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AGRONOMY

Wick Applicator for Applying Mepiquat Chloride on Cotton: II. Use in Existing Mepiquat Chloride Management Strategies

Alexander M. Stewart,* Keith L. Edmisten, Randy Wells, Alan C. York, and David L. Jordan

INTERPRETIVE SUMMARY

Mepiquat chloride (PIX™, Mepi-Chlor™, and others) is widely used in cotton production to control excessive vegetative growth. Although many rates and timings of application for mepiquat chloride have been investigated, almost all are made as a broadcast spray. A relatively new wick application system that can be calibrated has become available and may provide an alternative method of applying mepiquat chloride. The wick applicator delivers a very low volume of solution and can be easily mounted to implements and sprayers, allowing simultaneous mepiquat chloride applications with other crop protection chemicals without the need for tank mixes or auxiliary tanks mounted to tractors and sprayers. The objective of this study was to determine the effect of mepiquat chloride applied through a wick at different rates and timings and to establish guidelines for the height the wick should be mounted relative to the cotton.

Favorable responses to mepiquat chloride depend on environmental conditions at and following application. Therefore many researchers have investigated the effect of application timing on cotton yield. Some methods have employed automatic applications based on the growth stage of cotton; others employ plant-monitoring techniques to trigger a mepiquat chloride application. Timeliness of the application is important for achieving the desired results, particularly when using plant-monitoring techniques. Due to its simplicity, low volume of application, and the ability to treat only the tallest plants in the field, the wick applicator may facilitate more timely mepiquat chloride applications required by plant-monitoring guidelines.

An application method and timing experiment was conducted to compare the effects of mepiquat chloride on cotton growth and yield when applied with the wick delivery system and a broadcast sprayer at rates and timings typical of mepiquat chloride management strategies. Mepiquat chloride was applied at a rate of 4 and 8 fl oz per acre (0.012 and 0.024 lb a.i. per acre, respectively) at the 9 to 10 node stage and early bloom, using either the wick or sprayer. For the wick treatments, the wick was set to affect only the top 3 in of the plants. Plant height, main-stem nodes, nodes above white flower, lint yield, lint percentage, micronaire, fiber length, and fiber strength were measured.

Mepiquat chloride did not affect lint yield, lint percentage, micronaire, fiber length, or fiber strength irrespective of application system or timing. In the first year, plant height was reduced most by mepiquat chloride applied with a wick at the 9 to 10node stage followed by a spray application at early bloom. In the second year, height reduction by a wick application of 4 oz per acre at 9 to 10 nodes was equal to 4 oz per acre spray application at 9 to10 nodes followed by 8 oz per acre sprayed at early bloom, indicating a greater effect of mepiquat chloride when applied through a wick. Few differences between the application systems or among timings were noted for main-stem nodes, height-to-node ratio, or nodes above white flower at cutout.

A separate experiment was conducted to determine guidelines for the height the wick should be set relative to the cotton. A 6 oz-per-acre rate of mepiquat chloride was applied at the 9 to 10node stage as a broadcast spray and by wicking the cotton's top 3 in or top 9 in.

Wicking the top 9 in reduced yield compared to nontreated cotton in three of six environments, while wicking the top 3 in reduced yield twice. Mepiquat chloride applied with a spray did not

A.M. Stewart, Louisiana State Univ. Agric. Center, Dean Lee Research Station, Alexandria, LA 71302; K.L. Edmisten, R. Wells, A.C. York, and D.L. Jordan, Dep. Crop Science, North Carolina State Univ., Raleigh, NC 27695-7620. Received 03 July 2000. *Corresponding author (sstewart@agctr.lsu.edu).

affect yield compared to nontreated cotton and yielded more lint than did cotton receiving mepiquat chloride wicked on the top 8 in at one location. There was no difference in yield between wicking the top 3 in and the top 9 in. Mepiquat chloride reduced plant height irrespective of the application method and to the greatest extent by wicking the top 9 in. Main-stem nodes, height-to-node ratio, and nodes above white flower were all reduced by mepiquat chloride irrespective of application method.

