Development, Testing, and Evaluation of the Deep Furrow Drill Arm Assembly for the Rangeland Drill

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Highlight: *A deep-furrow drill-arm assembly for a Rangeland drill was developed, tested, and evaluated. Horizontal disk angle was the single most important factor affecting construction of an adequate furrow. This angle varied among sites and was influenced by vegetative cover and soil conditions. The final design was an assembly with an adjustable disk angle. Seedling stands in deep furrows were equal to or superior to those in standard furrows.*

Many workers have shown the value of deep-furrow planting for seedling establishment and survival in varied rangeland environments (McGinnies, 1959; Eckert and Evans, 1967; Evans et al., 1967, 1970; Hull, 1970; Klomp and Hull, 1972; and Eckert et al., 1973). In these studies, furrows were constructed with hand tools or with shovel-type openers not adapted to rough, rocky rangeland conditions.

A cooperative effort was initiated in 1968 to design, test, and evaluate a drillarm assembly for the Rangeland drill to make furrows with the desired micro-climate characteristics and one also adapted to large-scale operations.

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Development and Testing

In 1968, we modified one Rangeland drill by replacing the 20-inch disks with 24-inch disks. Four of the ten arm assemblies were removed, and the arms were reversed so that the disks cast to the outside. This arrangement resulted in row spacing of about 20 inches. With 100 lb weight on each arm, this equipment made good furrows in sandy and cultivated soils. In uncultivated, loamy soils, these arms could not support the additional weight of 400 lb required to cut an adequate furrow.

In 1969; the U.S. Forest Service Equipment Development Center fabricated two "heavy-weight" drill arms with 24-inch disks and capable of supporting 400 lb of "add-on" weight. These arms were tested on 350 acres, including a fire rehabiliation, a sagebrush spray-drill operation, and an atrazine fallow. On loam and clay-loam soils with rocks 5 to 15 inches in diameter, these arms with 400 lb of weight made furrows that averaged 3 inches deep and 4 inches wide at the top. The standard drill with standard weight (20 to 40 lb) made a furrow only 1 inch deep and 1 inch wide in moist soil and barely scratched the surface of dry soil.

Mechanical problems associated with weight additions were corrected, and six arm assemblies with 24-inch disks and various horizontal and vertical angles were tested in 1970. The horizontal angle is the pivot of the disk viewed from above. The vertical angle is the tilt of the

Fig. 1. *Drill arm assembly, showing adjustment for horizontal and vertical angles.*

disk viewed from above. No significant mechanical problems were encountered on 900 acres of extremely rough, rocky terrain on four sites. However, one very important fact became apparent. Small differences in disk angle drastically changed the weight requirement. For example, a disk at one angle with 80 lb cut a better furrow than a disk at another angle with 320 lb of "add-on" weight.

Construction of an adequate furrow was influenced by at least ten variables, the most important of which was the horizontal disk angle. Too much horizontal angle results in wide, shallow furrow and creates maintenance or breakage problems because the disk tends to dig at rocks and vegetation rather than roll over them. Conversely, with too little horizontal angle, the disk merely scratches the surface, and no furrow is cut. The disk angle required varies from site to site. Therefore, we recommended the manufacture of two adjustable disk-arm assemblies (Fig. 1).

The horizontal angle adjusts from 55 to 75° in 2.5° increments; the vertical angle adjusts from 4 to 18° in 2° increments. Adjustments on one arm can be made in 3 to 5 minutes. Conditions of vegetative cover and soil texture, moisture, or freezing, encountered indicated that adjustment once or twice a week was sufficient.

The new arms were tested on 1,300 acres in Nevada and Oregon in 1971. One 700-acre site was a mixture of rock-free and moderately rocky ground. On another site of 600 acres, 12- to 36-inch diameter rocks were encountered constantly. The adjustable arms could carry 200 lb of weight, yet only 100 lb were needed. Vertical angles used ranged from 4 to 6°; horizontal angles ranged from 60 to 67.5°. In all tests, the new arms made deep furrows with one-half the weight needed on fixed-angle arms.

So far only two minor disadvantages of deep furrowing have been noted. A drill-row spacing of 20 inches instead of 12 inches decreases plant density and perhaps reduces the soil-stabilization effect of the seeding. On many sites, however, this is the only effective seeding method, so there is really no comparison with the standard drill. More emphasis must also be placed on contour seeding because of furrow size.

Stand Evaluation

Seedling stands and stand establishment were compared in standard and deep furrows under different situations. Stands in deep furrows were equal to or superior to those in standard furrows. Stands were always superior in deep furrows under the more difficult seeding conditions. Superiority in deep furrows was indicated by larger, more vigorous plants; greater plant density and frequency; more seedlings headed; and greater survival. All these characteristics were not found in each comparison, but varied from site to site.

On a fire rehabilitation, frequency of crested wheatgrass (*Agropyron desertorum*) per ft of row was 20% in standard furrows, compared to 46% in deep furrows. Rhizomatous grasses and Sandberg bluegrass (*Poa secunda*) formed a dense sod. This sod was cut and lifted by the 20-inch disk on the standard drill, but after seeding, the sod dropped back to its original position covering the seed. The deep-furrow drill threw strips of sod completely out of the furrow.

On a 1,000-acre sagebrush spray-drill operation, the frequency and height of crested wheatgrass seedlings were 60% and 6 inches, respectively, in the deep furrow. Stand characteristics were 41% and 3 inches on areas seeded with disk assemblies that did not make adequate furrows. These disks, weighted with 200 lb, rolled over the top of the understory vegetation.

On four atrazine-fallow projects ranging from 80 to 1,200 acres, crested-wheatgrass seedlings were from 2.2 to 3.3 inches taller, survival was 13% greater, and 13% more of the seedlings produced reproductive culms in deep furrows than in standard furrows. Seedling densities of intermediate wheatgrass (*Agropyron intermedium*) and pubescent wheatgrass (*A. trichophorum*) were three to eight times more, height 0.5 to 2.4 inches greater, and frequency 43 to 51% higher in deep furrows than in standard furrows.

Summary and Recommendations

Since 1968, 2,300 acres on ten sites in four Bureau of Land Management districts in two states have been seeded with the deep-furrow technique. A standard Rangeland drill was the basis for comparison in most instances. Most testing was done under extreme operational conditions with no significant mechanical problems.

Seedling stands and stand establishment were generally much better in deep furrows. The standard drill was adequate on some sites; however, in uncultivated medium or heavy-textured soil, under rocky conditions, or where the understory was a sod of bluegrass, cheatgrass (*Bromus tectorum*), or rhizomatous grasses, the deep-furrow arm assembly was required to make an adequate furrow.

The U.S. Forest Service Equipment Development Center, San Dimas, California, has completed specifications for an adjustable, drillarm assembly capable of making the desired type of furrow under a wide range of vegetation and soil conditions.

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