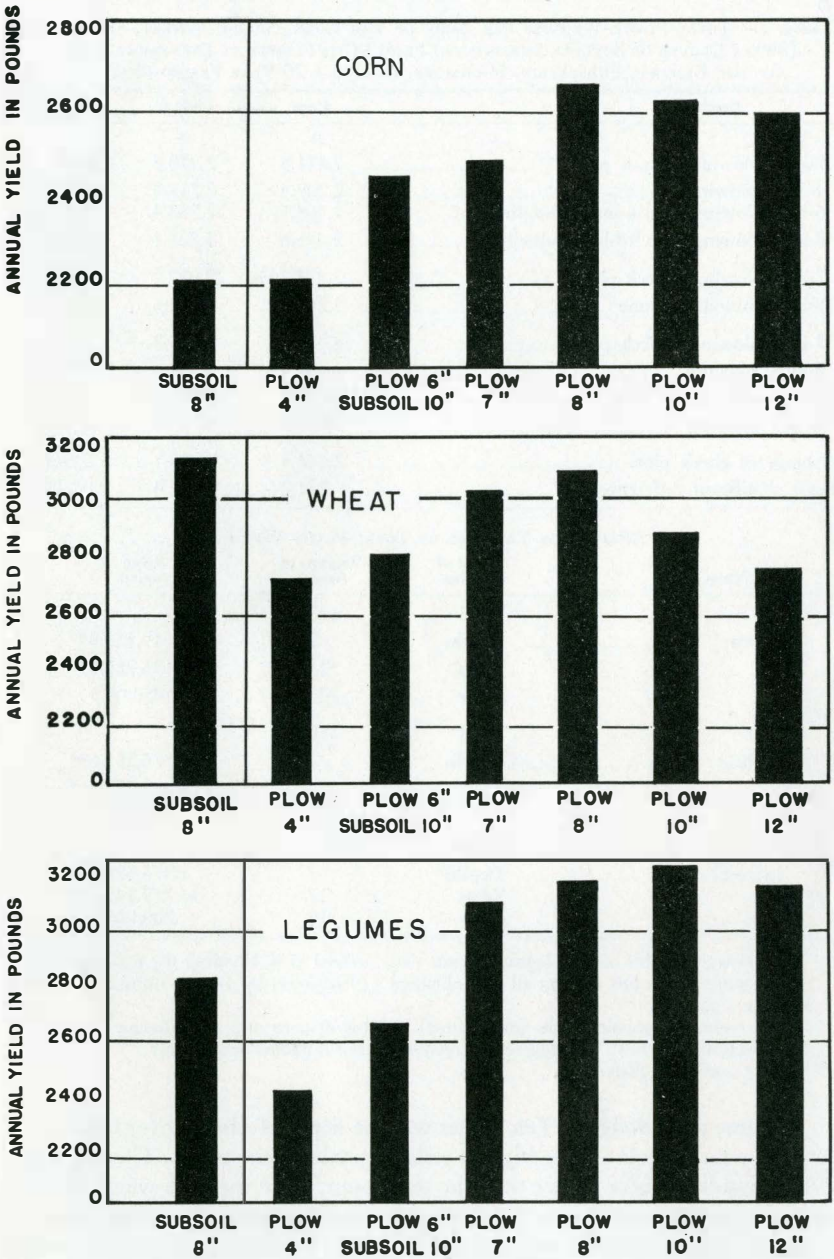
Weights of total plants of corn, wheat, and a legume were higher with deep plowing for corn than with shallow plowing (Table 2 and graphs on page 9). In general, trends of total-plant weights as related to depth of plowing were similar to trends of seed yields, which have been discussed.

Corn-plant weights. Total-plant yield of corn (grain plus stover) reached the maximum, 2,639.4 pounds per acre, after plowing to 8 inches. This is an increase of 432 pounds per acre over the yield with the shallowest plowing .

With subsoiling only, the weight of total plants was only 2,207.6 pounds per acre, a yield equal to the minimum yields obtained with plowing, which followed shallowest plowing.

Wheat-plant weights. As with corn yields and with seed yields for spring wheat, total-plant yields of spring wheat were highest (plowing depths only considered) when ground had been prepared for corn in the rotation with 8-inch plowing. At this depth the yield was 3,108.4 pounds per acre. This is an increase of 389 pounds per acre over the yield with shallowest plowing. Yields increased steadily from 4 to 8 inches but dropped with 10- and 12-inch plowing.

