EFFECTS OF DATE AND RATE OF BILLET PLANTING ON SUGARCANE YIELD

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ABSTRACT

The effects of date and rate of billet planting on yield of sugarcane cultivar LCP 85-384 were evaluated in three, 3-year field experiments. Date of planting had no consistent effect on yield across experiments during a mid-August to late-September planting season in Louisiana. The results suggested that early (beginning of August) and late (October) planting dates can reduce yield potential. A one billet (equivalent of one stalk) planting rate consistently resulted in lower yields, and a three billet planting rate produced lower yields in some comparisons. Cane tonnage and sucrose per hectare yields obtained from six, nine, and 12 billet planting rates were equivalent.

INTRODUCTION

Sugarcane (inter-specific hybrids of *Saccharum* L.) is a vegetatively propagated crop. In Louisiana, the propagation material traditionally used for planting has been the entire stalk, excluding the shoot apex. In most sugarcane production areas around the world, the planting material is stalk sections, or billets, of various lengths. Whole stalks are planted at high rates in Louisiana to ensure adequate stand establishment despite damage caused by stalk rot pathogens and adverse winter environmental conditions. In the past, this planting system was facilitated because the crop was harvested for the mill using whole stalk harvesters. However, the Louisiana industry largely shifted to chopper harvesters during the last decade of the 20th century. The shift in harvesting system then created interest in developing methods for successful billet planting.

Research has repeatedly demonstrated that yields obtained from billet planting in Louisiana are often lower than those obtained from whole stalk planting (Benda et al., 1978; Coleman and Abbott, 1954; Hoy et al., 2004b; Ricaud et al., 2001; Viator et al., 2005). Optimizing cultural practices associated with billet planting apparently offers the best means to ameliorate the detrimental effects of stalk rots, such as red rot, caused by *Colletotrichum falcatum* Went, and adverse environmental conditions on sugarcane stand establishment. Direct disease control measures, such as fungicide applications, were not effective in improving plant stands resulting from billet planting (Hoy et al., 2004b).

One variable that affects sugarcane stand establishment is planting date (Garrison et al., 2000; Matherne, 1976; Ricaud et al., 2001; Viator et al., 2005). One recent study comparing billet and whole stalk planting in Louisiana found that yield was greatest with a mid-August planting date compared to mid-September and October dates (Viator et al., 2005). Rate of planting is another variable with obvious but poorly documented effects on yield obtained from billet plantings. Therefore, field experiments were conducted to determine the effects of planting date and rate of planting on the yield potential of billet plantings under Louisiana conditions.

MATERIALS AND METHODS

The effects of date and rate of billet planting on sugarcane yield were evaluated in separate field experiments. Experiments were planted in late summer of 2000, 2001, and 2002 at the St. Gabriel Branch Experiment Station of the Louisiana State University Agricultural Center. The intention of the date of planting experiments was to plant billets at approximately 2-week intervals spanning the August-September planting season. There were five planting dates for the experiment planted in late summer of 2000: Aug 3, Aug 15, Aug 31, Sep 18, and Sep 28. Wet weather prevented early August planting in 2001. Four planting dates for the experiment planted in 2001 were Aug 23, Aug 28, Sep 17, and Sep 28. Wet weather prevented an early August planting date and a late September date in 2002. A late planting date during October was included for comparison in 2002. Planting dates for the experiment planted in 2002 were Aug 18, Aug 27, Sep 13, and Oct 18.

In all date of planting experiments, billets of cultivar ‘LCP 85-384’ (Milligan et al., 1994) were cut with a chopper harvester and planted with a rear-mounted, rotating drum mechanical planter. The length of billets (determined by measuring 50 randomly selected billets) averaged 52 cm with an average of three buds per billet in 2000 and 56 cm with 3.5 buds per billet in 2001 and 2002. Planting rates were estimated by counting the number of billets in a cross section of the planting furrow at 20 randomly selected locations for each date. The rate averaged 7.2 (range = 6.4-7.9) running billets in the planting furrow across experiments. Billets were covered with an average of 7.6 cm of packed soil. All experiments were planted in Cancienne silty clay loam soil. Cancienne series soil is a fine-silty, mixed, superactive, nonacid, hyperthermic Fluvaquentic Epiaquepts. Plantings received recommended weed and insect control and spring fertilization practices (Anon., 2001). The experimental design was a randomized complete block with four replicates. Each replicate contained two complete rows for each planting date.

