POWER REQUIREMENTS FOR AUGERING FERTILIZER AND THE EFFECT OF AUGERING ON FERTILIZER PULVERIZATION

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INTRODUCTION

The application of fertilizer on the prairie grain farm is accomplished in two ways.

1. Phosphate fertilizers (11-48-0 and 11-55-0) and low analysis nitrogen fertilizers (27-14-0 and 23-23-0), up to approximately 25 lbs. of nitrogen per acre, are applied with the seed using a fertilizer attachment on the seeder. Nitrogen in excess of 25 lbs. per acre may cause germination damage if applied with the seed (2). The 27-14-0 and 23-23-0 fertilizers, if used at high rates, could be applied with a broadcast spreader.
2. High analysis nitrogen fertilizers (33.5-0-0 and 46-0-0) are applied as surface applications either in the fall or in the spring prior to seeding, using a broadcast fertilizer spreader.

With the increased use of fertilizer, consumers are adopting bulk handling methods. The movement of fertilizer in bulk form, from dealer to farmer, may be accomplished in one of the following ways.

1. The dealer or manufacturer may deliver the fertilizer to the farm and put it into the farmer's storage bin using pneumatic means.
2. The farmer may haul his own fertilizer from the dealer. The fertilizer at the dealer's facility is loaded onto the farmer's truck either from a hopper bottomed bin or by means of a belt conveyor.

In the case of the latter approach, it is possible for the fertilizer to be subjected to three augerings. It could be augered from the truck into the farmer's storage bin, from the storage bin back onto the truck at seeding time and from the truck into the fertilizer attachment on the seeder or the broadcast fertilizer spreader.

The objective of this study was to determine:

1. The power requirements for augering fertilizer.
2. The tendency for the fertilizer to plug the auger.
3. The degree of pulverization of the fertilizer due to augering.
4. The effect of fertilizer pulverization on the distribution pattern produced by a broadcast fertilizer spreader.

PROCEDURE

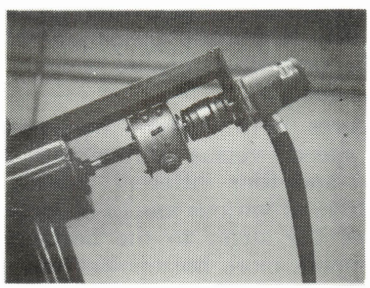
Throughput and power requirements to convey wheat, 11-48-0, 33.5-0-0, 23-23-0 and 46-0-0 fertilizers, with a 6-inch diameter auger, at various angles of inclination, were measured.

The effect of augering on fertilizer pulverization was evaluated by spreading 33.5-0-0 and 27-14-0 fertilizers, which had been subjected to a different number of augerings, using a broadcast fertilizer spreader.

Sieve Analysis

The amount of fertilizer pulverization due to augering was determined by performing a sieve analysis of fertilizer samples. Representative 250 gram samples were obtained using a sample divider. The samples were then placed in a stack of Tyler Canadian Standard Sieves, consisting of series numbers as shown in Tables 3 to 6, and vibrated for five minutes on a Syntron Shaker which was set at 90 volts.

The series of sieves listed in Tables 3 and 4 were so chosen that the sieve openings represented a geometric