The highest yield of total wheat plants (all methods used to cut the soil considered) was obtained with subsoiling only. This was true also of the wheat-seed yield, but, as mentioned earlier, the advantage of increased wheat yield with subsoiling only for corn in the rotation was more than lost in the poorer yields of corn and legume with subsoiling only. For example, if ground for corn was subsoiled only in preference to plowing to 8 inches, the amount of wheat gained would be 54.2 pounds per acre, but the amount of corn lost would be 431.8 pounds per acre and of legume lost 373.4 pounds per acre, according to the results of this 20-year experiment (Table 2).



Total-plant weights of ear corn, spring wheat, and a legume (sweet clover or soybean substitute) in rotation at the Central Substation, Highmore, Hyde county, over a 20-year period (1913-32) as related to depth of plowing for corn. (The bar for 7-inch plowing is based on the average yields of three check plots. Because subsoiling did not change the trend of yield variations with variations in plowing depths, only one of the two plots subsoiled under plowing is presented here.)

TABLE 2. TOTAL-PLANT WEIGHTS PER ACRE OF EAR CORN, SPRING WHEAT, AND LEGUMES (SWEET CLOVER OR SOYBEAN SUBSTITUTE) FROM PLOTS PLOWED TO DIFFERENT DEPTHS AT THE CENTRAL SUBSTATION, HIGHMORE, DURING A 20-YEAR PERIOD (1913-32)

Depths	Corn	Wheat	Legume†
	lb.	*lb.*	*lb.*
7-inch plowing (check plot)	2,411.5	2,978.0	2,942.2
4-inch plowing	2,207.4	2,719.4	2,429.8
6-inch plowing with 6-inch subsoiling	2,406.5	2,783.4	2,652.0
6-inch plowing with 10-inch subsoiling	2,495.6	2,821.2	2,726.4
7-inch plowing (check plot)	2,477.3	3,027.4	3,126.6
8-inch subsoiling alone	2,207.6	3,162.6	2,825.6
7-inch plowing (check plot)	2,444.0	2,675.2	2,835.4
8-inch plowing	2,639.4	3,108.4	3,199.0
10-inch plowing	2,638.7	2,887.0	3,221.6
12-inch plowing	2,610.2	2,745.9	3,165.8
Average of check plots	2,444.3	2,893.5	2,968.1
Least significant difference	211.2	207.0	304.8

ANALYSIS OF VARIANCE OF TOTAL-PLANT WEIGHTS‡

Crop	Source of variation	Degrees of freedom	Mean square
Corn	Total	147	
	Depths	7	619,154.0**
	Years	18	1,136,780.6**
	Error	122	105,904.5
Wheat	Total	150	
	Depths	7	576,261.6**
	Years	18	9,594,392.6**
	Error	125	102,581.1
Sweet clover	Total	143	
	Depths	7	1,478,528.6**
	Years	17	38,787,143.1**
	Error	119	209,088.3

† The average weights of total legume plants were arrived at by dividing the total production of the years when any crop at all was obtained (14 seasons) by 18, the number of years a crop was planted.

‡ There were four missing plots for the total weights of corn and one missing plot for the total weights of wheat, and degrees of freedom were subtracted accordingly.

** Highly significant difference.

Legume-plant weights. Ten inches was the depth of plowing for corn in the rotation which produced the highest yield of total legume plants. This yield was 791.8 pounds per acre higher than the minimum, more than the weight of one-third ton of field-cured hay. Gradual increases in yields followed increases in depth of plowing to 10 inches. Trends in yields of legume plants are similar to trends in yields of legume seed previously discussed.

Subsoiling land for corn in the rotation without plowing resulted in a yield of total legume plants lower than did plowing 7 inches or more. However, this yield was higher than yields that followed 4- or 6-inch plowing .

Summary and Conclusions

This bulletin is a report in terms of crop yields from plots of land at Central Substation, Highmore, South Dakota, otherwise similar but plowed at different depths. The seasons covered by this experiment extended from 1913 to 1932 inclusive.

The implements used for cutting the soil were a subsoiler, a moldboard plow, and a disk-deep tiller. As is generally known the subsoiler cuts through soil without turning it over. The moldboard plow and the disk-deep tiller turn the furrow-slice and so mix the surface soil. Depths of plowing were 4, 6, 7, 8, 10, and 12 inches.