Results suggest mepiquat chloride applied with a wick may reduce height more effectively than spray applications. Achieving maximum height control alone is not a justification for mepiquat chloride use. However, data from the wick height experiment show that if mepiquat chloride is to be applied with a wick, producers are likely to achieve similar overall results to a spray application by setting the wick to wipe the top 3 in rather than the top 9 in.

The wick applicator, because of its design and low volume of application, could be mounted easily to a herbicide or nitrogen applicator at the 9 to 10node stage, thereby saving a later trip across the field for a mepiquat chloride-only application. Where mepiquat chloride is needed, an early wick application may maximize potential benefits of the growth regulator with a lower application cost. The practical advantage to the wick delivery system for producers is in the lower volume of application, allowing for more acreage to be treated without refilling. Fewer auxiliary tanks are needed. Additionally, the simple design of the wick delivery system eliminates costly pumps, hoses, and nozzle fittings. The ability to mount the wick applicator to implements and sprayers for simultaneous application with other crop protection chemicals, while treating the tallest plants in a field, may also facilitate a more timely application of mepiquat chloride where needed.

ABSTRACT

Mepiquat chloride (1,1-dimethylpiperidinium chloride) is widely used in cotton (*Gossypium hirsutum* L.) to control excessive vegetative growth. One way to apply mepiquat chloride is with a wick applicator mounted at a specific height on implements or sprayers. Two experiments conducted in 11 environments compared wick application of mepiquat chloride to a conventional spray application in three mepiquat chloride management strategies and investigated the effect of setting the wick at two heights for cotton. In one experiment, mepiquat chloride did not affect yield regardless of application system when applied at 9 to10 nodes and/or early bloom. Plant height was reduced by mepiquat chloride applied with a wick at 9 to10 nodes more than by a spray application or a two-step approach of a spray followed by a wick application at early bloom. Height-to-node ratio, main-stem nodes, and nodes above white flower were reduced by mepiquat chloride irrespective of delivery system. In the second experiment, setting the height of the wick to touch the top 8 cm of the plant reduced yield compared with a spray in one of six environments. Setting the wick to brush the top 24 cm reduced yield in two environments. There was no difference in yield between wicking the top 8 cm and the top 24 cm. These data suggest that reduced plant height is the major difference that occurs between wick and spray delivery systems, and the wick should be set to treat only the top 8 cm of the plant.

Cotton is a perennial plant that can grow vegetatively at the expense of reproductive growth. In cultivating cotton as an annual crop, producers attempt to manage excessive vegetative growth through judicious use of N and irrigation, and sometimes with the application of mepiquat chloride (Silvertooth et al., 1999). Use of mepiquat chloride on cotton has become widespread since the 1980s, and its ability to create a more compact plant has been well documented (Kerby, 1985; Reddy et al., 1990; Stuart et al., 1984; York, 1983).

Because a favorable response to mepiquat chloride depends on environmental conditions at and following application, studies have investigated effects of application timing on cotton response. Guthrie (1989) reported that at nine North Carolina sites mepiquat chloride increased yield, compared with nontreated cotton when used in low-rate, multiple applications starting at match-head square or when applied once at early bloom. Weir et al. (1991) reported that multiple, low-dose applications of mepiquat chloride slightly increased yields over a single application at early bloom in 76-cm row cotton. However, one early bloom application performed better in 97 or 101 cm rows. Other research suggests that mepiquat chloride can be scheduled better by using plant monitoring techniques rather than automatic application based on growth stage. Fletcher et al. (1994) based applications on height-to-node ratio; Edmisten et al. (1995) used plant height, height-to-node ratio, and square retention as guidelines. Cotton yields with mepiquat chloride applications based on plant monitoring were equal to or greater than yields where mepiquat chloride was applied automatically. Also, less mepiquat chloride was used.

