AgEcon SEARCH
RESEARCH IN AGRICULTURAL & APPLIED ECONOMICS

The World's Largest Open Access Agricultural & Applied Economics Digital Library

This document is discoverable and free to researchers across the globe due to the work of AgEcon Search.

Help ensure our sustainability.

Give to AgEcon Search

AgEcon Search
http://ageconsearch.umn.edu
aesearch@umn.edu

*Papers downloaded from **AgEcon Search** may be used for non-commercial purposes and personal study only. No other use, including posting to another Internet site, is permitted without permission from the copyright owner (not AgEcon Search), or as allowed under the provisions of Fair Use, U.S. Copyright Act, Title 17 U.S.C.*

No endorsement of AgEcon Search or its fundraising activities by the author(s) of the following work or their employer(s) is intended or implied.

Innovative Production Methods on Wet Clay Soils for Rice and Soybean

By Michael P. Popp, Terry C. Keisling, Lanny O. Ashlock, Larry C. Purcell, Paul A. Counce, David C. Annis Jr., Patrick M. Manning, and Eddie Gordon








Abstract

Clayey soils have properties that can make conventional, early-season planting difficult. Several experiments on alternatives to conventional planting showed that airplane seeding can be successful, but that varying soil surface conditions and post-planting weather make it risky. High floatation tires showed promising, weather-dependent returns of -$4.69/acre to $36.07/acre.

Michael P. Popp is an Associate Professor in the Department of Agricultural Economics and Agribusiness at the University of Arkansas. He received his B. Comm, MBA, and Ph.D. from University of Manitoba, University of Colorado, and Colorado State University.

Terry C. Keisling is Professor Emeritus in the Department of Crop, Soil, and Environmental Sciences at the University of Arkansas.

Lanny O. Ashlock is Professor Emeritus in the Department o Crop, Soils and Environmental Sciences at the University of Arkansas. He is currently a soybean crop consultant for Cullum Seeds.

Larry C. Purcell is a Professor and Crop Physiologist in the Department of Crop, Soil, and Environmental Sciences at the University of Arkansas. He received his B.S. and M.S. degrees in Agronomy from the University of Georgia and his Ph.D. in Agronomy from the University of Florida.

Paul A. Counce is a Professor and Crop Physiologist in the Department of Crop, Soil and Environmental Sciences and the Rice Research and Extension Center, University of Arkansas. He has a B.S. from the University of Tennessee at Martin, an M.S. from Purdue University, and a Ph.D. from the University of Georgia.

David C. Annis, Jr. works with the Soil Fertility and Crops Discipline of the Samuel Roberts Noble Foundation in Ardmore, Oklahoma. He received his B.S. Plant Protection/Pest Management from the University of Arkansas and his M.S. Agriculture from Arkansas State University.

Patrick M. Manning is a Research Specialist in the Department of Agricultural Economics and Agribusiness at the University of Arkansas. He received a B.S. from the University of Florida and a M.S. from Colorado State University.

Eddie C. Gordon is a Research Specialist at the Northeast Research and Extension Center. He received a B.S.A. from the University of Arkansas, a M.S. in agronomy from the University of Arkansas. He is currently responsible for establishing and maintaining the soybean variety and breeding trials coordinated by the project leaders at the University of Arkansas and Arkansas State University.

Introduction

Clayey soils, especially those with 2:1 expanding clays, have always been a challenge to manage for agronomic production. Recently, research in Arkansas was initiated to investigate systems for utilizing the clay's properties while it was extremely wet as an advantage, instead of a detriment in crop management (Black, et al., 1999).

Production practices involving two crops, soybean and rice, are analyzed with respect to seedbed preparation and actual planting method in this paper. At issue are timely performance of key field tasks, as well as the potential to prepare the seedbed in the preceding fall to gain not only valuable time in the spring, but also to provide: i) wildlife habitat; ii) potential for revenue from selling hunting privileges; iii) conservation of irrigation water; and iv) cost savings on weed control.

Typically, an Early Soybean Production System (ESPS) (Staff, 2000a) consists of planting early maturing cultivars (Maturity Group III or IV) (Fehr et al., 1971) in April. The ESPS has been difficult to implement consistently on clayey soils as it tends to stay wet longer in the spring. Therefore, a flooded field approach with airplane seeding shows promise as: i) field conditions may allow seed penetration; ii) tracking the field to excess can be avoided; and iii) clayey soils are typically found in the lowest position of the landscape and thus tend to flood naturally. In addition to aerial seeding technology, new technology in tractor and combine tire design that prevents deep wheel tracks in fields at planting and harvest have recently become commercially available (Goodyear Tire And Rubber Company, 2000). A planting system that utilizes high floatation tire technology thus also appears promising as a less costly alternative compared to investment in rubber track technology with newer equipment and an alternative that would allow for planting operations earlier in the season.