Crops employed in the experiment were corn, spring wheat, and a legume (sweet clover or soybean substitute). They were produced in the order named in a systematic crop rotation over a period of 20 years. The land was plowed or subsoiled only in preparation for corn. The spring wheat was seeded directly on the corn ground and sweet-clover seed was put on with the wheat.

The average yield of crops taken separately either in terms of grain produced or in total weight of plants was lowest where plowing was shallowest, 4 inches.

In the series where the soil was turned to increasing depths below 4 inches, corn and wheat yields increased regularly with depth of plowing to a maximum yield for 8 inches, and legumes increased in yield with increase in depth of plowing to 10 inches.

One plot in the rotation was prepared for corn with no turning of the soil but with the use of the subsoiler which ran to a depth of 8 inches. The crop yields secured thus with no turning of the soil whatever were lower as a whole than from land prepared with plowing. With subsoiling only the one crop which produced a yield substantially equal to that of the maximum from the plowed land was wheat. This maximum yield of wheat produced without plowing was accompanied by a yield equivalent to the lowest yield of corn in the entire experiment and by a yield of sweet clover lower than those from plots plowed 7 inches or more.

Thus judging on the basis of comparative yields of crops in this experiment where land was prepared either without turning the soil or with plowing at different depths, it may be concluded that:

1. Under conditions in central South Dakota and similar Great Plains areas, greater total weights of corn plus wheat plus legumes in a rotation are produced after plowing 7 or 8 inches deep in preparation for corn than after merely subsoiling. Greater total yields of seeds from these crops are also obtained with 7- or 8-inch plowing than with subsoiling only.

2. In central South Dakota maximum weights of corn plus wheat plus legume in a rotation are obtained after plowing 8 inches deep in preparation for corn. Plowing shallower or deeper results in consistently lower yields. Largest total yields of seed are also obtained with 8-inch plowing.

3. Subsoiling only gives greater total weights of corn plus wheat plus legume than 4- or 6-inch plowing. Total yield of seed is about the same after subsoiling as after plowing 6 inches but is higher than after plowing 4 inches.

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(These references are reprinted from South Dakota Bulletin 344, *Depth of Plowing and Crop Yields*, by A. N. Hume, published in June, 1940.)

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APPENDIX

TABLE 1. YIELDS OF CORN AND STALKS FROM PLOTS PLOWED TO DIFFERENT DEPTHS IN PREPARATION FOR CORN IN A 3-YEAR ROTATION WITH WHEAT AND LEGUMES AT THE CENTRAL SUBSTATION, HIGHMORE, DURING A 20-YEAR PERIOD (1913-32)

(One bushel=70 pounds)