Weir (1993) separated average plant heights from 17 California tests into short, medium, and tall (96, 116, and 165 cm, respectively) categories and reported a more consistent response to mepiquat chloride when it was applied to tall cotton. In tests conducted on fields with variable plant height, Munier et al. (1995) applied mepiquat chloride at variable rates based on the tractor driver's perception of relative plant height, whereby larger plants received more mepiquat chloride. When pooled over nine locations, variable rate application was slightly less effective in increasing yield than broadcast application was, despite a high percentage of short and medium plants in the field. Possible explanations for this response may have been the inherent plant-to-plant variability in the field as well as the perspective of the operator. A system that applies mepiquat chloride only to the tallest plants, at the most appropriate growth stage, may hold promise for maximizing efficacy of mepiquat chloride.

Development of a wick delivery system for mepiquat chloride may allow applications that affect only the tallest plants. Research comparing wick application to spray application has revealed lower use rates were possible in the wick delivery system (Stewart et al., 2001). As a practical matter, the wick applicator can be easily mounted on other implements as well as on sprayers for simultaneous application with other crop protection chemicals. Optimizing performance of mepiquat chloride would be useful in cotton production systems. Therefore, the objectives of these experiments were: (i) to compare cotton response to mepiquat chloride applied by a wick and by a broadcast spray within the context of prevalent mepiquat chloride management systems; (ii) to establish a wick-mounting height requirement for cotton for effective application of mepiquat chloride through the wick delivery system.

MATERIALS AND METHODS

Method and Timing Experiment

The experiment was conducted at five locations in North Carolina in 1998 and 1999. Soils and locations in 1998 were Norfolk sandy loam (fine-loamy, siliceous, thermic Typic Paleudult) near Rocky Mount; Aycock sandy loam (fine-silty, siliceous, thermic Typic Paleudult) near Snow Hill; and Perquimans silt loam (fine-loamy, mixed, thermic Typic Ochraquult) near Edenton. The1999 sites were Goldsboro sandy loam (fine-loamy, siliceous, thermic Aquic Paleudult) near Lewiston, and Nahunta loam (fine-silty, siliceous, thermic Aeric Paleaquults) near Trenton. Cotton was planted between 25 April and 12 May and standard production practices for eastern North Carolina, with the exception of mepiquat chloride applications, were followed. Cotton was not irrigated.

Treatments included a nontreated control of 25 g a.i. ha^{-1} mepiquat chloride sprayed at the early bloom stage (three white blooms per 3 m of row), 25 g ha^{-1} mepiquat chloride wicked at early bloom stage, 12 g ha^{-1} mepiquat chloride sprayed on 9 to 10node cotton, 12 g ha^{-1} mepiquat chloride wicked on 9 to 10 node cotton, and 12 g ha^{-1} wicked when cotton had 9 to10 nodes, followed by 25 g ha^{-1} sprayed at early bloom. An additional treatment of 12 g ha^{-1} mepiquat chloride sprayed at 9 to10 nodes followed by 25 g ha^{-1} sprayed at early bloom was included in 1999. The experimental design was a randomized complete block with treatments replicated four times. The wick applicator described by Stewart et al. (2000) was set to wipe the top 8 cm of the cotton and calibrated to deliver 5 L ha^{-1}. Broadcast sprays were applied with a CO_2-pressurized backpack sprayer delivering 150 L ha^{-1} at 207 kPa through two flat-fan nozzles per row. Plots were 15 m long by four 92 or 97 cm rows.

Wick Height Experiment

The experiment was conducted at six locations in North Carolina in 1998 and 1999. Soils and locations in 1998 included: Torhunta loam (coarse-loamy, siliceous, thermic Acid Typic Humaquept) near Goldsboro; Stallings loamy fine sand (coarse-loamy, siliceous, thermic Aeric Paleaquult) near

Trenton; and Wando fine sand (Siliceous, thermic Typic Udipsamment) near Scotland Neck. The 1999 sites were Norfolk sandy loam near Snow Hill; Perquimans silt loam near Edenton; and Wando fine sand near Scotland Neck. Cotton was planted between 25 April and 12 May, depending on location, and standard production practices for eastern North Carolina were followed. Cotton at both Scotland Neck environments was irrigated.

