POTATO HARVESTER DRAFT REQUIREMENTS FOR FIXED AND ROTARY DISK BLADES

by [1]
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ABSTRACT

Field experiments were conducted to compare the draft (drawbar pull) force required for the rotary disk blade system to that for a conventional, fixed-blade potato harvester. The results show that in silt-loam soil the 36-inch diameter disk blades required 76 percent less draft than the fixed blade in one case and 57 percent less overall. The 41-inch disks required 43 percent less draft in that soil overall. In fine sand soil, draft forces among the three blade systems were not significantly different. The fixed blade used in the experiments was of low profile and the primary chain had all down links. These factors may have resulted in less draft for it than for the usual fixed blade. However, even with this efficient blade design, the draft force required increased very significantly with blade depth in deep digging.

This project's goal is the development of new concepts and practices for potato harvesting and handling equipment to achieve better production efficiency and higher tuber quality. This article discusses field experiments with a new rotary blade concept that shows much promise in improving harvester performance.

Thanks again to Stetner Brothers, Blue Ribbon Produce, the Washington State Potato Commission, Braco Mfg., and cooperating growers, the rotary disk harvester blade system was given a much more thorough testing this year. The experiments included comparisons of both 36-inch and 41-inch diameter disk blades to a 1983 fixed-blade Braco harvester in both Quincy fine sand and Shano silt loam soils. The harvesters were instrumented, and a portable computer was used to record draft (drawbar pull force), true ground speed and blade position.

The results showed considerable draft reduction for heavier soil, and indicate that with some blade configuration changes, similar reductions could occur in sandy soil as well. For a blade depth such that approximately 8 to 9 inches of loose soil were left behind the harvester, the average draft forces for the three blades in the two soil types were as shown in Table 1.

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This Presentation is part of the Proceedings of the 1985 Washington Potato Conference & Trade Fair.

Table 1. Potato Harvester Draft Force for Three Blade Types in Quincy Fine Sand and Shano Silt-Loam Soils.

	Draft force (lb)*		
Blade type	Fine sand	Silt-loam	Draft reduction**
Average over several tractor gears:			
Fixed	2711a*	4344a*	0%
41-inch disk	2981a	2490b	43%
36-inch disk	2959a	1877c	57%
Tractor in third gear:			
Fixed	----	3520a	0%
41-inch disk	----	2267b	36%
36-inch disk	----	836c	76%

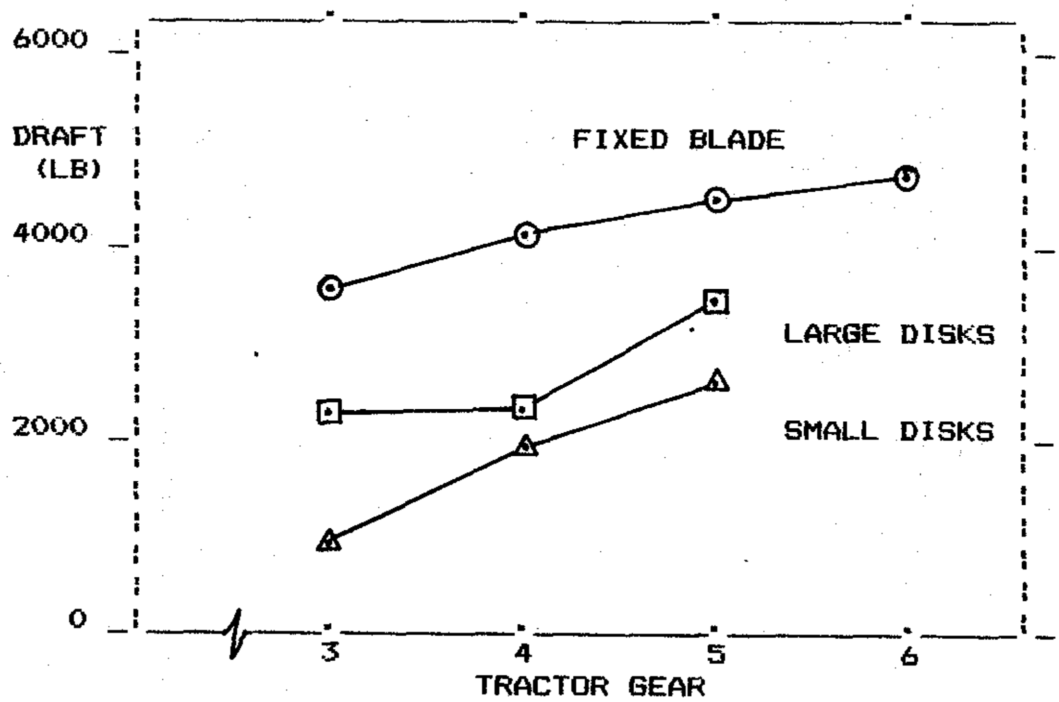
* Means with same letter are not different at the 5% level of significance.
** Compared to fixed-blade draft in heavy soil.

In the silt-loam soil, the fixed blade averaged 4344 lb. of draft force over several tractor gears compared to only 1877 lb. for the 36-inch disks and 2490 lb. for the 41-inch disks. This amounted to a draft reduction of the disk blades compared to the fixed blade of 43% for the large disks and 57% for the small ones. In third gear the differences were more dramatic, where the draft for the 36-inch disks was 76% less than that required for the fixed blade. Draft in the sandy soil did not vary significantly with blade type at the 8-inch loose soil depth; however, observations indicate that a change in blade shape, spacing and angle could make a marked improvement in performance in that soil as well. Main disk rotational speed was approximately 160 rpm, which gave periferal disk speeds 8 to 9 times the ground speed.

