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USE OF DRIP IRRIGATION AND VARIETY EVALUATION IN COTTON

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Abstract

Variety trial work using drip irrigation in cotton can be complicated by additional factors in field experimental design that ultimately influence final yield and lint quality. With water being limited in the Western United States, more work with drip irrigation should be used to evaluate new varieties and their performance under drip irrigation separately as well as in combined variety trial evaluations. Seed emergence ability, tolerance to drip irrigation scheduling, date-of-planting differences on varieties and limited tillage operations can all act to help farmers determine which cotton varieties work best under drip irrigation. Looking for new, better yielding cotton varieties should include an evaluation of plant adaptation to drip irrigation management; latitude to other environmental factors; ability for quick, strong emergence; strength in plant growth with limited water resources; and root growth that can utilize banded water reserves within a field while maintaining full boll load and carrying capacity as well as ultimate lint quality during the season and into harvest.

Introduction

Numerous studies have worked with sustainable cotton production from a limited irrigation aspect. And, although trials and farmer strip plots have worked with various varieties, irrigation scheduling, irrigation types and irrigation quantities, seldom are variety trials separated into irrigation treatment evaluations. Review of the current information on irrigated cotton through agricultural journals, reveals that additional studies that concentrate on seed germination and emergence as well as plant variety qualities that invoke sustainability with different crop water management trends may need to be more precise in evaluating cotton varieties in different regions under different irrigation management. 2004 in particular revealed that cotton varieties can react differently to irrigation as well as other soil conditions to such an extent that cotton variety selection may need to be more carefully evaluated and management of varieties under drip irrigation, in particular, should be considered within variety selection by producers.

Indeed, variation in yield has often been attributed to environmental factors and variations in water and fertilizer inputs (Reddy et al., 1992; Cook et al., 2003). Further, differences in response between irrigation treatments and use of a plant growth regulator have been shown to be attributable to irrigation and cultivar differences. Further studies show that more cotton can be produced using drop irrigation if management and variety selection are carefully evaluated (Taylor et al., 1983; Fowler et al., 1982; Wuertz, 1981; Porteous, H. 1981; Bar-Peled et al., 1980; Agmon et al., 1977; Levin et al., 1985; Perlstein et al., 1977; Weldon, 1975). Furthermore, references point to new cotton varieties that may have better potential under drip irrigation (Ariz. Farmer Rancher, 1984) or simply that in the Western United States, cotton yields under tested varieties have the potential for bigger yields (Megeath, 1982). Studies have also linked economic and sustainability to the use of drip irrigation in cotton (Wilson et al., 1984; Wilson et al., 1984). Further, drip irrigation has been suggested as a way to solve cotton yield problems in fields with significant slope or less soil moisture holding capacity or under limited irrigation conditions or with unusual soil contamination or other environmental problems that can affect cotton growth (Ariz. Farmer Rancher, 1984; Ariz. Farmer Rancher, 1984; Feigin et al., 1984; Tollefson et al., 1983; Levin et al., 1985; Gensler, 1985). Drip irrigation and some of the adaptation of varieties has also been mentioned based on specialized problems such as salinity associated with this type of irrigation (Ayars et al., 1985; French et al., 1985; Helevy et al., 1986; Ayars et al., 1984; Mantell et al., 1985).

Within the above references as well as numerous others, the information continues to accumulate that perhaps specific cotton varieties can work better under drip irrigation through an assortment of reasons including plant adaptation to drip irrigation management; latitude to other environmental factors; ability for quick, strong emergence; strength in plant growth with limited water resources; and root growth that can utilize banded water reserves within a field while maintaining full boll load and carrying capacity (Meek et al., 2002; Davidonis et al., 2003; A-El-Dahan et al., 2002; West-Emerson et al., 2002; West-Emerson et al., 2003). Unfortunately, variety trial information on cotton is often combined within a region across tests, thus eliminating the variety differences that might be seen among drip versus sprinkler, row or even flood irrigation. A closer inspection of variety adaptation to irrigation types while difficult to evaluate due to differences in management might be worthwhile for individual farmers who are wanting to optimize lint quantity, quality and field management.