The experimental design was a randomized complete block with treatments replicated four times. When cotton reached the 9 to 10 node stage, a random sample of 20 plants from each replication was taken to determine mean plant height. Mepiquat chloride at 18 g ha^{-1} was applied then as a broadcast spray, via wicking with the applicator set at a height to treat the top 8 cm of the plants, and via wicking with the applicator set to treat the top 24 cm of the plants. A non-treated control was included at all locations. The wick applicator and backpack sprayer described previously were used to apply mepiquat chloride. Plots were 15 m long by four 92 or 97 cm rows.

General Methods

Plant height, number of main-stem nodes, and nodes above white flower were determined from a random sample of five plants from the two inside rows of each plot when the earliest maturing treatments at each location were judged to have reached cutout. First- and second- position fruit retention by node were determined by plant mapping prior to defoliation. The center two rows of each plot were harvested once with a two-row spindle picker modified for small-plot harvesting. Approximately 300 g of seedcotton were obtained and ginned on a 12-saw gin to determine lint percentage. For the method and timing experiment in 1999 only, micronaire, staple length, and strength of recovered lint were determined by high volume instrumentation testing (HVI) at the Cotton Incorporated HVI laboratory in Raleigh, NC.

Data were analyzed using SAS Proc GLM procedures. Mean separation was achieved with Fisher's Protected LSD test at P = 0.05 (SAS, 1987). Data from the method and timing study are presented pooled across locations within years. Yield and fiber properties from the wick height experiment are reported by location.

RESULTS AND DISCUSSION

Method and Timing Experiment

In both 1998 and 1999, greatest height control was obtained with mepiquat chloride delivered through the wick at 9 to 10 nodes followed by a subsequent sprayed application at early bloom (Table 1). In 1999, height was similar with one wick application at 9 to 10 nodes and two sprayed applications at 9 to 10 nodes followed by an early bloom application. Cotton receiving a wick application at 9 to 10 nodes was shorter than cotton receiving an equal rate per hectare sprayed at 9 to 10 nodes, indicating a greater effect of mepiquat chloride when applied with a wick as compared with a spray. This may be due to the system concentrating the mepiquat chloride in a band (Stewart et al., 2001).

Few differences between delivery systems and among application timings were observed for

Table 1. Effects of mepiquat chloride application systems, rates, and timings on cotton growth in 1998 and 1999.

			Height		Nodes		Ht:node†		NAWF‡	
		Rate	1998	1999	1998	1999	1998	1999	1998	1999
Applicator	Timing	g ha^{-1}	cm		no.		cm $node^{-1}$		no.	
Untreated			95 a§	111 a	17.3 a	18.0 a	5.5 a	6.2 a	4.5 a	6.1 a
Spray	9-10 nodes	12.25	82 b	95 b	16.3 b	16.1 bc	5.0 a	6.1 ab	3.8 bc	5.3 abc
Wick	9-10 nodes	12.25	82 b	88 c	16.4 b	15.9 bc	5.0 a	5.5 abc	4.2 bc	5.0 bc
Spray	Early bloom	24.50	87 b	96 b	16.6 ab	16.9 b	5.3 a	5.7 abc	4.0 abc	5.3 abc
Wick	Early bloom	24.50	83 b	94 b	15.8 b	15.9 bc	5.3 a	6.1 ab	4.0 abc	5.5 abc
Wick then spray	9-10 nodes;	12.25	75 c	82 d	16.1 b	15.5 c	4.7 a	5.3 c	3.5 c	4.6 c
	Early bloom	24.50								
Spray then spray	9-10 nodes;	12.25		89 c		16.2 bc		5.4 bc		5.4 abc
	Early bloom	24.50								
CV(%)			7.7	6.8	4.6	8.2	7.0	14.3	13.7	18.6

† Height-to-node ratio.
‡ Nodes above white flower.
§ Means within a column followed by the same letter do not differ significantly (P < 0.05).