In the rate of billet planting experiments, rates compared included one, three, six, nine, and 12 continuously running billets in the planting furrow. Machine-cut billets were hand-planted to achieve the desired planting rates. August and September planting dates were compared in each experiment to determine if planting date interacted with planting rate. Planting dates for the experiment planted in 2000 were Aug 22 and Sep 18. Planting dates for the experiment planted in 2001 were Aug 23 and Sep 17, and planting dates for the experiment planted in 2002 were Aug 15 and Sep 16. In each experiment, planting rates were compared in four randomized complete blocks with a split plot design for planting dates. Individual plots consisted of three rows 9.1 m in length with a 1.5 m alley between plots.

Experimental treatments were compared for results obtained from the plant cane, first ratoon, and second ratoon crops. Yield components compared included stalk population, stalk weight, sucrose per ton of cane, tons of cane per hectare and tons of sucrose per hectare. Stalk population was estimated from stalk counts. Stalks were counted in four sections of row 8.5 m in length for each planting date replicate in the date of planting experiments, and all stalks were counted in each plot of the rate of planting experiments. Stalk weight was determined from a 15 stalk sample collected from each plot at harvest. Sucrose per ton of cane was estimated from the juice collected with a roller mill from each 15-stalk sample using Brix and pol measurements (Meade and Chen, 1977). Cane tonnage was determined by weighing each plot or plot row with a weigh wagon, except in 2002 when tonnage was estimated from the stalk population and stalk weight estimates. Sucrose per hectare was then calculated using the tonnage and sucrose per ton estimates.

Results data were analyzed using the GLM procedure of SAS (SAS Institute, Inc., 1985). Means were compared by Fisher's Protected Least Significant Difference. For the rate of planting experiments, no interaction was detected between the two planting dates, so data were combined for analysis.

RESULTS

The results from the three date-of-planting experiments were variable. In the 2001-2003 experiment, plant cane tonnage yield was highest for the mid-season planting dates, Aug 31 and Sep 18, and the yield of sucrose per hectare was highest for the Aug 31 date (Table 1). First and second ratoon cane and sucrose yields revealed no differences. In the 2002-2004 experiment, no differences were detected in cane tonnage or sucrose per hectare yields in plant cane and first ratoon (Table 1). In second ratoon, cane and sucrose per hectare yields were lower for the Aug 28 than for the Aug 23 date (Table 1). In the 2003-2005 experiment, plant cane tonnage and sucrose per hectare yields were higher for the Aug 18 (earliest) planting date than for Sep 13 and Oct 18 (latest) dates (Table 1). Yields were lower the Oct 18 date than for all three other planting dates. A difference in tonnage was again detected in first ratoon between the Aug 18 and Oct 18 dates. Second ratoon yields were similar for all dates.

Similar patterns in differences were detected for stalk population in the three experiments, while few differences were detected among planting dates for stalk weight (Table 2). In the 2001-2003 experiment, stalk population was higher for the Aug 31 date than for the Aug 3, Sep 18, and Sep 28 dates (Table 2), but no differences were detected in stalk weight (Table 2) or sucrose per ton of cane (results not shown). The stalk population for the Aug 3 date was lower than for all other dates. In first ratoon, the Aug 31 date had a higher stalk population than the Sep 28 date, but the stalk population for the Aug 31 date was lower than for all other dates in second ratoon (Table 2). No differences were found for the other yield components, stalk weight and sucrose per ton of cane (results not shown) in all crop years. In the 2002-2004 experiment, the plant cane stalk population for the earliest planting date (Aug 23) was lower than for the Sep 17 date (Table 2). The stalk weight for the same date was higher than for the Aug 28 date in plant cane and for the Aug 28 and Sep 17 dates in second ratoon (Table 2). No differences were detected in sucrose per ton of cane (results not shown). In the 2003-2005 experiment, differences detected among planting dates in plant cane stalk population were similar to differences in tonnage and sucrose per hectare yields. Stalk population was higher for the Aug 18 (earliest) planting date than for all other dates (Table 2). The population for the Oct 18 date was lower than for all three other planting dates. A difference in tonnage was again detected in first ratoon, with the Aug 18 and Aug 28 dates producing higher stalk populations than the Oct 18 date (Table 2). Stalk weight was similar among planting dates for all crop years. A difference in sucrose per ton of cane was detected in plant cane with the Aug 27 date producing a higher sucrose content than the Sep 13 and Oct 18 dates (results not shown), but this did not affect the treatment results for sucrose per hectare.