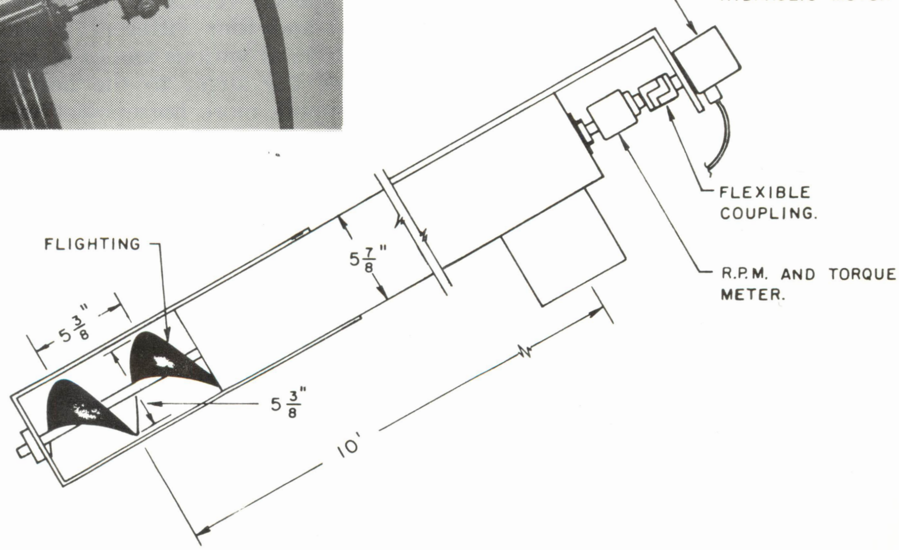


Figure 1. Test auger.

progression. The series used in Tables 5 and 6 follow no set pattern or standard but were chosen to give a representative analysis of the particle sizes encountered.

EQUIPMENT

The auger used for the tests was a 10-foot long, 6-inch-diameter auger with dimensions as shown in figure 1. A hydraulic motor was used to drive the auger. A torque and rpm meter (3) was installed between the hydraulic motor and auger. The output from the meter was recorded on a Brush Oscillograph. Simultaneously, the throughput was obtained from a recording on the Brush Oscillograph produced by the output from a transducer. The output voltage from the transducer was proportional to the cumulative weight of the fertilizer delivered by the auger for the same time period that torque and rpm were measured. Throughput in pounds per minute was calculated from the slope of the recorded straight line relating cumulative weight and time. Values of torque were obtained at various throughputs, speeds and angles of inclination of the auger to the horizontal. Throughput was varied by varying the speed of the auger.

The broadcast fertilizer spreader used to determine the effect of pulverization on the distribution pattern was equipped with two spinners which were driven by the tractor power take-off. The effect of spreader adjustment on the distribution pattern had been established by previous tests (4).

OBSERVATIONS AND RESULTS

Power Requirements

Information on horsepower requirements for conveying grain at various angles of inclination and throughput are available in the Agricultural Materials Handling Manual (1). Material characteristics such as bulk density, particle size and angle of repose are factors which determine the power required to convey them.

The bulk density of most fertilizers is greater than that of grain and thus the power requirements to convey the two materials differ. Bulk densities of fertilizer vary, depending on the manufacturer. Shown in Table 1 are some nominal bulk densities of fertilizers compared to the bulk density of selected grains. The bulk densities of the fertilizers were supplied by a fertilizer manufacturer and the bulk densities of the grains are based on the prescribed bushel weights of the grains (2).

TABLE I. BULK DENSITIES

Fertilizers		Grain	
11-48-0	59 lbs/ft.^{3}	Wheat	47 lbs/ft.^{3}
27-14-0	60 lbs/ft.^{3}	Barley	37 lbs/ft.^{3}
33.5-0-0	56 lbs/ft.^{3}	Oats	27 lbs/ft.^{3}
46-0-0	46 lbs/ft.^{3}	Flax	44 lbs/ft.^{3}

TABLE II. POWER REQUIREMENTS FOR A 6-INCH DIAMETER, 10-FOOT LONG AUGER AT AN ANGLE OF INCLINATION OF 60° AND A THROUGHPUT OF 800 LBS./MIN.

Material Augered	Horsepower	Percent Increase Over Wheat
Wheat	1.7	--
11-48-0	2.7	59%
23-23-0	2.2	30%
33.5-0-0	2.0	18%
46-0-0	2.0	18%

Figures 2 to 6 show horsepower and speed versus throughput for wheat and four different anlyses of fertilizers at various angles of inclination of the auger to the horizontal. In general, more horsepower was required to convey fertilizer than wheat. However, in the case of 33.5-0-0 and 46-0-0 at an angle of inclination of 30°, the power requirement was approximately the same.