Table 2. Effect of mepiquat chloride applied with a sprayer and with a wick applicator set at two heights on cotton yield and lint proportion.

		Lint	
		Yield	Proportion
Location	Treatment	kg ha^{-1}	%
Goldsboro,	Untreated	1440	41.6
1998	Spray	1480	41.1
	Wick top 8 cm	1370	41.9
	Wick top 24 cm	1130	40.0
	$LSD_{0.05}$	250	NS
Scotland Neck,	Untreated	1380	41.0
1998	Spray	1570	40.3
	Wick top 8 cm	1480	40.2
	Wick top 24 cm	1520	40.5
	$LSD_{0.05}$	NS	NS
Trenton,	Untreated	1080	42.7
1998	Spray	950	41.1
	Wick top 8 cm	920	41.5
	Wick top 24 cm	900	41.5
	$LSD_{0.05}$	140	1.0
Edenton,	Untreated	800	37.2
1999	Spray	830	37.4
	Wick top 8 cm	850	36.9
	Wick top 24 cm	860	37.1
	$LSD_{0.05}$	NS	NS
Scotland Neck,	Untreated	1030	38.6
1999	Spray	930	36.9
	Wick top 8 cm	980	38.1
	Wick top 24 cm	910	36.6
	$LSD_{0.05}$	NS	1.5
Snow Hill,	Untreated	510	37.9
1999	Spray	510	37.8
	Wick top 8 cm	440	36.5
	Wick top 24 cm	450	37.0
	$LSD_{0.05}$	50	NS

number of main-stem nodes, height-to-node ratio, and nodes above white flower. Mepiquat chloride reduced the number of main-stem nodes compared to nontreated cotton irrespective of delivery system or timing with the exception of 25 g ha^{-1} applied as a spray at early bloom in 1998 (Table 1). There were no differences in height-to-node ratio or nodes above white flower between delivery systems. However, enhanced maturity compared to nontreated cotton resulted from mepiquat chloride applied through a wick or as a spray at the 9 to 10 node stage in 1998 and through a wick only in 1999.

Mepiquat chloride, applied via wick or spray delivery systems, did not affect cotton yield, lint percentage, or fiber properties. Mepiquat chloride often does not affect yield when cotton is planted early (Cathey and Meredith, 1988) or when moisture is limiting (Boman and Westerman, 1994; Edmisten, 1994). York (1983) observed that yield responses to mepiquat chloride could be attributed to rainfall in most situations. The likely explanation for a lack of a positive or negative yield response in our experiment is that cotton was not irrigated and rainfall was light and sporadic enough to limit excessive vegetative growth, but not severe enough to cause a yield reduction.

Wick Height Experiment

A treatment-by-environment interaction was observed for yield; therefore, data are presented for each environment. When delivered as a broadcast spray, mepiquat chloride had no effect on yield (Table 2). Wicking mepiquat chloride on the top 24 cm of cotton reduced yield, compared with nontreated cotton 12 to 22% in three of the six environments. Wicking the top 8 cm reduced yield 14 to 16% in two environments. Compared with spray application, wicking mepiquat chloride on the top 24 cm of the plant reduced yield 24% at Goldsboro in 1998 and 12% at Snow Hill in 1999. Cotton receiving mepiquat chloride wicked on the top 8 cm yielded less than cotton with a spray application at Snow Hill in 1999. No differences, however, in yield were noted between wicking the top 8 cm and the top 24 cm of cotton. Yield

Table 3. Effect of mepiquat chloride applied with a sprayer and with a wick applicator set at two heights on cotton growth. Data pooled across six environments.