Table 1. Effect of planting date on cane and sucrose yields in three, 3-year crop cycles of billet-planted LCP 85-384.

Crop cycle/ planting date	Cane yield[1]			Sucrose yield[1]		
	Plant cane	1st ratoon	2nd ratoon	Plant cane	1st ratoon	2nd ratoon
	Mg ha^{-1}					
2001-2003						
Aug 3	97.1 b	96.6	61.8	9.98 b	10.00	4.89
Aug 15	99.8 b	93.1	62.5	10.32 b	9.53	4.69
Aug 31	110.7 a	94.6	56.8	11.56 a	9.63	4.92
Sept 18	110.4 a	93.6	68.8	10.45 ab	9.11	5.55
Sept 28	100.0 b	88.9	61.3	10.23 b	9.02	4.94
2002-2004						
Aug 23	97.8	67.9	79.0 a	9.93	5.78	7.21 a
Aug 28	93.6	65.2	65.9 b	9.44	5.85	5.78 b
Sept 17	102.3	69.4	72.4 ab	10.23	5.93	6.30 ab
Sept 28	102.3	70.1	74.8 ab	9.83	5.95	6.55 ab
2003-2005						
Aug 18	82.0 a	71.6 a	57.8	7.90 a	6.55	4.84
Aug 27	75.8 ab	62.5 ab	56.1	7.26 ab	6.08	4.82
Sept 13	71.9 b	66.0 ab	55.8	6.99 b	6.20	4.79
Oct 18	59.5 c	58.5 b	58.0	5.63 c	5.46	4.77

[1]Means within a column and crop cycle followed by the same letter were not significantly different ($P > 0.05$).

Yield was affected by billet planting rate in all three experiments. Stalk population was the yield component showing the greatest response to planting rate. Stalk population was lower for the one billet planting rate in plant cane, and this difference persisted into first and second ratoon (Table 3). Lower stalk populations also occurred with the three billet planting rate in at least one crop in each experiment (Table 3). In a few cases, the nine and 12 billet planting rates increased population compared to the six billet rate, but the 12 billet rate did not increase population compared to the nine billet rate. A lower stalk population sometimes results in an increase in stalk weight, and this was observed in a few cases in the first two experiments (Table 3). A difference in sucrose per ton of cane was only detected in first ratoon of the 2002-2004 experiment when the six billet planting rate had a lower sucrose level (results not shown).

Similar differences in cane tonnage and sucrose per hectare to those observed for stalk population were detected among billet planting rates in the 2001-2003 experiment (Table 4). The one billet planting rate had the lowest tonnage and sucrose per hectare yields in all crop years, and the yields for the three billet planting rate were lower than for other higher planting rates in some cases. In the 2002-2004 experiment, few differences were detected; the one billet planting rate was only lower than some other rates in second ratoon. In the 2003-2005 experiment, the results for cane tonnage and sucrose per hectare were similar to the 2002-2004 yields (Table 4). The one billet planting rate produced lower yields than one or more of the other planting rates in all three crop cycle years. The yield produced by the three billet planting rate was lower than for the nine billet planting rate in first ratoon.

Table 2. Effect of planting date on stalk population and weight in three, 3-year crop cycles of billet-planted LCP 85-384.

Crop cycle/	Stalk population[1]			Stalk weight[1]		
planting date	Plant cane	1st ratoon	2nd ratoon	Plant cane	1st ratoon	2nd ratoon
	------------ stalks x 1000 ha^{-1} --------			-------------------- kg ------------------		
2001-2003						
Aug 3	119.3 d	132.9 ab	123.0 a	0.66	0.73	0.63
Aug 15	131.2 ab	136.6 ab	123.3 a	0.67	0.69	0.66
Aug 31	135.4 a	138.8 a	108.9 b	0.66	0.69	0.67
Sept 18	126.7 bc	135.6 ab	126.7 a	0.68	0.69	0.64
Sept 28	121.5 c	127.0 b	120.0 a	0.69	0.70	0.67
2002-2004						
Aug 23	120.3 b	108.9	113.4	0.82 a	0.67	0.70 a
Aug 28	131.9 ab	111.9	111.4	0.72 b	0.63	0.60 b
Sept 17	136.1 a	114.6	123.0	0.76 ab	0.61	0.59 b
Sept 28	131.2 ab	110.9	118.1	0.78 ab	0.61	0.64 ab
2003-2005						
Aug 18	121.8 a	114.6 a	124.5	0.93	0.63	0.54
Aug 27	109.4 b	112.4 a	118.1	0.84	0.56	0.56
Sept 13	108.4 b	111.4 ab	120.8	0.90	0.62	0.56
Oct 18	91.6 c	105.0 b	117.3	0.89	0.56	0.60

[1]Means within a column and crop cycle followed by the same letter were not significantly different ($P > 0.05$).