Year	Series number	7″ plowing (Plot 1)		4″ plowing (Plot 2)		6″ plowing 6″ subsoil (Plot 3)		6″ plowing 10″ subsoil (Plot 4)		7″ plowing (Plot 5)		8″ subsoil (Plot 6)		8″ plowing (Plot 7)		10″ plowing (Plot 8)		12″ plowing (Plot 9)		7″ plowing (Plot 10)		Average of 7″ plowing (Check plots)	
		Grain	Stalks	Grain	Stalks	Grain	Stalks	Grain	Stalks	Grain	Stalks	Grain	Stalks	Grain	Stalks	Grain	Stalks	Grain	Stalks	Grain	Stalks	Grain	Stalks
		bu.	*lb.*	*bu.*	*lb.*	*bu.*	*lb.*	*bu.*	*lb.*	*bu.*	*lb.*	*bu.*	*lb.*	*bu*	*lb.*	*bu.*	*lb.*	*bu.*	*lb.*	*bu.*	*lb.*	*bu.*	*lb.*
1913	1201-10	4.00	360	3.66	350	5.60	330	4.54	340	4.40	330	7.31	220	4.11	470	3.49	420	3.89	510	4.11	410	4.17	367
1914	1221-31	13.07	1,180	14.60	1,290	21.60	1,210	18.64	1,200	15.14	1,260	13.14	1,290	15.78	1,300	19.57	1,320	19.31	1,200	19.00	1,380	15.74	1,273
1915	1211-20	29.07	1,970	29.28	1,600	27.21	1,770	25.93	1,720	19.86	1,540	18.43	1,260	27.21	2,040	34.93	1,970	31.57	1,940	30.14	2,020	26.36	1,843
1916	1201-10	27.14	1,270	27.28	1,250	28.00	1,200	29.43	1,300	29.00	1,400	23.00	1,130	28.71	1,300	29.28	1,380	30.00	1,320	25.86	1,270	27.33	1,313
1917	1221-31	6.36	1,290	8.64	1,320	10.64	1,480	12.86	1,470	9.86	1,280	9.50	870	8.86	1,280	8.71	1,240	8.18	1,320	6.14	1,450	7.45	1,340
1918	1211-20	29.21	1,580	27.71	1,630	28.21	1,730	28.14	1,830	31.86	1,860	29.86	1,660	33.00	2,160	33.28	1,970	35.28	1,900	30.36	1,680	30.48	1,707
1919	1201-10	25.43	1,130	25.40	1,120	26.78	1,300	28.36	1,310	25.71	1,280	16.26	830	29.07	1,350	28.07	1,380	27.71	1,430	26.57	1,500	25.90	1,303
1920	1221-31	26.64	990	36.64	1,260	36.64	1,220	40.14	1,390	32.57	1,210	26.71	1,040	31.57	1,280	33.00	1,190	36.00	1,220	34.00	1,240	31.07	1,147
1921	1211-20	5.00	1,220	3.57	1,180	4.43	1,370	14.00	1,600	27.14	1,700	26.71	2,010	25.28	1,820	16.00	1,740	19.14	1,730	11.71	1,340	14.62	1,420
1922	1201-10	35.28	1,200	22.86	650	29.14	650	29.14	800	25.14	600	28.57	600	28.43	750	25.28	850	27.57	900	25.28	950	28.57	917
1923	1221-31	47.14	2,100	47.43	1,790	48.85	1,650	48.14	1,750	50.00	1,850	35.71	1,500	47.14	1,800	44.28	1,700	43.00	1,665	41.86	1,520	46.33	1,823
1924	1211-20	6.86	1,450	5.00	1,350	8.86	1,300	14.57	1,200	23.86	1,350	22.14	1,150	22.28	1,400	12.00	1,450	11.14	1,300	8.57	1,400	13.10	1,400
1925	1201-10	0.00	1,900	0.00	1,450	0.00	1,900	0.00	1,770	0.00	1,530	0.00	1,870	0.00	1,750	0.00	1,750	0.00	1,950	0.00	1,730	0.00	1,720
1926	1221-31	0.00	1,570	0.00	1,200	0.00	1,250	0.00	1,300	0.00	1,400	0.00	1,450	0.00	1,300	0.00	1,600	0.00	1,300	0.00	1,600	0.00	1,523
1927	1211-20	34.00	1,700	31.86	1,580	33.00	1,600	35.00	1,600	38.57	1,780	30.00	1,240	37.00	1,780	39.00	1,750	37.00	1,750	35.00	1,600	35.86	1,693
1928	1201-10	2.29	1,880	2.00	1,680	2.71	1,730	1.71	1,680	1.14	1,630	0.50	1,130	3.14	1,680	3.71	1,910	2,86	1,880	3.00	1,880	2.14	1,797
1929	1221-31	0.00	1,150	0.00		0.00		0.00	1,280	0.00	1,150	0.00		0.00	1,700	0.00	1,850	0.00	1,660	0.00	1,220	0.00	1,173
1930	1211-20	13.57	1,100	10.43	1,050	7.79	900	8.57	800	9.00	700	0.00		12.86	880	15.07	950	16.00	850	14.29	880	12.29	893
1931	1201-10	0.00	490	0.00	480	0.00	500	0.00	500	0.00	360	0.00	220	0.00	550	0.00	700	0.00	550	0.00	360	0.00	403
1932	1221-31	0.00		0.00		1.50		0.50		0.64		0.64		0.00		0.50		0.54		0.14		0.26	
Totals		305.06	25,530	296.36	22,230	320.96	23,090	339.67	24,840	343.89	24,210	288.48	19,470	354.44	26,590	346.17	27,120	349.19	26,375	316.03	25,430	321.67	25,055
Averages		**15.25**	**1,344**	**14.82**	**1,235**	**16.05**	**1,283**	**16.98**	**1,307**	**17.19**	**1,274**	**15.18**	**1,145**	**17.72**	**1,399**	**17.31**	**1,427**	**17.50**	**1,388**	**15.80**	**1,338**	**16.08**	**1,319**
Sums of the averages (pounds)		2,411.5		2,207.4		2,406.5		2,495.6		2,477.3		2,207.6		2,639.4		2,638.7		2,610.2		2,444.0		2,444.3	