In rice culture on these soils, growers have almost completely adopted a stale seedbed approach for planting. They prepare the seedbed in the fall and use a burndown herbicide treatment in the spring about two weeks prior to planting without additional field preparation prior to planting (Helms, 1996). As with soybean production, growers must wait until the soil has dried sufficiently to support a tractor to keep from making deep wheel tracks in the field when planting (Bryant, 1999). Thus, use of high floatation tire technology also appears promising for earlier plantings of rice on clay soils.

With these opportunities in mind, a series of preliminary field experiments were conducted to: i) document preliminary research findings on aerial soybean seeding trials on clayey soils; ii) summarize early empirical evidence on soybean seed establishment for various field and weather conditions (i.e., extent and duration of winter flooding, weather conditions immediately following planting, tillage, and seedbed preparation practices); and iii) analyze economic repercussions utilizing high floatation tire technology for both rice and soybean production.

Materials and Methods

The first set of field experiments were conducted at the Southeast Branch Experiment Station located at Rohwer on a soil classified as a Sharkey-Silty-Clay-McGehee-Silt-Loam complex (see Table 1 for a descriptive summary). Given the promising yield results obtained in the first year of study

Table 1. Description of aerially seeded soybean field trials at Rohwer, Arkansas.

Year	Plot Location	Planting Date	Cultivar	Harvest Date	Yield (bu/acre)
1998	91° 16' 45" W, 33° 47' 34"N	4/23/1998	NKS42-60	9/4/1998	56
	91° 16' 45" W, 33° 47' 36"N	4/23/1998	DP3478	9/17/1998	48
1999	91° 16' 45" W, 33° 47' 35"N	4/28/1999	SG498RR	9/14/1999	42
	91° 16' 45" W, 33° 47' 39"N	4/8/1999	DP3478	8/25/1999	44

(1998), the experiment was repeated in 1999, and an additional trial site at another location was added to examine various production factors associated with aerial seeding as well as the use of floatation tires. These complimentary experiments were conducted on a forty acre field at the Northeast Research and Extension Center at Keiser, AR (90° 5' 24" W, 35° 39' 30" N) where the soil is classified as a Sharkey Silty Clay. Main study attributes are summarized in Table 2 and broken down into two categories: i) aerial seeding trials and ii) floatation tire trials. For both sets of studies, weed control, irrigation, and other cultural practices followed those commensurate with soybean production in the area (Staff, 2000b). Additional information, not presented in the table and the rationale for the study sequence are presented below.

Aerial Seeding Trials

For all aerial seeding experiments, seed were sown by dropping them from a height of *circa* sixty feet out of an airplane flying in excess of 120 mph. Soybean cultivar 'DP3478' with a target seeding rate of seven to eight seeds per square foot, 75 lbs/acre, or 335,000 viable seeds per acre was used in studies one to six. The first study presents the results of the two year study at Rohwer, Arkansas. Fields were prepared in the fall and flooded during the winter as a preparation for seeding in the following spring. The second study was performed at Keiser, Arkansas to replicate results across locations and on a heavier clay soil. In addition, this study reports on post-seeding weather conditions that can affect planting success. The third study focused on the duration of flooding prior to seeding and the use of two conventional seedbed preparation methods (stale seedbed and plowing). In the fourth study, seed depth placement and seed soil coverage were the issues of contention in extremely wet soils. In the fifth study, a range of surface conditions as well as post seeding weather conditions were the object of study.

Table 2. Summary of planting method and seedbed preparation studies.