Table 2 shows a typical comparison of the power required to convey the different materials at the throughput and angle of inclination shown. Also, the percent increase in horsepower required to convey fertilizers as compared to wheat is given. It was noted that after the fertilizer became pulverized (augered 20 to 30 times) more power was required to convey it.

Plugging

One of the problems encountered during the test was plugging or stoppage of the auger. Plugging occurred if the auger was not emptied of fertilizer after use and if the intake was left buried. The fertilizer, in this case, accumulated in the lower section of the auger tube and formed a compacted core. Plugging was more severe and occurred more rapidly as the angle of inclination of the auger to the horizontal was increased. It was also observed that the auger tended to plug more readily with pulverized fertilizer. To free the auger after plugging occurred, the buried end had to be exposed, allowing the compacted fertilizer to run out. Thus, to insure trouble-free auger performance when conveying fertilizer, it would be advisable to empty the auger before allowing it to stand idle.

If the auger was left idle for only a short time (10 to 15 minutes), plugging did not occur since the fertilizer did not have time to compact at the

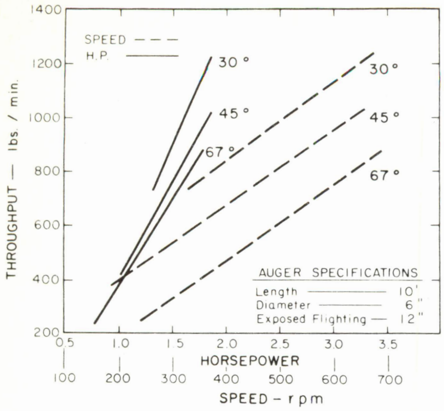


Figure 2. Speed and horsepower vs. throughput while conveying wheat at three angles of inclination.

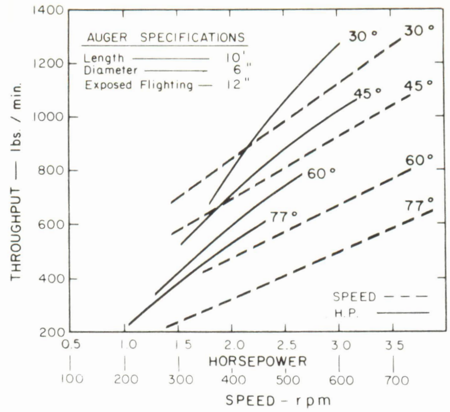


Figure 3. Speed and horsepower vs. throughput while conveying 11-48-0 fertilizer at four angles of inclination.

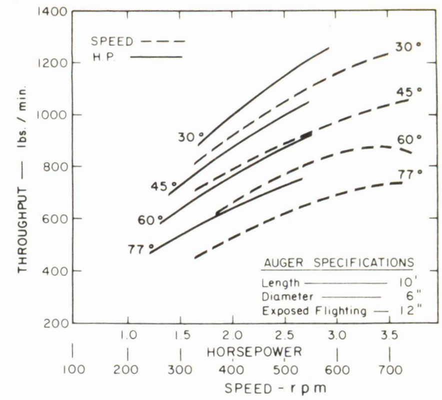


Figure 4. Speed and horsepower vs. throughput while conveying 23-23-0 fertilizer at four angles of inclination.

bottom of the tube. But even in this case the starting torque required was at least double the actual running torque required for normal operation. Compaction of the fertilizer occurs more rapidly and is more severe if the full auger is in a truck bouncing over rough terrain.

Pulverization

Pulverization of fertilizer is dependent upon the moisture content of the fertilizer. If the fertilizer is dry, pulverization is increased. Pulverization was also found to vary with the analysis of the fertilizer. Differences in the degree of pulverization were even noted among the same analysis of fertilizer, produced by different manufacturers.

