

## Pennsylvania State University

**TITLE:** Mass Balance Assessment of Pesticides and Nutrients Applied to  
Golf Turf (Runoff Segment)

**INVESTIGATORS:**

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**CLIMATIC REGION:** Cool Humid

**USGA REGION:** Northeastern/Mid-Atlantic

SURFACE RUNOFF OF PESTICIDES AND NUTRIENTS  
APPLIED TO GOLF TURF

The Pennsylvania State University

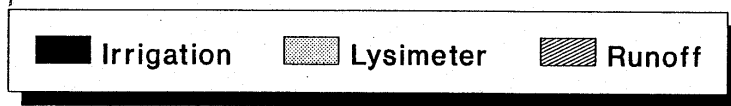
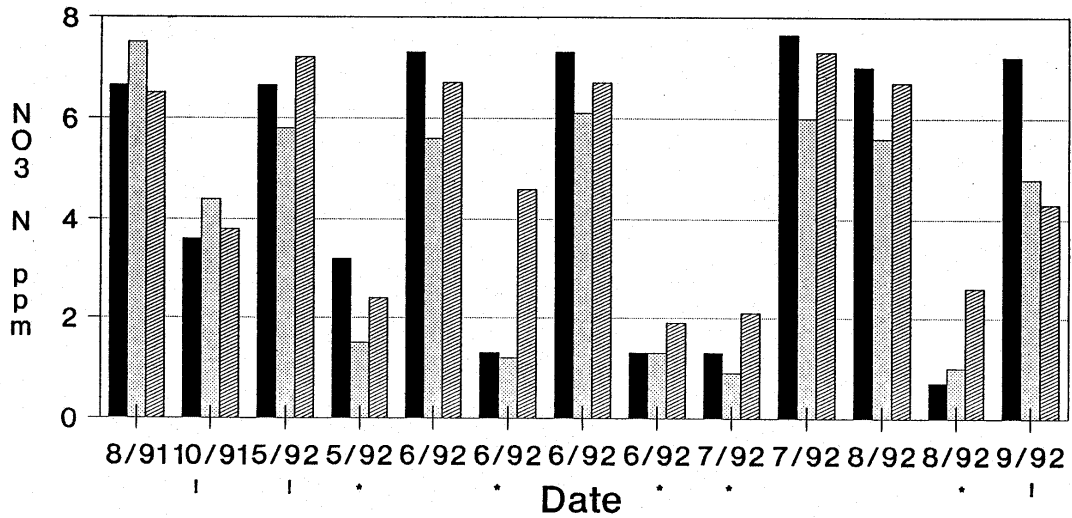
During 1991, sloped plots of creeping bentgrass and perennial ryegrass were established and maintained as fairway turf. By the fall of 1991, runoff rates for all slopes had declined substantially in contrast to those found when turf was in the seedling stage.

Both species continued to mature as a turfgrass sward during 1992 (bentgrass began to stolonize and produce a small amount of thatch). A significantly different hydrograph has developed for each species over time. Runoff occurs quicker and with greater peak flow from ryegrass than from creeping bentgrass. By mid-summer of 1992, approximately twice as much water was required to produce runoff from bentgrass as from ryegrass (see attached hydrographs for August 1991 through October 1992). For irrigation events, runoff is also expressed on the hydrographs as a percentage of the amount applied. Research is currently underway to determine the magnitude of other possible fates of applied irrigation (infiltration, thatch, and soil water holding capacities, evaporation, transpiration, and foliar interception and retention).

Nitrogen ( $\text{NO}_3\text{-N}$ ) and phosphorus ( $\text{PO}_4$ ) concentrations found in both runoff and leachate have been consistently low. Neither nutrient has been found in concentrations above the public drinking water standard even when runoff was forced with irrigation within 24 hours of fertilizer applications (see graphs and tables). Typically,  $\text{NO}_3\text{-N}$  concentrations in runoff were slightly below that found in the irrigation water, while the concentration in leachate samples was usually about the same as the irrigation water.

Pesticide concentrations in runoff and leachate are currently being analyzed at the Penn State Pesticide Analyses Laboratory, and that data will be available for the next reporting period.