Materials and Methods

Two trials were run in 2004 on various cotton varieties in order to ascertain differences in cotton varieties under drip irrigation and to then compare these trials to other row irrigated trials in the region for differences in crop quantity and quality. The first trial was an Upland cotton trial that included six different Delta & Pine Land varieties including: DP 555, DP 488, DP 449, DPLX 01, DPLX02 and DPLX03. The first three varieties are commercially available cotton while the last three in this first trial are new experimental varieties. The second trial consisted of four different Upland cotton varieties including: DP 555, DP 488, Stoneville ST 5599 and Stoneville ST 5242. Each trial had each variety replicated in strips four times in a randomized, replicated plan. Both dates of planting were April 30, 2004 at a seeding rate of six seed per foot at a depth of 1 to 1.5 inches. Row length of each strip was 1112 feet and each strip of each variety was four, 40-inch rows, making each variety strip about 0.3404 acres in size, replicated four times through each trial. Eight-row John Deere equipment was used to plant the trials with four boxes containing one variety and four boxes containing another variety that then was flagged to each randomized, replicated strip for the two varieties with the only constraint a preset randomization based on the two-variety planting manner. The soil type for the field was a sandy clay loam that was very uniform across the field with drip irrigation just established in the field new for this season at seven inches in depth, a replacement of a previous drip system that was established closer to the soil surface. This depth of drip irrigation is not unusual for drip irrigation in the region due to tillage demands from soil dispersion and compaction from some salinity in the irrigation water that is derived from water held in the Elephant Butte Irrigation district reserves that hold water runoff from the Rio Grande River as well as other sources. Likewise, irrigation water used from wells in the region often are only 60 to 250 feet in depth, varying based on vicinity to the Rio Grande river and recharge effects from water within the soil profile which too can be fairly saline. This particular field for both trials was located just west of La Union, New Mexico, near the farmer’s residence. Soil temperatures the previous week were up above 65F at the three inch depth and although consistent for another week, did dip back down to below 55F during the two weeks following initial seed germination. First watering utilized the drip irrigation with two back-to-back irrigations of 12 hours each in order to saturate the soil zone up to the seed from the deep drip tape. Later irrigations were not doubled but merely supplemented the soil moisture content in order to push cotton growth and development. Readings were taken on emergence and vigor twice within the first two months and yield was taken based on boll buggy weights obtained from picking each strip of each variety separately. These weights were then converted to pounds per acre. Samples were taken of each variety strip and replication and run for lint quality and turnout. This information was then used to determine actual bales per acre obtained for each variety strip and then averaged across each variety in each trial to determine yield. These results were then analyzed statistically to determine differences in varieties across the trials.

Results and Discussion

The results from both trials revealed that certain varieties did yield better under this drip management and that possibly two main characteristics of the top varieties were better emergence and germination as well as plant variety latitude toward lessening soil moisture conditions between irrigations. While many plant variety characteristics have been examined over the years through research, a definitive way to characterize cotton by soil moisture stress has largely been limited to general drought-tolerant studies or growth chamber or greenhouse physiology studies to determine overall drought-tolerance of varieties rather than specific bounce-back characteristics of varieties between irrigations. Indeed root growth and development, soil type and texture as well as irrigation water quality can all influence cotton growth and latitude of continued development between irrigations; however, some cotton varieties seem to simply adjust to changing environmental and soil moisture conditions better than others, beyond growth conditioning that has occurred through the season. In particular, early germination and emergence when the cotton plant is not yet conditioned to changing field factors including soil moisture as well as during boll development and fill, cotton varieties seem to respond differently to the management and situation.

Early results from vigor and emergence ratings are shown below:

Table 1. Drip trial one variety vigor ratings with ratings based on a 1-5 scale with 1 showing the best vigor.

Company	Variety	Avg. Vigor	0.05
D&PL	555	2.19	b
D&PL	488	2.19	b
D&PL	449	2.00	b
D&PL	DPLX 01	2.44	a
D&PL	DPLX 02	2.50	a
D&PL	DPLX 03	2.63	a
Trial Mean		2.33	

Table 2. Drip trial one emergence ratings based on stand (number of plants) per acre.

Company	Variety	Avg Stand/A	0.05
D&PL	555	35588.50	a
D&PL	488	31752.13	b
D&PL	449	37384.25	a
D&PL	DPLX 01	35098.75	a
D&PL	DPLX 02	30282.88	b
D&PL	DPLX 03	29711.50	b
Trial Mean	33303.00		

Table 3. Drip trial two variety vigor ratings with ratings based on a 1-5 scale with 1 showing the best vigor.

Company	Variety	Avg Vigor	0.05
D&PL	555	2.31	a
D&PL	488	2.00	b
Stoneville	5599	1.81	b
Stoneville	5242	2.31	a
Trial Mean		2.11	

Table 4. Drip trial two emergence ratings based on stand (number of plants) per acre.