The nitrogen fertilizers (27-14-0 and 33.5-0-0) pulverized more readily than did the phosphate fertilizers (11-48-0). A comparison of the breakup after continued augering, between 27-14-0 and 11-48-0 is shown in Tables 3 and 4. As an arbitrary figure for comparison the percentage of material passing the Tyler Canadian Standard Sieve Series Number 16 was chosen. As can be seen by comparing Tables 3 and 4 the 27-14-0 pulverized to a greater degree than the 11-48-0.

There has been some concern expressed that pulverization of fertilizer due to augering would affect the distribution pattern produced by a broadcast fertilizer spreader. To determine the effect of pulverization on the distribution pattern, a fertilizer spreader was adjusted to give the best distribution pattern established in previous tests (4). A 27-14-0 fertilizer was then used to determine the distribution pattern obtained with fertilizer which had not been augered and augered 10 times. The 27-14-0 fertilizer is composed of a blend of 11-48-0 and 33.5-0-0 fertilizer particles. Since the 33.5-0-0 particles pulverize more readily than do the 11-48-0 particles, it was thought that particle separation may occur during broadcast spreading and thus affect the distribution pattern. The resulting distribution patterns are shown in figures 7 and 8. No appreciable difference in the distribution pattern resulted and the mean application rate remained unchanged. Sieve analysis of the fertilizer (table 5) indicated that very little pulverization occurred.

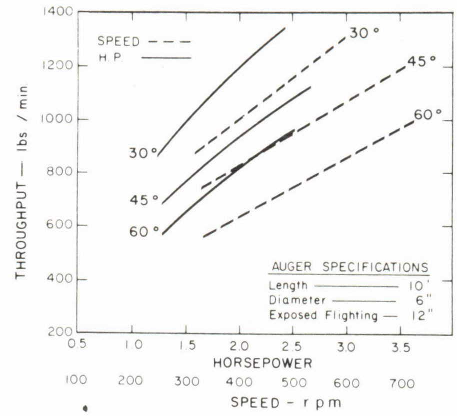


Figure 5. Speed and horsepower vs. throughput while conveying 33.5-0-0 fertilizer at three angles of inclination.

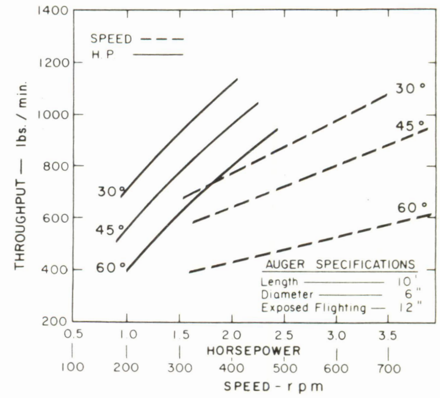


Figure 6. Speed and horsepower vs. throughput while conveying 46-0-0 fertilizer at three angles of inclination.

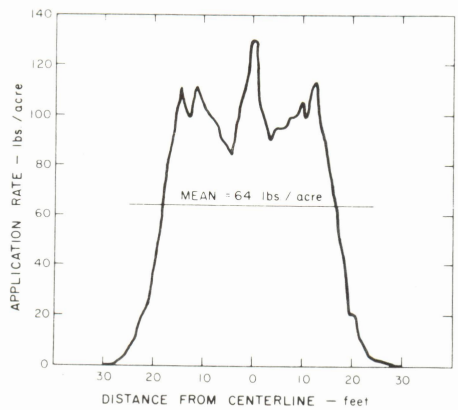


Figure 7. Distribution pattern obtained while spreading 27-14-0 fertilizer that was not previously conveyed by an auger.