Production characteristic	Aerial Seeding					Floatation Tire	
	Study 1	Study 2	Study 3[1]	Study 4[2]	Study 5[3]	Study 6	Study 7
Location	Rohwer	Keiser	Keiser	Keiser	Keiser	Keiser	Keiser
Crop	Soybean	Soybean	Soybean	Soybean	Soybean	Soybean	Rice
Winter flooded	Yes	Yes	No	Yes	Partially	Yes	Yes
Cultivation previous fall	Yes	Yes	Yes	Yes	Partially	Yes	Yes
Cultivation prior to planting	No	No	Partially	No	No	No	No
Planting Method	Aerial	Aerial	Aerial	Aerial/Manual	Aerial	Seeder	Seeder
Seeding Date(s)	4/23/98, 4/8/99 & 4/28/99	5/4/1999	5/6/1999	5/7/1999	5/2/2000	5/10/99 & 5/11/99	5/11/1999
Seed soil penetration	na[4]	1 - 1.5 times seed diameter	Remained on soil surface	1 - 1.5 times seed diameter (aerial) and 1 in. (manual)	Submersed (in slurry) & none on dry soil	1 in.	1 in.
Seed soil coverage	na	Seed floated in water	None	Yes (aerial, except for seed dropped in standing water) and none (manual)	Dependent on soil penetration	Yes	Yes
Post plant weather	na	~ 4 in. rainfall	na	High drying condition	High humidity, minor rainfall and low wind	na	na
Stand establishment	Good (poor in areas of standing water)	None	None	Very poor	Good	Good	Good

1 The study was conducted following a major rain (~4 in). One area was seeded into a stale seedbed, another disk-harrowed.
2 Manually planted seeds (~1 in) were not covered by soil to study the effect of partial exposure to air drying.
3 Part of the field had not been submerged over the winter. In addition, surface conditions included partially disked the previous fall and no-till rice straw
4 Specific observations regarding this production characteristic were not collected.

Floatation Tire Trials

In these two studies (6 & 7), a 225 hp, front-wheel-assist tractor was equipped with high floatation tires and rims. The rear tires were Goodyear 68/50.00X32, and the front tires were Goodyear 54/37.00X25. In Study six, soybeans were planted just as the clay soil had dried enough to form a surface crust sufficiently thick to prevent mud from fouling the three-point-hitch drill planter. The planting rate was ninety lbs/acre. In Study seven, the rice cultivar "Jefferson" was planted at a depth of one inch and a seeding rate of 100 lbs/acre. A preemergence application of herbicide was applied at planting. Nitrogen was applied at 140 lbs/acre when the nodal roots of the rice were 1/4 to 1/2 inches long on June 23, 1999 and a permanent flood was applied to the crop. Other than planting, the crops were grown using production practices commensurate with those of the surrounding area (Helms, 1996). These studies were conducted to determine the effect of assured seed soil coverage as well as the impact of field traffic in wet conditions for both soybeans and rice.

Economics

Floatation Tires

To capture the economic impact of using floatation tires on soybeans (Study 6) and rice (Study 7), as well as associated changes in the production practices, a partial budgeting approach was used to reflect changes in production costs. University of Arkansas Cooperative Extension Service budgets representing conventional practices of Arkansas growers are used as a baseline. Benefits derived from the use of floatation tires are expected in the form of changes in production costs. As discussed above, earlier access to fields may ultimately result in cost savings due to reduced irrigation requirements. Also, the potential for less field operations to restore field surfaces during wet conditions at harvest/planting as well as changes in herbicide applications may lead to lower production costs. Added costs of depreciation and opportunity cost related to the additional investment in floatation tires are modeled using the capital recovery method (Boehlje and Eidman, 1984). There are also additional labor charges that are incurred when changing tires on tractors and combines. These cost savings and additional expenses are estimated using the Mississippi State Budget Generator (MSBG) (Spurlock and Laughlin, 1992) as well as representative production costs provided by the University of Arkansas Cooperative Extension Service (Windham and Sills, 1999).

Further, the partial budgeting analysis was performed across a variety of operation sizes to determine the impact of operational scale on cost changes. This was done by spreading fixed investment and tire exchange costs of floatation tires over different operation sizes. Changes in variable cost per acre were not varied by operation size, as those costs were assumed to remain relatively stable.

Since yields were not expected to change dramatically from conventional practices as long as a good plant population was established, the changes in production cost adequately reflect expected changes in net returns to land, labor, and management. The economic results discussion thus focuses on cost changes only.

Aerial Seeding

Finally, the study also compares soybean production costs of airplane seeding with that of conventional seeding practices. Again, University of Arkansas Cooperative Extension Service budgets (Windham and Sills, 1999) are used as a baseline and are modified to reflect changes in practices when airplane seeding is implemented.

Results

Aerial Seeding

Study 1

The aerial sowing technique was employed successfully in this situation. Yields ranging from 42 to 56 bu/acre (Table 1) are considered comparable to yields observed on clayey soils using conventional planting followed by irrigated production in Arkansas.