NOTE: The averages for grain are for 20 years. The averages for stalks are for 19 years except on plots 2, 3, and 6, which are for 18 years. In 1925 drought and heat at tasseling time prevented formation of ears. In 1926 no ears formed due to drought. In 1930 plot 6 was taken by gophers and pheasants; consequently it was omitted, and averages were secured by dividing by the number of yields available. In 1931 there was no grain because of drought. Records for stalks on plots 1222, 1223, and 1226 missing in field book. In 1932 there is no record of stalks. Varieties of corn grown: from 1913 to 1915, S. D. 86 (Minn. 13); from 1916 to 1932, Alta, S. D. 1095. Alta was developed at Highmore mainly from S.D. 86. The yields for 12 inches for 1914, 1917, 1920, 1923, 1929, and 1932 are the averages of yields from plots 1229 and 1231 both of which were plowed 12 inches deep with the deep-tilling machine.

TABLE 2. YIELDS OF SPRING WHEAT GRAIN AND STRAW FROM PLOTS PLOWED TO DIFFERENT DEPTHS IN PREPARATION FOR CORN IN A 3-YEAR ROTATION WITH WHEAT AND LEGUMES AT THE CENTRAL SUBSTATION, HIGHMORE, DURING A 20-YEAR PERIOD (1913-32)

(One bushel=60 pounds)

Year	Series number	7″ plowing (Plot 1)		4″ plowing (Plot 2)		6″ plowing 6″ subsoil (Plot 3)		6″ plowing 10″ subsoil (Plot 4)		7″ plowing (Plot 5)		8″ subsoil (Plot 6)		8″ plowing (Plot 7)		10″ plowing (Plot 8)		12″ plowing (Plot 9)		7″ plowing (Plot 10)		Average of 7″ plowing (Check plots)	
		Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw
		bu.	*lb.*	*bu.*	*lb.*	*bu.*	*lb.*	*bu.*	*lb.*	*bu.*	*lb.*	*bu.*	*lb.*	*bu.*	*lb.*	*bu.*	*lb.*	*bu.*	*lb.*	*bu.*	*lb.*	*bu.*	*lb.*
1914	1201-10	11.17	1,970	10.17	2,000	10.17	1,900	10.67	1,790	10.00	1,850	11.00	1,910	10.50	2,090	10.17	2,150	9.67	2,120	10.50	2,110	10.56	1,977
1915	1221-31	27.83	3,500	23.50	3,000	23.67	2,800	21.83	2,700	22.67	3,400	21.67	3,700	22.33	2,800	22.17	2,550	23.83	2,800	25.33	2,800	25.28	3,233
1916	1211-20	19.33	2,500	16.83	2,250	16.33	2,600	17.33	2,550	16.67	2,900	17.00	3,000	17.17	2,700	18.17	2,750	19.17	2,650	18.33	2,350	18.11	2,583
1917	1201-10	15.50	1,580	14.00	1,520	14.00	1,500	15.67	1,500	15.50	1,500	14.83	1,400	17.17	1,600	16.67	1,680	16.67	1,600	16.67	1,500	15.86	1,527
1918	1221-31	10.17	2,240	11.00	1,890	17.33	1,910	15.50	2,170	12.00	2,330	16.17	2,480	10.67	2,260	12.83	2,080	11.33	2,020	6.50	1,960	9.56	2,177