	Height	Nodes	Ht:node†	NAWF‡
Treatment	cm	no.	cm	no.
Untreated	105	18.6	5.7	5.9
Spray	92	17.7	5.2	5.3
Wick top 8 cm	89	17.2	5.1	5.1
Wick top 24 cm	85	17.3	5.0	5.0
$LSD_{0.05}$	4	0.5	0.2	0.3
CV(%)	8.1	4.5	7.5	9.6

† Height-to-node ratio.
‡ Nodes above white flower.

reductions resulting from the wick delivery system relative to the spray application may have been caused by mechanical injury to the plant, particularly when wicking the top 24 cm. Future studies should compare wick applications with no mepiquat chloride to nontreated cotton to determine if mechanical injury to the plant is significant.

A greater effect of mepiquat chloride has been noted when applied through a wick delivery system compared to a spray (Stewart et al., 2001). Logic suggests that the more the foliage is impacted by the wick applicator, the greater the volume of mepiquat chloride solution that will be applied, leading to excessive rates. Therefore, at Scotland Neck (1998), Snow Hill (1999), and Trenton (1998), the rate of mepiquat chloride applied through the wick may have been excessive for cotton in that particular environment. Further considerations for research could examine the issue of a mepiquat chloride rate response when wicked at different heights in the cotton canopy. It is important to note that in 19 trial locations where mepiquat chloride spray application was compared to wicking the top 8 cm of the cotton, yield was increased once and decreased once by wicking, with no effect noted in the remaining 17 trials (Stewart et al., 2000).

Mepiquat chloride reduced plant height relative to the nontreated control regardless of the application system (Table 3). Wicking the top 24 cm reduced plant height more than the spray application; no difference between wicking the top 8 cm and the spray application was observed. Stewart et al. (2001) demonstrated the potential for mepiquat chloride rate reductions with a wick application versus a spray when the wick treated the top 8 cm; however, that response was not seen in this experiment.

Mepiquat chloride reduced main-stem node formation and height-to-node ratio relative to the nontreated control regardless of delivery system (Table 3). The wick delivery system reduced main-stem nodes and height-to-node ratio at least as well as spray applications. Earliness was enhanced by mepiquat chloride, as evidenced by reduced nodes above white flower relative to nontreated cotton. However, there were no differences among delivery systems.

CONCLUSIONS

Reduced height resulting from application of mepiquat chloride through the wick delivery system did not translate into advantages in yield or earliness (measured as nodes above white flower). Although yield response to mepiquat chloride varied across environments, wicking the top 8 cm compared to wicking the top 24 cm resulted in a yield decrease relative to the spray only once. In no case was yield positively influenced by mepiquat chloride, regardless of the method of application. Results from these studies suggest mepiquat chloride applied through the wick delivery system may reduce height more effectively than spray applications. Achieving maximal height control alone is not a justification for mepiquat chloride use. However, data show that if mepiquat chloride is to be applied with a wick, producers are likely to achieve similar overall results to a spray by setting the wick to wipe the top 8 cm rather than the top 24 cm. Growers should be cautioned, however, that mepiquat chloride will not result in a yield increase in every case, as its response is very dependent on environmental conditions.

These data also indicate that greater height control is possible when mepiquat chloride applications are initiated at the 9 to 10 node stage. Mepiquat chloride applications through a wick at the 9 to 10 node stage did not adversely affect cotton yield, compared with spray applications. The wick applicator may facilitate early applications in nonuniform fields because only the tallest plants would be affected if a height differential existed as a result of delayed emergence or field variability.

Regardless of whether mepiquat chloride rate reduction is possible with the wick delivery system, the practical advantage for producers is the lower volume of application. The wick applicator, due to its design and low volume of application, could be mounted easily to a herbicide or nitrogen applicator at the 9 to 10 node stage, thereby saving a later trip across the field for a mepiquat chloride-only application. This advantage allows for more hectares to be treated without refilling and greatly reduces the need for auxiliary tanks to be mounted on a tractor or sprayer. Additionally, the simple design of the wick delivery system eliminates costly pumps, hoses, and nozzle fittings. The ability to mount the wick applicator to implements and sprayers for simultaneous application with other crop protection chemicals may facilitate a more timely application of mepiquat chloride where needed.

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