The effect of planting date was not significant in the rate of planting experiments. No interactions between date and rate of planting were detected, so combined results are presented in Tables 3 and 4. In the 2002-2004 and 2003-2005 experiments, plant cane yields for the three billet planting rate were lower than for higher planting rates with the September but not August planting date (results not shown).

DISCUSSION

Considered across experiments, there were no consistent effects of date of planting on yield of LCP 85-384 planted as billets during the normal planting season extending from mid-August to late September. Previous research (Garrison et al., 2000; Matherne, 1976; Ricaud et al., 2001) demonstrated that yield of different cultivars varied in response to planting date when planted as whole stalks, and the two later studies found that LCP 85-384 was less sensitive to date of planting than other cultivars. In one recent study comparing billet and whole stalk planting (Viator et al., 2005), three cultivars, including LCP 85-384, produced the highest yield with August compared to September and October planting. In an earlier study (Benda et al., 1978), billet and whole stalk yields were lower with an October compared to an August planting date.

Table 3. Effect of planting rate on stalk population and weight in three, 3-year crop cycles of billet-planted LCP 85-384.

Crop cycle/	Stalk population[1]			Stalk weight[1]		
planting rate	Plant cane	1st ratoon	2nd ratoon	Plant cane	1st ratoon	2nd ratoon
	------------ stalks x 1000 ha^{-1} --------			------------------- kg ------------------		
2001-2003						
1 billet	112.6 c	98.3 d	84.2 d	0.89 a	0.93	1.10 a
3 billets	146.5 b	118.3 c	108.2 c	0.80 ab	0.88	1.06 ab
6 billets	162.0 ab	129.2 b	121.3 b	0.82 ab	0.87	0.97 bc
9 billets	166.0 ab	141.8 a	130.3 a	0.82 ab	0.84	0.94 c
12 billets	174.9 a	145.2 a	133.4 a	0.75 b	0.84	0.97 bc
2002-2004						
1 billet	147.2 b	93.9 c	110.4 c	0.78 a	0.75 a	0.71 a
3 billets	167.5 a	101.5 b	126.2 b	0.72 a	0.65 b	0.73 a
6 billets	172.7 a	106.2 ab	133.1 a	0.68 b	0.68 ab	0.69 a
9 billets	171.7 a	108.9 a	134.6 a	0.69 ab	0.67 b	0.65 ab
12 billets	174.1 a	109.7 a	136.8 a	0.66 b	0.60 b	0.58 b
2003-2005						
1 billet	120.0 b	105.2 b	124.0 b	0.69	0.61	0.59
3 billets	134.4 a	110.9 b	139.1 a	0.68	0.58	0.63
6 billets	134.9 a	120.8 a	137.1 a	0.68	0.55	0.61
9 billets	140.3 a	123.3 a	141.5 a	0.69	0.59	0.60
12 billets	139.6 a	123.5 a	144.7 a	0.67	0.55	0.61

[1]Means within a column and crop cycle followed by the same letter were not significantly different ($P > 0.05$).

In this study, an early planting date (Aug 3) was included in one experiment and a late (Oct 18) planting date in another. The results suggested that yield obtained from billet planting might be lower with an early or late planting date. Two factors associated with planting date that could affect productivity are stalk height and maturity when cut for seedcane and then the extent of stand establishment before the onset of winter. Stalks would be shorter at early planting dates, and billet seedcane would contain a higher proportion of immature stalk sections. However, a longer period of time would be available for crop establishment before winter. In contrast, later planting dates would allow less time for stand establishment. This could be important in a cane producing region like Louisiana where sugarcane is grown at the northern limit of its cultivation range. Billets have a high bud germination rate, and young shoots in poorly established stands are vulnerable to winter kill.