Additional study observations were made on wildlife damage as a direct result of winter flooding with this system. Since the field was winter flooded for wildlife habitat, some water fowl feeding activity resulted in uneven field conditions (potholes with standing water where seed could not establish a stand). These potholes would lead to varying degrees of harvest disruptions depending on the damage resulting from the cutter bar running into the ground. In addition, levee breaching was a result, not only of wildlife damage caused by nutria (digging rodents), but also wind erosion over the winter months.

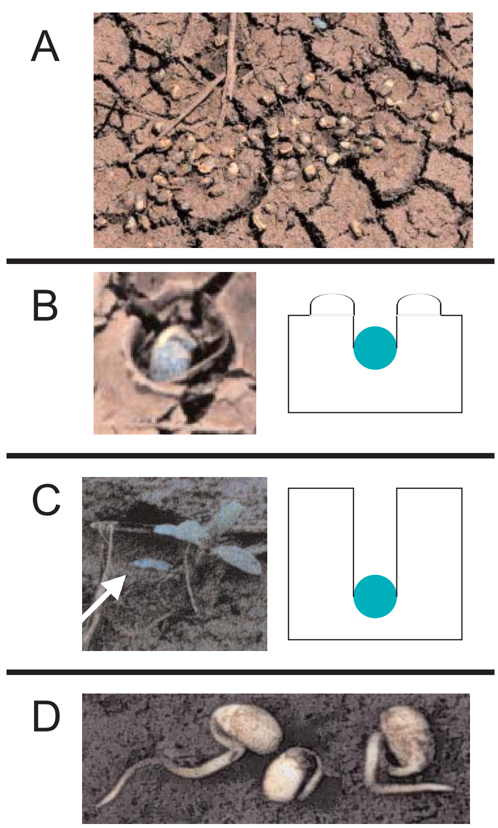
Study 2.

Aerial seeding of soybean resulted in successful soil penetration and good soil contact, but during the evening and night immediately after planting, a heavy rain (~ 4 in.) occurred. As a result, water was standing to a depth of approximately 2-1/2 inches over the entire test area and seed was dislodged from the soil and began to float. Subsequent winds moved the seed from the seeded area to the water's edge where the seed accumulated in masses (Fig. 1A). There was essentially no germinated stand obtained from this seed application; thus, the heavy rain had terminated the study. Thus, even if good soil penetration occurs, a producer stands to lose with adverse weather conditions immediately following seeding.

Study 3

Following sufficient rain to wet the soil, the soil in a stale seedbed was not soft enough for the soybean seed dropped from an airplane to penetrate. The seed bounced and remained on the soil surface. These same results were observed in the area that had been recently plowed. No stand of germinated soybeans was obtained in this study. Thus, prolonged periods of standing surface water appear necessary to allow for soil conditions in the following spring that are conducive to sufficient seed penetration.

Figure 1. Figure 1. Observations made in airplane seeding studies. A. Seed movement by water when seeding is followed by heavy rain and standing water occurs all over the field. B. Soybean seed dropped from airplane burying into mud. C. Soybean seed pushed into soil about 1 inch deep. Note the small weed by the hole as well as the fact that the top part of the seed is showing. D. Soybean seed dropped from airplane into standing water. Note the lack of root hairs, lack of geotropism, and cork-screw growth habit.



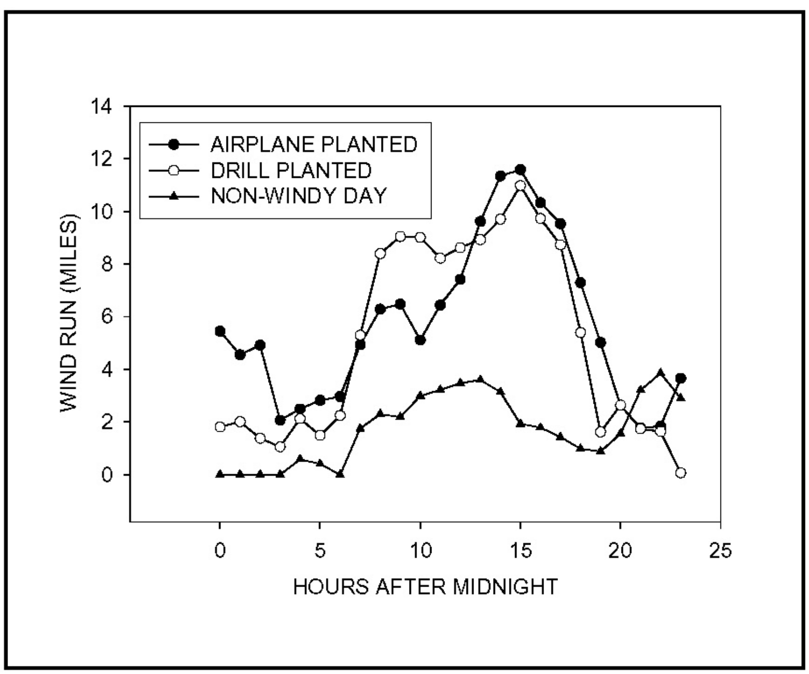
Study 4
Soybean seeds planted with an airplane within one hour after the water receded were embedded in mud about 1 to 1-1/2 times the diameter of the seed (Fig. 1B). The seed imbibed water immediately and showed the tip of the radicle the next morning. At this time, the wind began to blow and desiccated the germinating seeds, resulting in seed mortality. Only an occasional soybean plant survived.