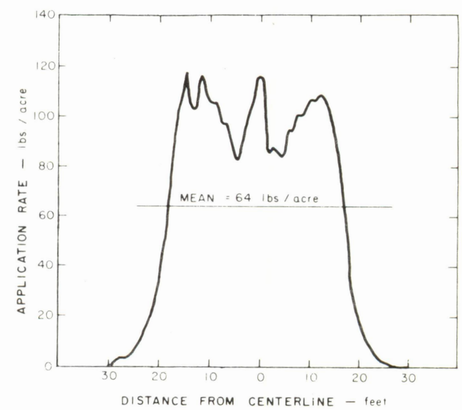


Figure 8. Distribution pattern obtained while spreading 27-14-0 fertilizer that was augered 10 times through a 10-foot long, 6-inch-diameter auger at a 45° angle of inclination and a speed of 600 rpm.

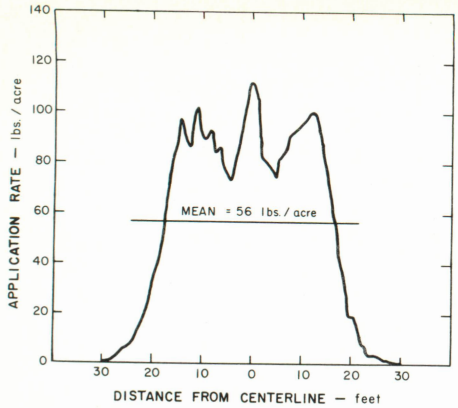


Figure 9. Distribution pattern obtained while spreading 33.5-0-0 fertilizer that was not previously conveyed by an auger.

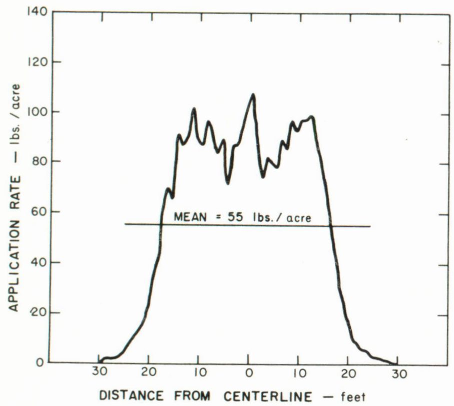


Figure 10. Distribution pattern obtained while spreading 33.5-0-0 fertilizer that was augered five times through a 10-foot long, 6-inch-diameter auger at a 45° angle of inclination and a speed of 600 rpm.

Distribution patterns were similarly obtained for a 33.5-0-0 fertilizer that had not been previously augered (figure 9) and augered 5 times (figure 10). There was no noticeable change in the distribution patterns and the sieve analysis (table 6) showed little pulverization due to augering.

Fertilizer, on the farm, would not normally be augered more than three times. Thus, it can be said that under normal conditions, pulverization due to augering will be negligible and has very little effect on the application of the fertilizer.

CONCLUSIONS

Conveying fertilizer with an auger requires more power than is required for conveying wheat.

If a full auger is left idle with the end buried in fertilizer, plugging will occur, necessitating the freeing of the buried end and emptying of the

TABLE III. PULVERIZATION OF 27-14-0 FERTILIZER

Tyler Canadian Standard Sieve Series No.	Percent of Material Retained on Sieves		
	Unaugered	Augered 4 Times	Augered 40 Times
4	0	0	0
8	9.6	8.6	6.4
16	84.8	85.4	69.2
30	5.2	5.4	19.4
50	0.4	0.4	2.6
100	--	0.2	1.0
Pan	--	--	1.4
% of Material Passing No. 16 Sieve	5.6	6.0	24.4

TABLE IV. PULVERIZATION OF 11-48-0 FERTILIZER

Tyler Canadian Standard Sieve Series No.	Percent of Material Retained on Sieves			
	Unaugered	Augered 6 Times	Augered 26 Times	Augered 60 Times
4	0	0	0	0
8	8.4	6.2	4.8	5.0
16	91.2	91.2	90.4	86.8
30	0.4	2.4	4.6	6.8
50	--	0.2	0.2	0.8
100	--	--	--	0.4
Pan	--	--	--	0.2
% of Material Passing No. 16 Sieve	0.4	2.6	4.8	8.2