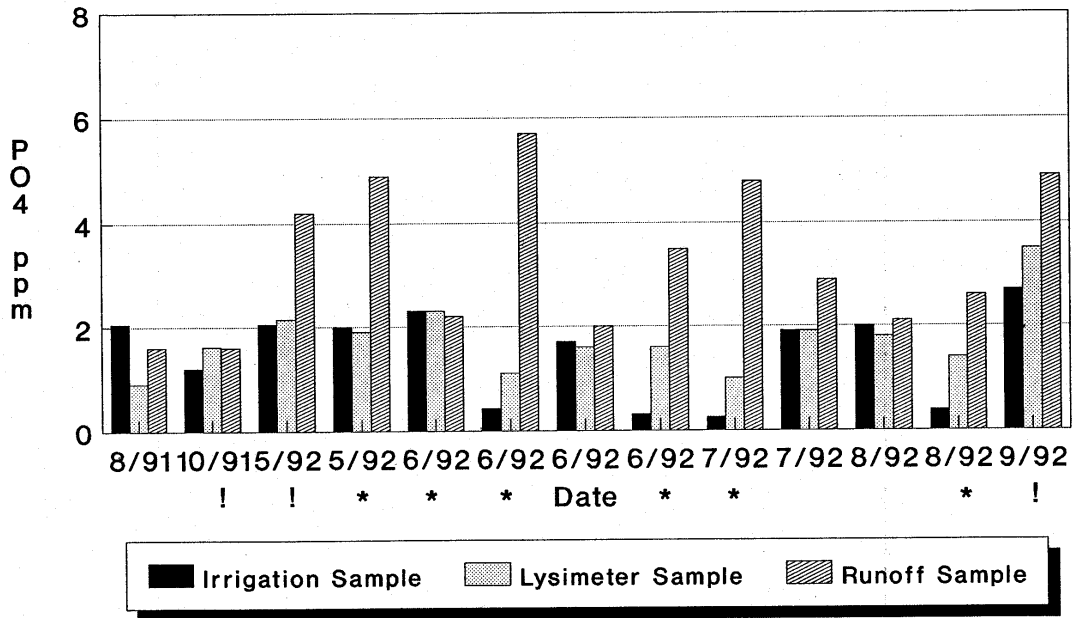
# USGA Mass Balance Evaluation Project Concentration of Nitrate N



\* Natural Precipitation  
| Fertilizer Application

# USGA Mass Balance Evaluation Project Concentration of Phosphate P

00128



\* Natural Precipitation  
! Fertilizer Application

**Surface loss of Nitrate N Resulting from Application of Fertilizer Nitrogen\* to Turfgrass Established in Hagerstown Silt Loam.**

Species	Single N application rate (kg N/ha)	Total annual N rate	Date applied	Irrigation/Precipitation (mm)	Nitrate** Concentration in water (mg/L)
Lolium perenne	0		Aug 91	51	0
	0		Aug 91***	13	0
	49		Oct 91	51	<1
		49			
Agrostis palustris	0		Aug 91	51	0
	0		Aug 91***	13	0
	49		Oct 91	51	<1
		49			
Lolium perenne	49		May 92	38	<1
	0		May 92***	13	0
	0		June 92	76	0
	0		June 92***	15	2
	0		June 92	76	0
	0		June 92***	19	<1
	0		July 92***	17	1
	0		July 92	3	0
	0		Aug 92	3	0
	49		Sept 92	3	0
	98				
Agrostis palustris	49		May 92	38	<1
	0		May 92***	13	<1
	0		June 92	76	0
	0		June 92***	15	6
	0		June 92	76	0
	0		June 92***	19	<1
	0		July 92***	17	<1
	0		July 92	3	0
	0		Aug 92	3	<1
	49		Sept 92	3	0
	98				

\* The Nitrogen sources are  $\text{NH}_4^-\text{N}$ , Methylene Urea, Urea.