Planting rate is of interest with billets because farmers must balance the risk of damage from stalk rots and the potential for stand problems with the high cost of using large amounts of seedcane. Billet planting is expensive in Louisiana primarily due to the amount of seedcane used (Salassi et al., 2004). The lowest planting rate of one running billet produced lower yield in each of three crop cycles. The mechanical planters in use in Louisiana are not capable of planting a consistent one billet rate, but attempting to plant at a reduced rate can result in portions of rows being planted at a low rate due to variable seedcane distribution by planters. In some comparisons, the three billet planting rate also yielded less than higher planting rates. In a previous study using hand-cut billets (Ricaud et al., 2001), a three billet planting rate produced a lower stalk population than seven and nine billet rates. Planting date did not significantly interact with billet planting rate in this study; however, the reductions in yield associated with low planting rates, especially with the three billet rate, were more obvious with the September compared to the August planting date (Hoy et al., 2004a, 2005, 2006). In all tonnage and sucrose per hectare comparisons, the six and nine billet planting rates were equivalent, and the highest planting rate of 12 billets did not provide additional yield. So, a very high planting rate did not provide any yield benefit.

Table 4. Effect of planting rate on cane tonnage and sucrose yields in three, 3-year crop cycles of billet-planted LCP 85-384.

Crop cycle/ planting rate	Cane yield[1]			Sucrose yield[1]		
	Plant cane	1st ratoon	2nd ratoon	Plant cane	1st ratoon	2nd ratoon
	---------- Mg ha^{-1} ----------					
2001-2003						
1 billet	98.8 c	90.3 c	91.9 c	9.80 b	8.53 b	8.73 c
3 billets	114.8 bc	102.8 bc	112.8 b	11.49 ab	9.88 ab	10.71 b
6 billets	130.1 ab	111.7 ab	116.1 ab	13.57 a	11.34 a	11.28 ab
9 billets	134.1 a	117.9 ab	121.0 ab	13.88 a	10.82 a	11.91 ab
12 billets	129.2 ab	120.1 a	128.3 a	12.91 a	11.59 a	12.96 a
2002-2004						
1 billet	114.1	70.2	77.5 c	11.73	6.33	8.14 b
3 billets	119.4	65.0	90.8 a	12.39	5.72	9.41 a
6 billets	116.2	71.5	90.4 ab	10.93	6.23	9.30 ab
9 billets	118.1	71.9	86.6 abc	11.94	6.25	8.65 ab
12 billets	114.8	65.7	78.6 bc	11.89	5.76	8.24 ab
2003-2005						
1 billet	82.4 b	63.3 b	72.6 b	7.36 b	6.24 b	6.07 b
3 billets	90.6 ab	63.7 b	86.6 a	8.12 ab	6.24 b	7.04 a
6 billets	90.4 ab	65.5 ab	83.2 a	8.28 ab	6.56 ab	6.80 ab
9 billets	97.0 a	72.4 a	84.4 a	9.04 a	7.15 a	6.86 ab
12 billets	92.8 ab	67.3 ab	87.0 a	7.67 ab	6.52 ab	7.53 a

[1]Means within a column and crop cycle followed by the same letter were not significantly different (P > 0.05).

CONCLUSIONS

Billet planting in Louisiana is desirable because of reduced labor requirements, the elimination of duplication in harvesting equipment, and the lodging that can occur in seedcane sources. These potential benefits are offset by the increased cost and potential for stand problems. Billet plantings may experience problems because billets are more susceptible to any plant stress than whole stalks. The lodging of seedcane is one factor not under the control of farmers that can necessitate billet planting. To maximize the chances of success with billet planting, farmers need to optimize planting and other cultural practices to minimize plant stress. Date and rate of planting are two obvious factors that need to be considered.

Planting date within the planting season of mid-August to late September does not have a major effect on billet planting performance for LCP 85-384. The results from this study suggest that very early and late planting dates can result in reduced productivity. The rate of billet planting, the most important cost factor with this planting method, does have an effect on yield potential. The results indicate that a planting rate averaging six running billets in the planting furrow is needed to maximize yield. In these experiments, the reduced yields associated with low planting rates were not due to the occurrence of large gaps without established plants. However, the frequent gaps in plant cane stands sometimes observed with billet planting would be more likely with low planting rates. When this occurs, there is potential for even greater yield reductions and possibly even stand failures. The suggested optimal planting rate will not allow for a reduction in the documented high cost of billet planting, but it is necessary to insure against significant losses that are possible with this planting method under Louisiana conditions.

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