1919	1211-20	19.10	2,180	18.41	2,270	17.06	2,300			15.67	2,400	12.67	2,440	15.33	2,480	19.67	2,520	19.67	1,920	18.67	1,680	17.81	2,087
1920	1201-10	19.67	4,220	18.67	4,380	17.33	3,960	17.83	4,080	18.50	4,000	12.50	4,330	16.17	3,980	15.67	4,060	16.17	3,950	18.83	3,670	19.00	3,963
1921	1221-31	6.67	1,650	7.00	1,630	6.83	1,290	7.17	1,570	7.17	1,750	6.00	1,540	5.67	1,610	6.00	1,590	6.17	1,580	5.00	1,650	6.28	1,683
1922	1211-20	20.83	2,200	19.67	2,080	20.33	2,380	25.50	2,530	27.83	2,540	30.50	2,670	35.67	3,200	28.50	3,070	26.67	2,950	22.67	2,290	23.78	2,343
1923	1201-10	23.92	2,165	20.67	1,760	21.50	2,060	21.17	1,980	21.00	1,340	21.67	1,500	23.00	1,870	23.50	1,740	23.33	1,800	22.83	1,830	22.58	1,778
1924	1221-31	19.83	2,810	17.83	1,930	17.83	2,080	20.33	2,450	18.50	2,890	16.17	3,110	19.33	3,340	18.33	2,070	18.50	2,120	18.17	2,060	18.83	2,587
1925	1211-20	10.33	1,630	9.33	1,890	10.83	2,080	13.00	2,400	15.67	2,760	21.00	3,020	19.67	3,200	12.33	2,260	9.17	2,200	11.33	1,870	12.44	2,087
1926	1201-10	2.67	940	1.17	490	2.33	710	2.00	680	1.83	590	2.17	670	2.25	645	2.67	690	2.67	590	3.58	735	2.69	755
1927	1221-31	27.17	2,420	24.17	2,060	22.50	2,000	23.17	2,010	28.17	2,410	30.00	2,680	22.50	2,150	22.67	1,690	21.33	1,620	20.00	1,700	25.11	2,177
1928	1211-20	9.00	1,810	9.17	2,000	9.17	2,050	12.33	1,960	16.83	2,170	15.50	2,050	19.83	1,770	14.42	1,735	12.17	1,870	10.83	2,050	12.22	2,010
1929	1201-10	5.00	1,850	5.83	1,500	7.67	1,640	6.67	1,500	4.50	1,250	8.50	1,490	4.33	1,490	4.00	1,520	2.83	1,280	3.17	1,230	4.22	1,443
1930	1221-31	15.33	1,620	13.33	1,370	12.17	1,350	13.33	1,150	15.33	1,590	16.50	1,570	14.67	1,550	13.50	1,320	12.33	1,300	12.50	1,350	14.39	1,520
1931	1211-20	0.67	610	0.95	493	0.52	409	1.25	625	1.72	927	2.50	950	1.32	921	0.73	806	0.95	743	0.98	591	1.12	709
1932	1201-10	9.50	2,280	9.00	2,110	11.50	2,310	9.33	1,890	10.50	2,120	12.67	2,240	10.00	2,150	10.67	2,210	10.50	1,270	10.00	2,050	10.00	2,150
Totals		273.69	40,175	250.70	36,623	259.07	37,329	254.08	35,535	280.06	40,717	289.02	42,750	287.58	41,806	272.67	38,491	263.13	36,423	255.89	35,476	269.84	38,789
Averages		**14.40**	**2,114**	**13.19**	**1,928**	**13.64**	**1,965**	**14.12**	**1,974**	**14.74**	**2,143**	**15.21**	**2,250**	**15.14**	**2,200**	**14.35**	**2,026**	**13.85**	**1,915**	**13.47**	**1,867**	**14.20**	**2,042**
Sums of the averages (pounds)		2,978.00		2,719.40		2,783.40		2,821.20		3,027.40		3,162.60		3,108.40		2,887.00		2,745.89		2,675.20		2,894.00	