\*\* Mean of replications

\*\*\* Precipitation

**Subsurface loss of Nitrate N Resulting from Application of Fertilizer Nitrogen\* to Turfgrass Established in Hagerstown Silt Loam.**

Species	Single N application rate (kg N/ha)	Total annual N rate	Date applied	Irrigation/ Precipitation (mm)	Nitrate** Concentration in water (mg/L)
<hr/>					
Lolium perenne	0		Aug 91	51	2
	0		Aug 91***	13	-
	49		Oct 91	51	<1
		49			
<hr/>					
Agrostis palustris	0		Aug 91	51	<1
	0		Aug 91***	13	-
	49		Oct 91	51	<1
		49			
<hr/>					
Lolium perenne	49		May 92	38	0
	0		May 92***	13	0
	0		June 92	76	0
	0		June 92***	15	<1
	0		June 92	76	0
	0		June 92***	19	<1
	0		July 92***	17	0
	0		July 92	3	0
	0		Aug 92	3	0
	49		Sept 92	3	0
		98			
<hr/>					
Agrostis palustris	49		May 92	38	0
	0		May 92***	13	0
	0		June 92	76	0
	0		June 92***	15	0
	0		June 92	76	0
	0		June 92***	19	<1
	0		July 92***	17	0
	0		July 92	3	0
	0		Aug 92	3	<1
	49		Sept 92	3	0
		98			

\* The Nitrogen sources are  $\text{NH}_4^- \text{N}$ , Methylene Urea, Urea.  
 \*\* Mean of replications  
 \*\*\* Precipitation

Surface loss of Phosphate PO<sub>4</sub> Resulting from Application of Fertilizer Phosphorus\* to Turfgrass Established in Hagerstown Silt Loam.

Species	Single Phosphorus application rate (kg P <sub>2</sub> O <sub>5</sub> /ha)	Total annual rate	Date applied	Irrigation/Precipitation (mm)	Phosphate** Concentration in water (mg/L)
Lolium perenne	0		Aug 91	51	0
	0		Aug 91***	13	1
	5		Oct 91	51	<1
		5			
Agrostis palustris	0		Aug 91	51	0
	0		Aug 91***	13	<1
	5		Oct 91	51	<1
		5			
Lolium perenne	5		May 92	38	3
	0		May 92***	13	3
	0		June 92	76	<1
	0		June 92***	15	6
	0		June 92	76	<1
	0		June 92***	19	4
	0		July 92***	17	6
	0		July 92	3	<1
	0		Aug 92	3	<1
	5		Sept 92	3	2
	10				
Agrostis palustris	5		May 92	38	1
	0		May 92***	13	3
	0		June 92	76	<1
	0		June 92***	15	4
	0		June 92	76	<1
	0		June 92***	19	3
	0		July 92***	17	<1
	0		July 92	3	1
	0		Aug 92	3	<1
	5		Sept 92	3	2
	10				

\* The Phosphorus source is Monoammonium Phosphate.

\*\* Mean of replications

\*\*\* Precipitation

**Subsurface loss of Phosphate PO<sub>4</sub> Resulting from Application of Fertilizer Phosphorus\* to Turfgrass Established in Hagerstown Silt Loam.**