The seed that were manually pushed to a 1 in. depth did not emerge (Fig. 1C - Ignore the small weed and the appearance of shallower seed depth due to characteristics of drying clay soil). Even though the seed were in the soil, they died after imbibing germination water due to the wind drying them out before they could become established (Fig. 2).

Observations of soybean seed dropped from an airplane into standing water were also made in this study. The seed did not penetrate the soil but remained in the water. The seed germinated; however, the radicle grew parallel to the soil surface without penetrating into the soil (Fig. 1D). When the surface water finally evaporated and/or infiltrated, the radicles died from desiccation. These study results suggest that soil coverage is essential to avoid the possibility of poor stand establishment if harsh drying conditions occur after planting.

Study 5
Soybean seed dropped onto wet soil began to imbibe water and swell (Fig. 3.B and C). We observed that when the wet soil was in the form of a slurry, the seed were covered completely with soil (Fig. 3.C). Seed dropped on dry ground did not swell (Fig. 3.A) until it rained the next day. The occurrence of rain showers and other favorable atmospheric conditions (fog and high relative humidity with no or very little wind) during the subsequent days after seeding kept the seed sufficiently wet to become established (Fig. 3.D, E and F) regardless of the initial seedbed condition. It is worth noting that when seed is covered with soil in extremely wet conditions, additional moisture after seeding is not deleterious to seed establishment unless seeds become dislodged from the soil and float to the field's edge

Figure 2. Average wind run, the time-weighted average velocity recorded in 10 second increments, for the day of planting and the following day for the airplane seeded (day 1 and day 2) in the mud and the drill seeded (day 1 and day 2) with large floatation tires. A non-windy day is shown for reference.



(Figure 3.C and F). However, should weather conditions be harsh immediately after seeding, soil coverage protects against seed desiccation similar to conventional planting. This lessens the chance of having to reseed as would be the case with seed placement similar to those situations shown in Figures 1.A through C and 3.A and B with harsh post-plant weather.

To summarize, complete seed soil coverage offers protection against weather risk for the period immediately following the start of the germination process. Various degrees of soil coverage and depth of seed placement in combination with differing severity of weather conditions after planting result in a wide array of success in stand establishment.

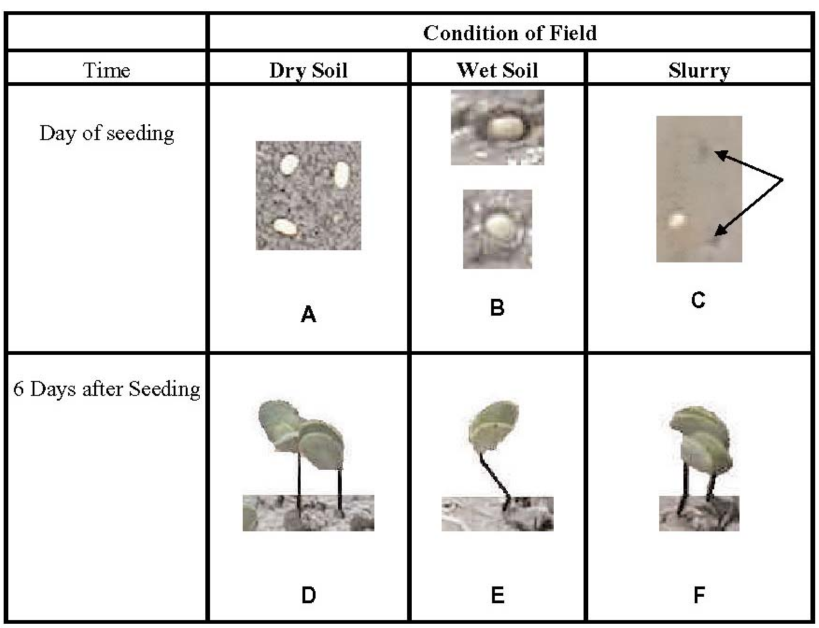
Floatation Tires

Study 6
The soybean crop was established in five days. Although the wide wheel tracks were evident, there appeared to be no need to smooth the field surface due to tracking. The soybean yield for the experiment was 54 bu/acre.