NOTE: The averages for plot 4 are for 18 years instead of 19. The field record was lost. Varieties of wheat grown: 1914, Red Fife, S.D. No. 67; and 1915 and 1916, Kubanka, S.D. No. 75; 1917 to 1932, Acme, S.D. No. 284. Kubanka and Acme are durum wheats.

TABLE 3. YIELDS OF LEGUME SEED (WHITE SWEET CLOVER OR SOYBEANS) FROM PLOTS PLOWED TO DIFFERENT DEPTHS IN PREPARATION FOR CORN IN A 3-YEAR ROTATION WITH WHEAT AND LEGUMES AT THE CENTRAL SUBSTATION, HIGHMORE, DURING A 20-YEAR PERIOD (1913-32)

(Seed threshed from given pounds of straw)

Year	Series number	7″ plowing (Plot 1)		4″ plowing (Plot 2)		6″ plowing 6″ subsoil (Plot 3)		6″ plowing 10″ subsoil (Plot 4)		7″ plowing (Plot 5)		8″ subsoil (Plot 6)		8″ plowing (Plot 7)		10″ plowing (Plot 8)		12″ plowing (Plot 9)		7″ plowing (Plot 10)		Average of 7″ plowing (Check plots)	
		Seed	Straw	Seed	Straw	Seed	Straw	Seed	Straw	Seed	Straw	Seed	Straw	Seed	Straw	Seed	Straw	Seed	Straw	Seed	Straw	Seed	Straw
		bu.	*lb.*	*bu.*	*lb.*	*bu.*	*lb.*	*bu.*	*lb.*	*bu.*	*lb.*	*bu.*	*lb.*	*bu.*	*lb.*	*bu.*	*lb.*	*bu.*	*lb.*	*bu.*	*lb.*	*bu.*	*lb.*
Sweet clover*																							
1915	1201-10							No seed crop.															
1916	1221-31	1.12	2,850	1.33	2,600	0.96	2,800	1.08	2,600	1.25	3,150	1.33	3,100	2.12	3,000	2.12	2,700	2.00	2,600	1.71	2,650	1.36	2,883
1917	1211-20	1.75	870	1.33	660	2.08	700	2.08	1,080	1.92	1,320	1.08	980	1.83	1,900	3.75	1,360	2.83	1,100	2.08	780	1.92	990
1918	1201-10	3.00	2,240	2.17	1,560	3.00	1,720	2.67	1,855	2.00	1,390	2.83	1,580	3.25	1,955	3.83	2,270	4.17	2,200	3.67	1,830	2.89	1,820
1919	1221-31	1.38	1,127	0.63	823	0.83	860	1.50	987	2.08	1,255	1.88	1,137	0.80	1,002	1.13	882	0.80	922	1.22	1,077	1.56	1,153
1920	1211-20							Second cutting not threshed; included in hay record.															
1921	1201-10	0.67	780	0.58	745	0.75	735	0.75	855	0.67	840	0.33	760	0.70	958	0.83	900	0.83	970	0.58	815	0.64	812
1922	1221-31	1.00	1,840	0.67	1,070	1.67	1,560	1.50	1,520	1.83	1,920	1.17	1,530	1.58	1,935	1.00	1,540	1.00	1,550	1.00	1,590	1.28	1,783
1923	1211-20	1.92	4,485	0.71	3,738	1.58	4,105	3.83	3,220	5.00	5,700	6.67	4,000	7.08	4,025	5.67	3,460	4.85	4,060	2.75	3,685	3.22	4,623
1924	1201-10	1.33	570	0.42	475	0.67	530	0.50	420	0.42	425	0.92	525	0.67	490	0.50	500	0.75	575	0.58	515	0.78	503
1925	1221-31							No seed. Only one cutting which was harvested for hay.															
1926	1211-20							Sweet clover failed. Seeded to soybeans.															
1927	1201-10							Sweet clover failed; nothing harvested. Very dry in 1926 when sweet clover was seeded.															
1928	1221-31							First cutting for hay. No second cutting.															
1929	1211-20							First cutting for hay. No second cutting.															
1930	1201-10							Entire failure due to drought.															
1931	1221-31							First cutting for hay. No seed crop; very dry.															
1932	1211-20							Entire failure due to drought.															
Soybeans																							
1926	1211-20	2.50	250	2.67	290	1.92	245	3.00	300	3.00	260	2.00	200	3.50	310	3.83	370	3.00	260	2.50	190	2.67	233
Sweet clover and soybeans:																							
Totals		14.67	15,012	10.51	11,961	13.46	13,255	16.91	12,807	18.17	16,260	18.21	13,812	21.53	15,575	22.66	13,982	20.23	14,237	16.09	13,125	16.32	14,800
Average 18 years		**0.82**	**834**	**0.58**	**665**	**0.75**	**736**	**0.94**	**712**	**1.01**	**903**	**1.01**	**767**	**1.20**	**865**	**1.26**	**777**	**1.12**	**791**	**0.89**	**729**	**0.91**	**822**
Sweet clover (18 years)																							
Totals		12.17	14,762	7.84	11,671	11.54	13,010	13.91	12,507	15.17	16,000	16.21	13,612	18.03	15,265	18.83	13,612	17.23	13,979	13.59	12,935	13.65	14,567
Average		**0.68**	**820**	**0.44**	**648**	**0.64**	**723**	**0.77**	**695**	**0.84**	**889**	**0.90**	**756**	**1.00**	**848**	**1.05**	**756**	**0.96**	**777**	**0.76**	**719**	**0.76**	**809**
Soybeans (1 year)																							
Totals		2.50	250	2.67	290	1.92	245	3.00	300	3.00	260	2.00	200	3.50	310	3.83	370	3.00	260	2.50	190	2.67	233

* Biennial white sweet clover, S. D. 190, was used throughout the entire period of this investigation.