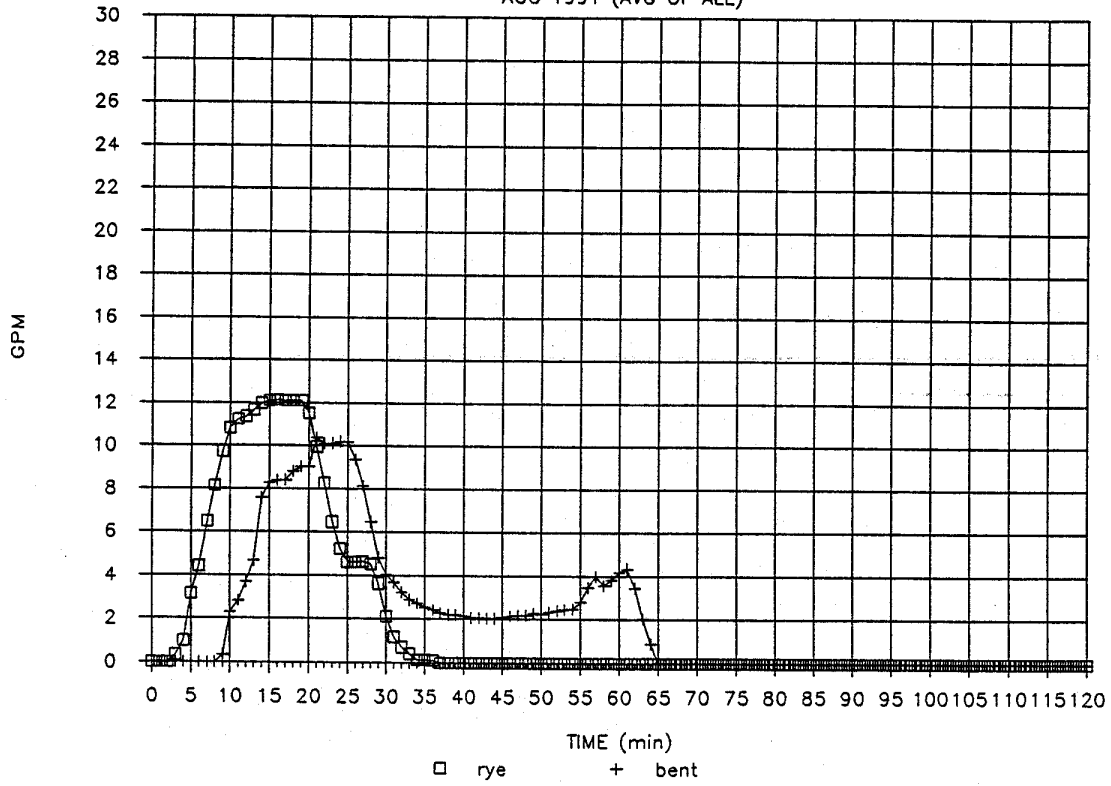
Species	Single Phosphorus application rate	Total annual rate	Date applied	Irrigation/ Precipitation (mm)	Phosphate** Concentration in water (mg/L)
	(kg P <sub>2</sub> O <sub>5</sub> /ha)				
Lolium perenne	0		Aug 91	51	0
	0		Aug 91***	13	-
	5		Oct 91	51	<1
		5			
Agrostis palustris	0		Aug 91	51	0
	0		Aug 91***	13	<1
	5		Oct 91	51	<1
		5			
Lolium perenne	5		May 92	38	<1
	0		May 92***	13	<1
	0		June 92	76	<1
	0		June 92***	15	<1
	0		June 92	76	<1
	0		June 92***	19	1
	0		July 92***	17	<1
	0		July 92	3	<1
	0		Aug 92	3	<1
5		Sept 92	3	<1	
		10			
Agrostis palustris	5		May 92	38	<1
	0		May 92***	13	<1
	0		June 92	76	0
	0		June 92***	15	<1
	0		June 92	76	0
	0		June 92***	19	1
	0		July 92***	17	<1
	0		July 92	3	<1
	0		Aug 92	3	0
5		Sept 92	3	0	
		10			

\* The Phosphorus source is Monoammonium Phosphate.  
 \*\* Mean of replications  
 \*\*\* Precipitation



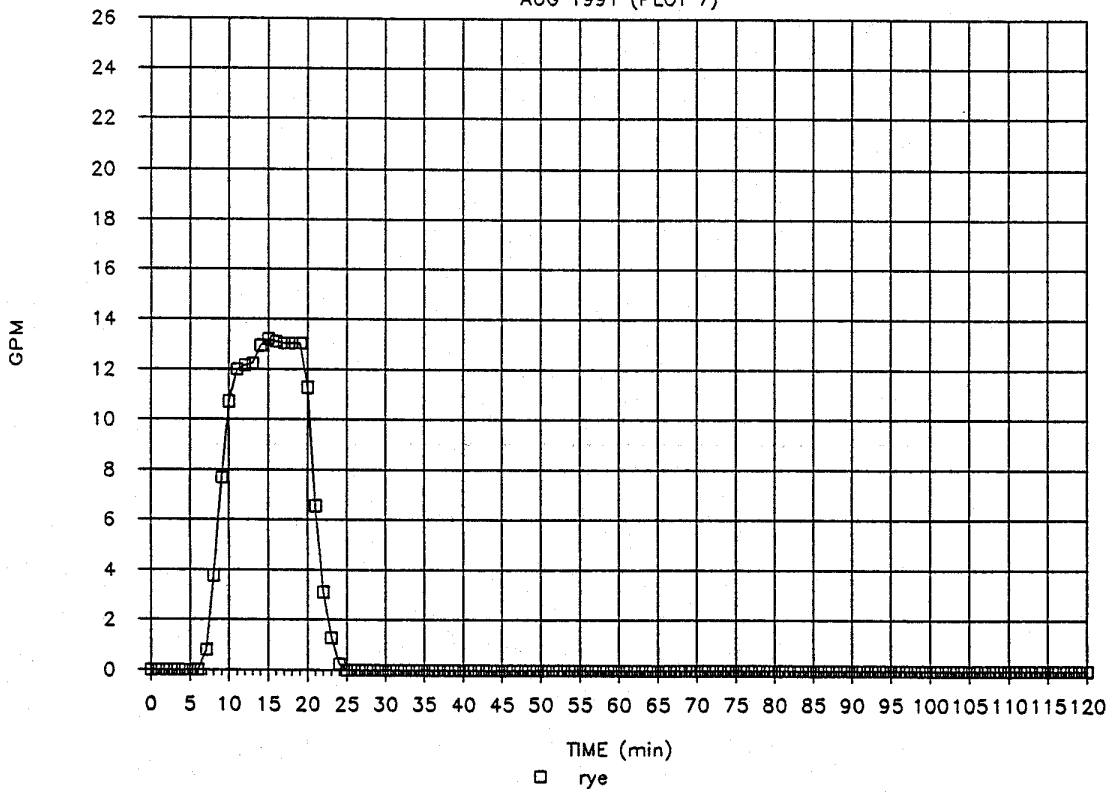
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AUG 1991 (AVG OF ALL)