We observed that a crop canopy was formed more quickly than we had observed in the past. The crop's need for irrigation was delayed about ten days compared to crops planted at the same time in adjacent fields using conventional methods (conventionally seeded fields were not flooded to create wet planting conditions). As a result, the fields that were allowed to flood with natural rainfall in the winter required less flood irrigation (~ 4 in.). No other crop growth differences were observed.

Study 7
Rice emerged to a uniform stand eleven days after planting. The residual of the pre-emergence herbicide and the early flooding time eliminated the need for any additional herbicide

Figure 3. Differences in moisture content of seedbed and seed penetration from airplane dropped seed: A. Dry soil, seed on top of soil. B. Wet soil, seed partially submerged and with seed commencing to imbibe water immediately. C. Extremely wet soil, seed covered and with seed commencing to imbibe water immediately (arrows point to covered seed). D, E, F. Seed development for A, B, and C, respectively at 6 days after seeding with continuous humid weather condition after seeding.



applications. The rice remained relatively weed free the entire season and a dry rice yield of 149 bu/acre was harvested. Applying the early flood while the soil had high moisture content allowed the flood to be established in less than half the time as normally planted rice. This resulted in a savings of about six inches of water that did not have to be pumped.

Economics

Floatation Tires

The use of floatation tires compared to conventional tires was associated with added production costs as well as cost savings (Table 3). While weather dependent, it is noteworthy that, regardless of operation size, the potential irrigation cost savings were sufficient to offset the additional investment in tractor tires and tire exchange. For both crops, some additional benefits in the form of variable equipment cost savings and use of less expensive but equally effective herbicide programs are somewhat more weather dependent. If, as a consequence of the use of floatation tires at time of harvest, fields do not have to be disked ($4.88/acre) and leveled ($6.93/acre), no-till production in rice leads to the opportunity of using a herbicide program that leads to net savings of $38.62/acre by switching from conventional custom applied herbicides to a herbicide program that utilizes clomazone and glyphosate only. In summary, cost savings on soybeans and rice may be as high as $17.77/acre and $56.74/acre, respectively.

Overall, the use of floatation tires appears to be a profitable alternative to conventional production. The net impact of the change in production systems is somewhat weather dependent, but can lead to significant increases in net returns to land, labor, and management. Return estimates ranged from -$4.69/acre with no weather dependent cost savings on a 500 acre operation to $36.07/acre in situations where cost savings are achieved and averaged over both crops in a two year rice-soybean rotation on 2000 acres (Table 3).

Finally, additional benefits that are not easily quantifiable in these studies include issues related to soil compaction, water quality, production risk, and preservation of wildlife habitat. Lessened soil compaction with floatation tires may prevent future yield losses. Reduced dependence on irrigation water, which may be of poor quality, would lead to fewer salinity problems. In addition, saved water may: i) be applied for production of other crops; ii) allow for additional irrigated acreage; or iii) be conserved for future use in cases were water supplies are becoming increasingly scarce. Improved access to

Table 3. Impact of floatation tires for planting and harvest in a Rice-Soybean rotation

	Soybean	Rice
Added Cost (compared to Conventional)		
Capital Recovery Charge on Floatation Tires	$1,943 per year ($15,000 with 10 yr useful life @ 5% interest)	
Tire Change (on Tractor and Combine)	$400 per year	
Range in Cost/acre (depending on farm size)	$1.17/acre (2,000 acre) to $4.69/acre (500 acre)	
Cost Savings (compared to Conventional)		
Irrigation Savings (not including fixed costs)	$5.96/acre 4 in. water savings	$6.31/acre 6 in. water savings
Field Preparation[1] (not including fixed costs)	Disking = $4.88/acre (2 passes at $2.44/acre each) Leveling = $6.93/acre	
Herbicide[2]	no change	$38.62/acre
Range of Savings/acre (regardless of farm size)	$0 to $17.77/acre	$0 to $56.74/acre

1 Assuming the farmer keeps the disk and land float. If the farmer were to sell those pieces of equipment, additional fixed cost savings would be available.
2 Savings is the difference between $70.48/acre for a conventional herbicide program and $31.86/acre for a clomazone and glyphosate herbicide program.

fields is expected to lead to larger planting and harvest operating windows with the use of floatation tires in wet conditions. This would in turn reduce the likelihood of untimely completion of field work and thus lead to potential yield increases. Producers that maintain water in fields during the winter for ducks and other wildlife may also be able to leave fields flooded for longer periods, thus affording the opportunity for higher wildlife and hunting benefits.