The power required to rotate both blades varied with field conditions and forward speed, but ranged from 20 to 50 horsepower. The drawbar power requirements vary directly with ground speed as well as with draft force. In third gear (Table 1) the ground speed was 2.11 mph, and the corresponding draft horsepower for fixed blade, the 41-inch disks, and the 36-inch disks are 20, 13, and 5 horsepower, respectively.

The variation of draft with tractor gear (ground speed in this case) is shown in more detail in Figure 1. At 2200 engine rpm, ground speed ranged from 2.1 mph in 3rd gear to 3.5 mph in 6th gear for the John Deere 4450 tractor with 15-speed power shift transmission that was used.

Figure 1. Potato harvester draft force for three blade types over four tractor gears for a blade depth that produced approximately 8 inches of loose soil behind the harvester (Shano silt-loam soil).



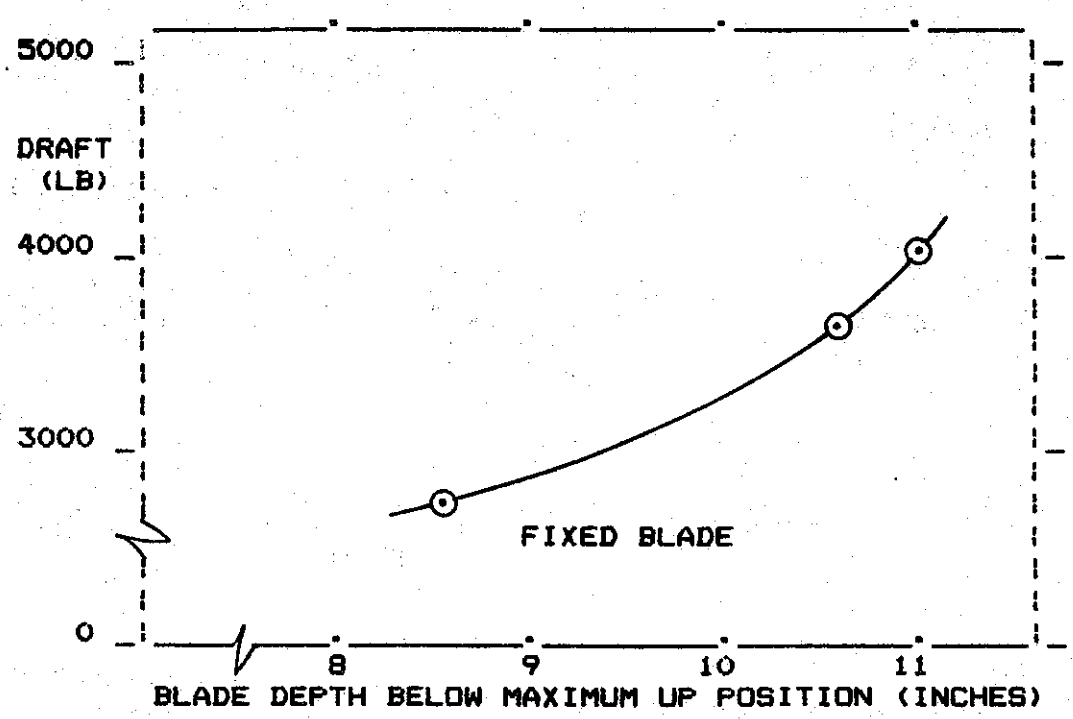
The graph indicates a gradual increase in draft for increased ground speed for the fixed blade. The draft for the small disks is much smaller, but has a much steeper increase with ground speed than for the fixed blade draft. The draft for the large disks lies between that for the fixed blade and the small disks, but the slope of the curve is somewhat irregular. In general, this data indicates that the ground speed may be more critical for the disk blades than for a fixed blade.

The blade attack angle was increased from 25 to 27 degrees during the trials to accomodate the slightly smaller radius of curvature (deeper dish) of the 41-inch disks. As with the smaller disks, too small an attack angle resulted in excessive disk torque because the rounded portion of the disk was forced into the undug soil by the forward motion of the machine. The increased angle tended to slightly restrict flow of material through the blade system and so slightly reduced machine capacity. The lateral tilt angle was kept at 9 degrees.

Considerable data were taken at several blade depths in the fine sand soil with the fixed blade harvester to estimate relationship between blade depth and the force required to pull the harvester.

The data indicate that in going from an 8 to a 9 inch blade depth requires about 450 lb more draft, but going from 10 to 11 inches requires a 900 to 1000 lb increase in pull (Figure 2).

Figure 2. Draft force variation with blade depth for the fixed-blade potato harvester in fine sand soil.



We now know much more about how the disk blade system works and can work with the soil in potato harvesting. Under certain conditions, such as in third gear with the 36-inch disks in heavy soil (Table 1 above), the rotating blades nearly pulled the harvester through the field. Observations of the flow of soil around and over the blades in both heavy and sandy soils convinced us that the two soils act quite differently under these conditions. We are now also beginning to understand why the difference shape of the potato ridge here, compared to that in the U.K. has such a large influence on rotary blade performance.

With the new knowledge gained in the field experiments, we are now ready to undertake a series of blade and blade substitute experiments to find the best configurations for our harvesting conditions. I am convinced that the right rotary blade shape, attack angle, and tilt angle to match our soils and ridge shapes can result in significantly reduced harvester draft using less than the 30 horsepower needed to drive the disk blades in their present configuration.