Company	Variety	Stand/a	0.05
D&PL	555	44404.00	a
D&PL	488	38853.50	b
Stoneville	5599	43502.86	a
Stoneville	5242	41961.78	a

Trial Mean	42180.54

Within these results, it was surprising that the variety with the smallest seed did not germinate or emerge the quickest. Germination is partially a product of water imbibition by the seed for the seed processes to react toward germination and then emergence. The uptake of water by seeds is an essential, initial step toward germination (Bewley et al., 1985). The total amount taken up during imbibition is generally quite small and may not exceed two to three time the dry weight of the seed. Many factors govern the movement of water from soil into the seed but in particular, the water relations of the seed and of the soil make the difference in germination and eventually can affect ultimate emergence. Pure water, of course has the highest potential for initiating germination in seed. Cells in a seed are also affected by three components in water potential: the osmotic potential (concentration of dissolved solutes influencing uptake), the matric component (the ability of the seed to be hydrated and bind water), and, the pressure potential exerted as water enters the seed cells and the contents swell and exert a force on the external cell walls. The soil, too, has its own water potential. But, the difference in water potential between seed and soil helps determine availability and rate of flow of water to the seed. Indeed, capillary and vapor movement of water near the seed is influenced by soil compaction (bulk density) and in mechanical restraints of swelling seed and decreased imbibition. Other factors also include degree of contact of the seed with soil moisture (seed-soil contact). This varies with seed size and shape and with the texture and compactness of the soil itself. Small seeds with relatively smooth coats tend to be the most efficient in absorbing water owning to their greater contact with soil as well as their larger surface area and volume ratio.

Indeed, even the uptake of water by seeds is triphasic. In phase one, imbibition, water uptake occurs regardless of whether the seed is dormant or non-dormant, viable or nonviable. Water uptake in seed has three characteristics within this imbibition stage: first, a sharp wetting front separates the wet and dry portions of the seed, second, the seed continues swelling as water reaches new regions and third, an increase in water content of the wetted area occurs. Metabolism can commence in the seed during this first phase, even within minutes of water introduction in the seed. In phase two, the lag phase of water uptake, major metabolic events take place in preparation of radicle emergence from non-dormant seeds. In phase three, germinating seeds increase water uptake and changes in cells of the radicle occur as radicle elongation begins. The duration of each of these phases depends on certain inherent properties of the seed including such factors as hydratable substrate levels, seed coat permeability, seed size, oxygen uptake and such hydration conditions as temperature, moisture levels and composition of the substrate.

In cotton, as in other seed, this initiation stage is very important not only to stand establishment but also to jump start the development process of cotton, particularly in drip irrigation. Looking more at various cotton seed germination and emergence potentials as well as at "latitude" across changes in conditions whether environmental or management made can optimize variety selection, possibly to even determining better varieties under different management and irrigation type as well as timing and water quality.

More work should be done on variety adaptation between irrigations as well as general overall drought tolerance now being research in the effort to optimize cotton water use and in finding possible drought-related genes that can enhance cotton production. And, even within certain phenotypes of cotton, there may be more room for further exploration of cotton latitude toward irrigation management of cotton plants beyond leaf type or more upright plant structure as has been proven to work in such crops as cotton and soybeans. The difficulty with evaluation of a perennial plant such as cotton that is grown as an annual is that the adaptation toward water management does not seems as direct a relationship in cotton as is seen in soybeans. Indeed, the perennial plant life cycle properties of cotton may indeed provide a mechanism that can be further explored in order to not only emphasize cotton's possible latitude toward water management, particularly late in the season during the critical times of boll development and fill but may also serve genetic scientist with fodder for other annual crops such as soybeans on drought-stress genes that may adapt other varieties to more of a sustainable production in drier years or under less irrigation. Examining more varieties specifically under drip irrigation in different situations and conditions will help in evaluating cotton varieties over time.

In the finding between the two drip irrigation trials run in 2004, the quantity and quality results were as follows:

Table 5. Drip trial one quantity and quality results for each variety.

Company	Variety	Yield lbs/a	Lint % %	Micronaire	Length Inches 2.5% span	Strength HVI	Elongation %	Lint lbs/a	Bales bales/a	0.05
D&PL	555	3855.76	43.75	4.09	1.13	19.02	6.44	1686.70	3.51	b
D&PL	488	4014.39	42.04	4.17	1.16	20.45	7.81	1687.55	3.52	b
D&PL	449	4931.70	41.46	4.37	1.15	20.79	7.38	2044.81	4.26	a
D&PL	DPLX 01	2027.76	40.47	3.83	1.17	20.62	7.69	820.64	1.71	c
D&PL	DPLX 02	4051.85	42.85	1.12	1.12	20.75	7.31	1736.02	3.62	b
D&PL	DPLX 03	4250.88	40.70	3.69	1.16	19.68	7.13	1730.00	3.60	b
Trial Mean		3855.39	41.88	3.54	1.15	20.22	7.29	1617.62	3.37	

Table 6. Drip trial two quantity and quality results for each variety.