Aerial Seeding

Major differences between aerial and conventional production methods are timing of operations, changes in seedbed preparation as well as seeding rates, and methods as shown in Table 4. Winter flooding fields for aerial seeding changes the timing of laser survey and levee establishment from early summer to the previous fall. In addition to a slightly increased use of water, surface drainage is important and requires the cutting of additional water-furrows for proper drainage. For weed control prior to planting, there is also the added need for burndown herbicide in the spring using the aerial method whereas the same weed control is achieved mechanically using the conventional method. Aerial seeding was cheaper than conventional seeding since a field cultivator rather than a land plane was used for surface smoothing after disking in order to obtain a puddled field surface after flooding (a condition that increases the likelihood of proper seed placement with aerial seeding). Other notable differences are in the seeding rate. While aerial seeding requires additional seed compared to conventional seeding, lower custom aerial seeding costs partially offset this added seed cost. One final issue is the

Table 4. Comparison of average soybean production costs for aerial vs. conventional seeding on clayey soils in Arkansas, 2000.

Description of Production Costs	Aerial			Conventional		
Seedbed Preparation	Qty[1]	Time	Cost ($/acre)	Qty	Time	Cost ($/acre)
Disking	2	Fall	17.59	2	Spring	17.59
Field Cultivator	1	"	3.59	-	-	-
Floating	-	-	-	2	Spring	13.94
Water Furrows	0.2	Fall	3.90	.04	"	0.78
Flooding (Laser Survey, Levee Building & Pumping Costs)	1	"	15.91	-	-	-
Custom Applied Herbicides	1	Spring	13.38	-	-	-
Drainage	2	"	1.18	-	-	-
Planting Operations[2]						
Custom Seeding/Conventional Planting	1	Spring	3.37	1	Spring	7.21
Treated Seed	75 lbs/acre	"	17.28	45 lbs/acre	"	11.28
Post-Planting Operations						
Custom Applied Herbicides	1	Spring	15.00	1	Spring	15.00
Desiccant	0.25	Summer	3.25	0.25	Summer	3.25
Irrigation						
Laser Survey & Levee Building	-			1	Summer	11.14
Pumping Costs	3	Summer	10.77	3	"	10.77
Butt & Cut Levees	6	"	7.08	6	"	7.08
Levee (Knock-down)	.05	"	0.49	.05	"	0.49
Harvesting	1	Fall	19.50	1	Fall	19.50
Miscellaneous (Interest on Operating Capital)			4.64			3.53
Total[3]	-	-	136.93	-	-	121.56

1 Number of passes per acre. Fractions indicate that either not all areas need to be treated or that treatment would not occur every year.
2 In situations where replanting is needed using the aerial method, another application of burndown herbicide, flooding, draining and reseeding are required. This would amount to additional costs of $39.98/acre.
3 Yield dependent hauling charges and operator labor are not included. Net returns to land, labor, and management could be calculated once sales net of hauling charges are estimated and production costs are subtracted.

essentially prohibitive cost of replanting with the aerial method. To ensure proper wet soil conditions, the field would need to be treated for weed control, reflooded, drained, and reseeded at an estimated cost of $39.98/acre. This compares to $18.49/acre using the conventional method under similar conditions.

Discussion and Conclusions

These observations reflect the problems that can occur in obtaining a crop stand when all necessary factors are not present for germinating seed and establishing a seedling (Wilson and Loomis, 1964). A continuous water supply to replenish that lost by evaporation is necessary to keep the germinating seed from dehydrating and dying. This period lasts from the time that the seed imbibes sufficient water to hydrate its protoplasm and activate its enzyme systems until it is established (i.e., its root system can supply its water needs). The exact timing of the beginning of this process is hard to determine, but it is well underway when the radicle emerges from the seed coat. After this process begins, the protein system cannot be dehydrated and again reactivated. Thus, anything that causes dehydration to occur will kill the "germ" of the seed.