TABLE V. SIEVE ANALYSIS OF 27-14-0 FERTILIZER*

Tyler Canadian Standard Sieve Series No.	Percent of Material Retained on Sieves	
	Unaugered	Augered 10 Times
8	12.0	12.0
10	34.0	33.0
14	48.0	43.0
16	4.0	6.0
20	1.0	4.0
28	1.0	1.0
Pan	--	1.0
% of Material Passing No. 16 Sieve	2.0	6.0

***NOTE: The discrepancy between the unaugered 27-14-0 sieve analysis contained in this table and the unaugered 27-14-0 sieve analysis contained in table 3 is due to the difference in fertilizer particle sizes from two different manufacturers.**

TABLE VI. SIEVE ANALYSIS OF 33.5-0-0 FERTILIZER

Tyler Canadian Standard Sieve Series No.	Percent of Material Retained on Sieves	
	Unaugered	Augered 5 Times
8	11.0	13.0
10	32.0	28.0
14	51.0	50.0
16	4.0	6.0
20	1.0	2.0
28	0	0
Pan	1.0	1.0
% of Material Passing No. 16 Sieve	2.0	3.0

auger before operation can be resumed.

Under normal conditions (augering three to four times) pulverization of the fertilizer is negligible and does not affect distribution of the fertilizer from a broadcast spreader. With increased augerings (20 to 60 times), however, pulverization became more severe.

REFERENCES

1. Agricultural Materials Handling Manual, Section 2. 3 "Auger and Bucket Conveyors" prepared by National Committee on Agricultural Engineering of National Coordinating Committee on Agricultural Services, Canada Department of Agriculture.
2. Guide to Farm Practice in Saskatchewan, 1966, prepared jointly by representatives of the University of Saskatchewan, Saskatchewan Department of Agriculture and Canada Department of Agriculture.
3. Mickleborough, R. O. "Design and Construction of a Strain Gauge Torquemeter", Unpublished B.Sc. thesis, University of Saskatchewan, Saskatoon, Saskatchewan, 1962.
4. Reed, W. B. and Wacker, E. "Determination of the Distribution Pattern of Dry Fertilizer Applicators", presented at a meeting of the A.S.A.E., December, 1968, Paper No. 68-606.

SOME NEEDS AND . . .

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ern electronic services for information collection, classification, storage, retrieval, and communication to which facts and technical data lend themselves admirably. Agricultural engineers, by virtue of their special interests and knowledge, are in an advantageous position to contribute to such a development.

The research scientist, in turn, relieved of this tedious and endless activity and provided more adequately with relevant facts, would be more likely to exercise his imagination in identifying significant problems within a system and, as a consequence, to generate ideas for their solution. The administrator would be more likely to end up with a team of 'systems analysts' who are scarce, than of 'programmers' who are plentiful. Conceivably, the trend, which is not unknown even among agricultural engineers, to become specialists, and thereby run the risk of assignment to irrelevant routine tasks, could be overcome.

The grassland-animal product situation outlined earlier appears to present interesting possibilities for application of the approach suggested.

THESE THINGS . . .

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Committee of Agricultural Engineering is an excellent sounding board for action, and it seems logical that the C.S.A.E. initiate, through this body, ideas that will only bide well for the healthy condition of Agricultural Engineering in Canada.

It bears repeating that problems of pollution in air, ground and water are going to be amplified in the near future and that efficiency in production will ever be needed on the farms in this country. These will be handled by individuals and probably handled well, but it will not be enough to cope with the obvious growth of our nation. Team work is essential and will occur through either accident or design. Let us predict it will be by design.

Our Society will grow and with each new Agricultural Engineer new hopes, new ideas, and new developments will necessarily result. We cannot afford to fail in our dedication to our chosen field when so many are dependent upon so few.

"These things shall be — a loftier race shall rise."