Company	Variety	Yield lbs/a	Lint % %	Micronaire	Length Inches 2.5% span	Strength HVI	Elongation %	Lint lbs/a	Bales bales/a	0.05
D&PL	555	3898.35	43.78	3.47	1.13	19.43	7.05	1706.80	3.56	bc
D&PL	488	4045.24	41.64	3.65	1.18	20.57	7.13	1684.34	3.51	c
Stoneville	5599	4351.74	42.56	3.54	1.13	19.51	7.25	1852.25	3.86	a
Stoneville	5242	4012.19	43.96	4.09	1.10	18.52	7.25	1763.86	3.67	b
Trial Mean		4076.88	42.99	3.69	1.14	19.51	7.17	1752.51	3.65	

As the results show, even with lower than average growing degree days in 2004 under drip irrigation, differences in varieties were seen. In particular, the smallest seeded variety (DP 555) that was expected to get the best jump start for the season, did not. However, other reports across the cotton belt have mentioned with the introduction of DP 555, that it is slower to emerge although some reports state otherwise (Howard et al., 2004). Further studies on seed characteristics as well as latitude of the plant to stresses should be better evaluated. A recent study run through the USDA-ARS-SRRC textile laboratory out of New Orleans compared eight different cotton varieties through the new advanced fiber information system (AFIS) showed that one of the varieties, DP 555 had the potential for less uniform fiber lengths within the cotton staple (Textile Manuf. Symp., 2004). Further, recent mill rejections in Georgia during 2003-2004 has brought up the question of further refining testing of cotton through quality control throughout processing of cotton fiber. In order to compete with world markets, continued work in variety selection for better jump start growth as well as latitude throughout the season to changes in field conditions as well as ultimately fiber quality by reducing short fiber content, reducing neps and seed coat fragments as well as reducing maintenance of cotton lint, even in poor harvesting conditions such as 2004 is needed.

As with other seed characteristics, if possible, a better information base on seed germination and emergence as well as fiber lint quality and quantity should be collected through universities. Use of not only the high volume instrument (HVI) for lint quality but that of AFIS should be further explored for turn-around advice to farmers on cotton variety selection particularly as Southwest farmers look for more sustainable production with limited irrigation and with irrigation water of various water quality. Along with possibly better varieties for quick germination and emergence under drip irrigation management and with latitude to limited to broader stresses in fields where drip is being used to economized water use and ebb out limited water resources with variable quality, more farmer strip trials and research work should be implemented to test cotton varieties more completely for best fit for various regions.

Conclusions

The variation in seed germination and timing could not be correlated to seed size in these trials but varieties that had early emergence yielded better within similar maturity ratings. Drip irrigated trials have shown that different cotton varieties tend to have varied germination and emergence timings and that like most other crops can show early differences among varieties from this early advantage or disadvantage in growth. Too often, some of our close variety trial yield results may simply be a product of this early difference. Additional research including more work on variety differences in yield and quality should be run to more specifically determine if many of our closely yielding cotton varieties really have differences overlooked in the early germination and emergence timing. Also, variety trial results as available with different irrigation types should be evaluated for better varieties with specific irrigation management in order to more closely evaluate the best seed candidate for different farmers in specific regions and irrigation management needs rather than averaging results across different irrigation types. While in the best of irrigation modes, varieties should react similarly, we are finding in the arid Southwest, that more data on drip irrigation is needed across cotton varieties and water qualities. Drip irrigation may be the best method to optimize yield by lessening drought stress between irrigations with more frequent water availability and less evaporative losses.

Recent five year results from many universities at the 2004 Cotton Beltwide Conference also indicate that many of the commercial cotton varieties are possibly reaching a yield plateau and that gains might be better derived from row-spacing and plants per acre as well as accompanied by irrigation management. Through recent results in cotton breeding in Acala and Pima varieties here at New Mexico State, some additional genetic gains in yields still seem promising for commercial products (Zhang, 2004). However, the most promising, quick avenue toward consistent yield gains appears to be further exploration of cotton variety "latitude" toward management pros and cons particularly during germination and emergence as well as during the boll formation and fill and ultimately revealed as lint quality and quantity. This optimization must be managed by picking varieties that have greater adaptability to changes in the environment, including moisture stress problems. Optimizing the cotton varieties in each field becomes more essential as worldwide fiber supplies are held steady or enlarged beyond mill needs and consumer demands. Tracking more information on specific cotton seed latitude to changes in seasonal conditions in the field becomes more in demand. Not only is the cotton market one of quantity but as requests for quality lint continue to drive price, premiums and demands, more specific work in optimizing cotton growth by variety latitude under drip irrigation and its management will be imperative to the Southwest cotton belt.

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