Conditions as those reported for the above trials are not only common to Arkansas but many crop production regions in the U.S. with traditionally difficult-to-manage clayey soils. Given these conditions, this study portrays a large number of pitfalls to plant establishment using aerial seeding. The risk of having to reseed at high cost exists even with deep seed soil penetration as seed exposed to air in sufficiently high drying conditions can be dehydrated and killed. Except where soils are wetter than the upper Atterberg plastic limit, i.e., essentially saturated (Baver, 1956), soybean seed being dropped from an airplane will not result in the upper part of the seed being covered with soil and therefore harsh atmospheric conditions will likely kill the seed. Further, this wet soil condition is difficult to establish across an entire field at the same time. In other words, a trade off exists between unsuccessfully seeding into water covered parts of the field or waiting too long with the result of soil crusting in dry parts of the fields. Finally, excessive precipitation, immediately following planting can dislodge seeds from the soil unless sufficiently embedded in the soil. As a result, unless favorable weather conditions exist immediately following planting, aerial seeding is quite risky.

Conversely, drill planting into extremely wet soil using floatation tire technology protects the seed and ensures that it will not dry out prior to establishment. Therefore, use of the drill essentially eliminates weather risk at the time of planting by protecting the seed from dehydration and allows for irrigation water savings, no-till seedbeds, and alternative herbicide regimes - benefits that lead to substantial costs savings while at the same time allowing for earlier planting, larger operating windows during planting and harvest, and potentially lower risk of poor stand establishment. However, to get the drill to work properly, a soil crust must form to prevent the drill openings from becoming fouled. In addition, operating speeds should not exceed four mph in these wet clay soils as seed adheres to the disk openers and is expelled out the back. This reduces daily planting capacity which somewhat offsets the advantage of wider operating windows during planting.

Acknowledgments

The authors wish to acknowledge the Arkansas Soybean Promotion Board for financial support, the staff of the Northeast Research and Extension Center,and the Southeast Research and Extension Center. Special thanks go to Larry Earnest, resident director of the Southeast Branch Experiment Station at Rohwer, Arkansas. The authors wish to thank E. Ritter Equipment Co., Marked Tree, Arkansas, and Webco Tire and Wheel, Inc., Monroe, Louisiana, for providing equipment and tires for these studies, and C and L Farms, Osceola, Arkansas, for harvesting the rice study.

References

Baver, L. D. *Soil Physics, Third edition*. (New York: John Wiley and Sons, Inc., 1956).

Black, W., L. R. Oliver, and T.C. Keisling. Optimum Seed Rates for Roundup Ready® Soybeans in a Clod-furrow Planting System. Annual meeting of the Arkansas Crop Protection Association, Fayetteville, AR, 1999.

Boehlje, M. D. and V.R. Eidman. *Farm Management.* (New York: John Wiley & Sons, Inc. 1984).

Bryant, M. Presentation given at the Southern Soybean Conference. February 7-9, 1999. Memphis, TN.

Cahoon, J., J. Ferguson, D. Edwards D. and P. Tacker. A Microcomputer-based Irrigation Scheduler for the Humid Mid-south Region. *Applied Engineering in Agriculture* 6(3, 1990): 289-295.

Fehr, W. R., C. E. Caviness, D. T. Burmood and J. S. Pennington. Stage of Development Descriptions for Soybeans *Glycine Max* (L.) Merrill. Crop Science 11(1971): 929-931.

Goodyear Tire and Rubber Company. Farm and Industrial: Farm Tire Handbook. [http//www.goodyear.com/us/tires/farm/handbook.html] as of 3/14/2000.

Helms, R.S. ed. *Rice Production Handbook*. University of Arkansas, Cooperative Extension Service, MP 192, 1996.

Spurlock, S. R. and D.H. Laughlin. *Mississippi State Budget Generator User's Guide, Version 3.0*. Mississippi Agriculture and Forestry Experiment Station Agricultural Economics Technical Publication #88, 1992.

Staff, University of Arkansas Division of Agriculture. *Soybean Update*. 1999 Soybean Varietal Performance. Early Soybean Production Systems (5, 2000a.).

Staff, University of Arkansas Division of Agriculture. *Arkansas Soybean Handbook.* University of Arkansas Cooperative Extension Service, MP197, 2000b.

Wilson, C. L. and W. E. Loomis. *Botany, Third Edition*. (New York: Holt, Rinehart, and Winston, Inc., 1964).

Windham, T. E. and J. Sills. *Estimating 2000 Costs of Production*. Cooperative Extension Service, University of Arkansas Ag-551-12-99, 1999.