TABLE 4. YIELDS OF LEGUME HAY (WHITE SWEET CLOVER OR SOYBEAN) FROM PLOTS PLOWED TO DIFFERENT DEPTHS IN PREPARATION FOR CORN IN A 3-YEAR ROTATION WITH WHEAT AND LEGUMES AT THE CENTRAL SUBSTATION, HIGHMORE, DURING A 20-YEAR PERIOD (1913-32)

Year	Series number	7" plowing (Plot 1)	4" plowing (Plot 2)	6" plowing 6" subsoil (Plot 3)	6" plowing 10" subsoil (Plot 4)	7" plowing (Plot 5)	8" subsoil (Plot 6)	8" plowing (Plot 7)	10" plowing (Plot 8)	12" plowing (Plot 9)	7" plowing (Plot 10)	Average of 7" plowing (Check plots)
		lb.	*lb.*	*lb.*	*lb.*	*lb.*	*lb*	*lb.*	*lb.*	*lb.*	*lb.*	*lb.*
1915	1201-10	3,640	3,180	2,790	3,080	3,200	3,550	3,800	4,179	4,060	3,740	3,527
1916	1221-31	2,350	3,200	3,350	3,300	3,220	3,150	2,750	3,400	2,825	3,200	2,923
1917	1211-20	3,000	2,800	3,000	3,100	3,250	3,350	4,000	5,250	4,350	3,800	3,350
1918	1201-10	2,770	2,950	3,420	3,340	2,300	2,560	3,030	3,590	3,780	3,410	2,827
1919	1221-31	2,400	1,850	2,050	2,120	2,320	2,650	2,530	2,050	2,050	2,050	2,257
1920	1211-20*	4,420	3,780	4,060	3,700	4,830	2,720	3,680	4,650	5,020	4,110	4,453
1921	1201-10	2,360	1,680	2,080	1,890	2,100	1,630	2,260	2,150	2,270	2,000	2,153
1922	1221-31	3,800	2,780	3,500	3,420	3,570	3,360	4,320	3,980	4,135	4,170	3,847
1923	1211-20	270	000	120	790	1,690	1,500	1,570	1,470	1,200	520	827
1924	1201-10	6,750	4,800	5,000	4,940	4,830	5,300	5,250	5,450	5,430	5,280	5,620
1925	1221-31	2,200	2,000	1,600	2,000	2,520	2,500	2,500	1,880	1,810	1,920	2.213
1926	1211-20	Sweet clover failed. Seeded to soybeans. See seed record and hay weight in Appendix Table 3.										
1927	1201-10	Sweet clover failed; nothing harvested. Very dry in 1926 when sweet clover was seeded.										
1928	1221-31	1,150	690	1,030	1,100	1,670	1,340	1,340	1,070	1,210	1,040	1,287
1929	1211-20	1,830	1,380	1,560	2,400	3,190	2,080	3,610	3,470	2,810	1,650	2,223
1930	1201-10	No crop due to drought.										
1931	1221-31	120	50	120	70	240	270	70	130	135	60	140
1932	1211-20	No crop. Sweet clover failed. Failure due to drought in 1931.										
Totals		37,060	31,140	33,680	35,250	38,930	35,960	40,710	42,810	41,085	36,950	37,647
Average—18 years		**2,059**	**1,730**	**1,871**	**1,958**	**2,163**	**1,998**	**2,262**	**2,369**	**2,283**	**2,053**	**2,092**
		Note: The yields for 12-inch plowing for 1916, 1919, 1922, 1925, and 1928 are the averages from plots 29 and 31.										
		SUMMARY OF SWEET CLOVER CROPS: SEED, STRAW, AND HAY YIELDS										
		bu.	*bu.*	*bu.*	*bu.*	*bu.*	*bu.*	*bu.*	*bu.*	*bu.*	*bu.*	*bu.*
Average seed		0.68	0.44	0.64	0.77	0.84	0.90	1.00	1.05	1.01	0.76	0.76
		lb.	*lb.*	*lb.*	*lb.*	*lb.*	*lb.*	*lb.*	*lb.*	*lb.*	*lb.*	*lb.*
Average straw		820	648	723	695	889	756	848	756	798	719	809
Average hay		2,059	1,730	1,871	1,958	2,163	1,998	2,262	2,369	2,283	2,053	2,092
Average hay and straw		2,879	2,378	2,594	2,653	3,052	2,754	3,110	3,125	3,081	2,772	2,901

Average seed from all plots, 0.81 bushels. Average straw from all plots, 765 pounds. Average hay from all plots, 2,075 pounds. Average hay and straw from all plots, 2,840 pounds. Average pounds of dry matter per acre (seed, straw, and hay) for 18 years, 2,889 pounds.

* There were two cuttings of hay in 1920.

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