# USGA BACKGROUND (CORRECTED)

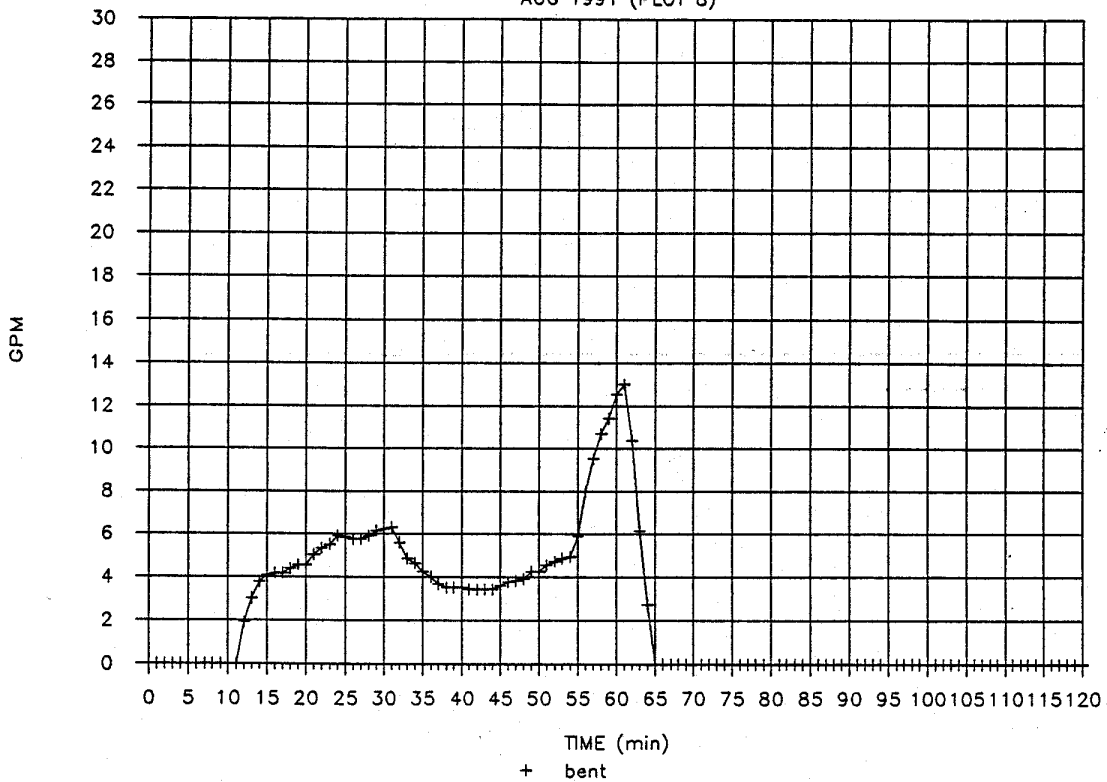
AUG 1991 (PLOT 7)



00133

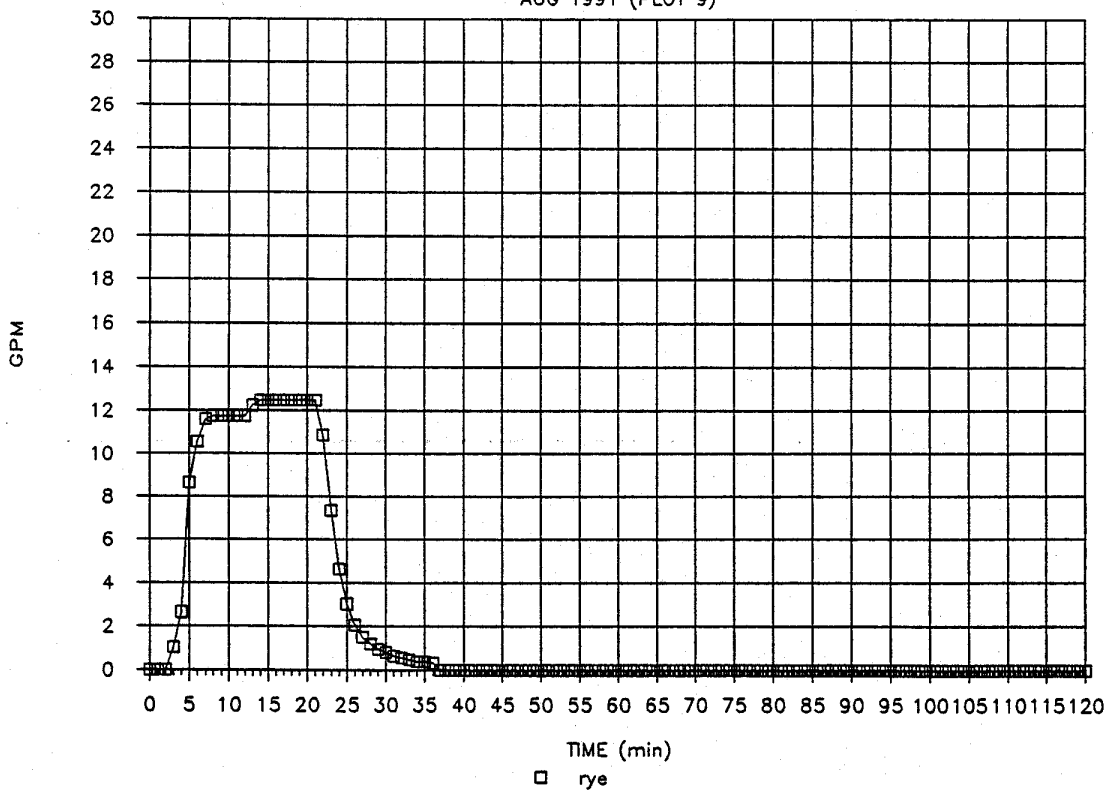
USGA BACKGROUND (CORRECTED)

AUG 1991 (PLOT 8)



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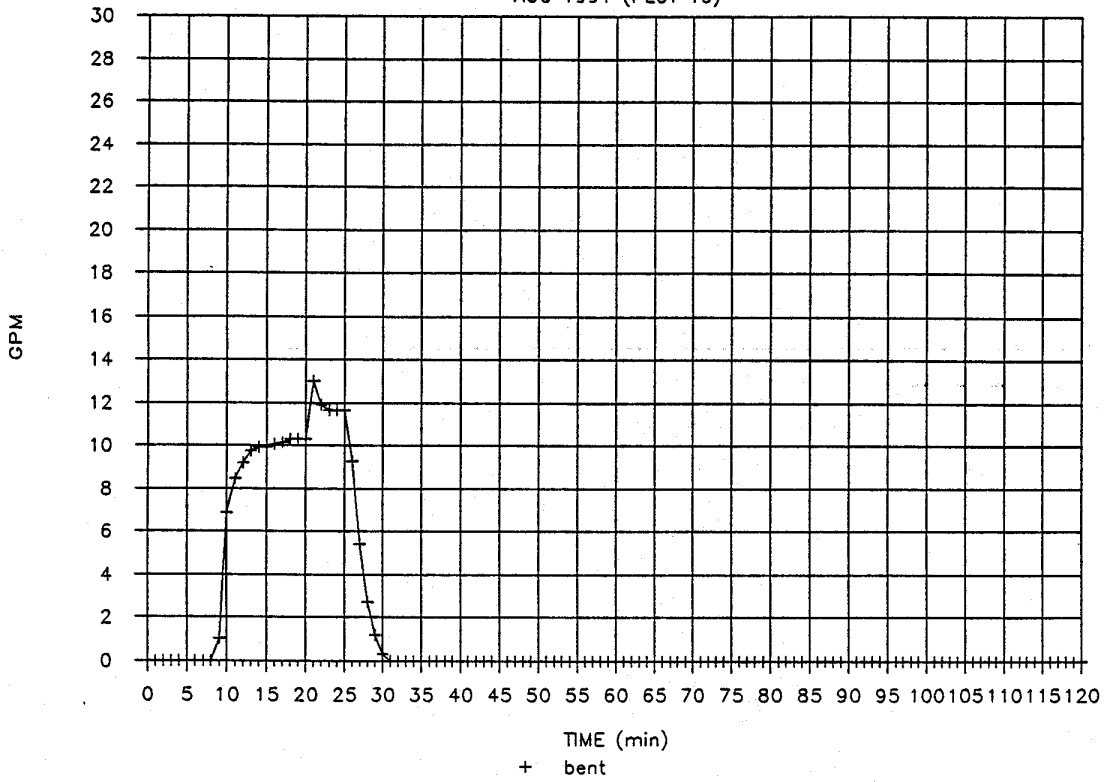
AUG 1991 (PLOT 9)



00134

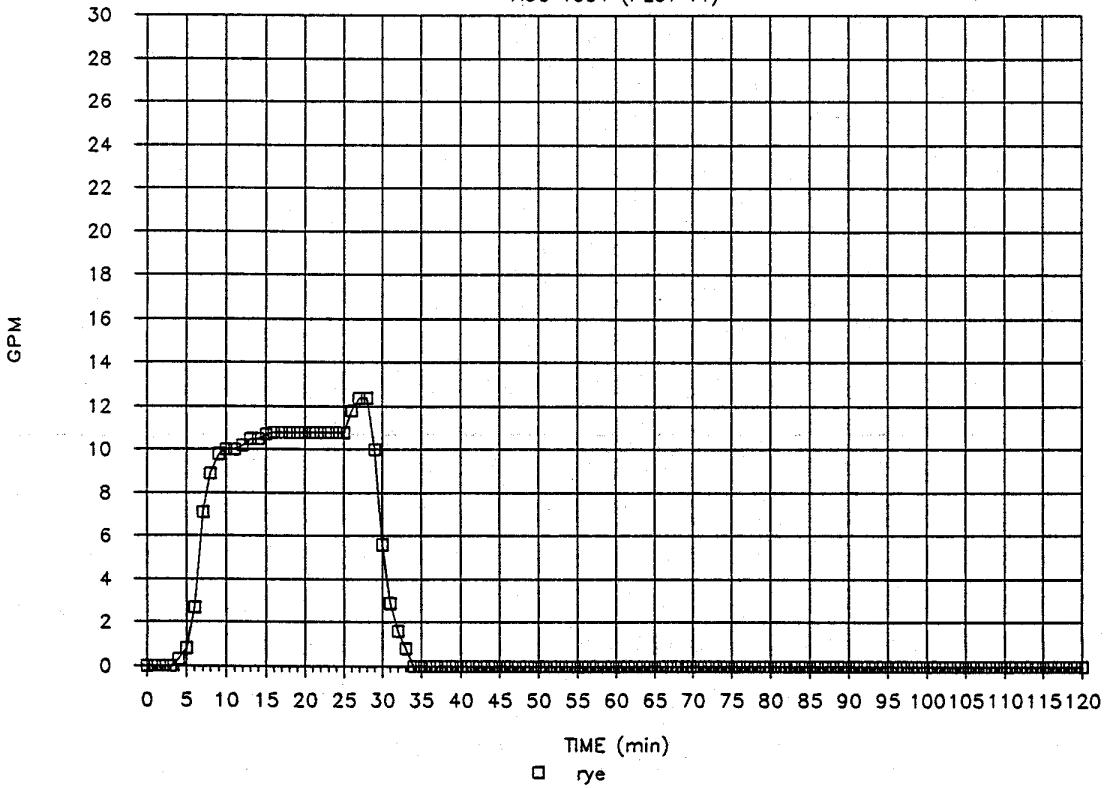
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AUG 1991 (PLOT 10)



USGA BACKGROUND (CORRECTED)

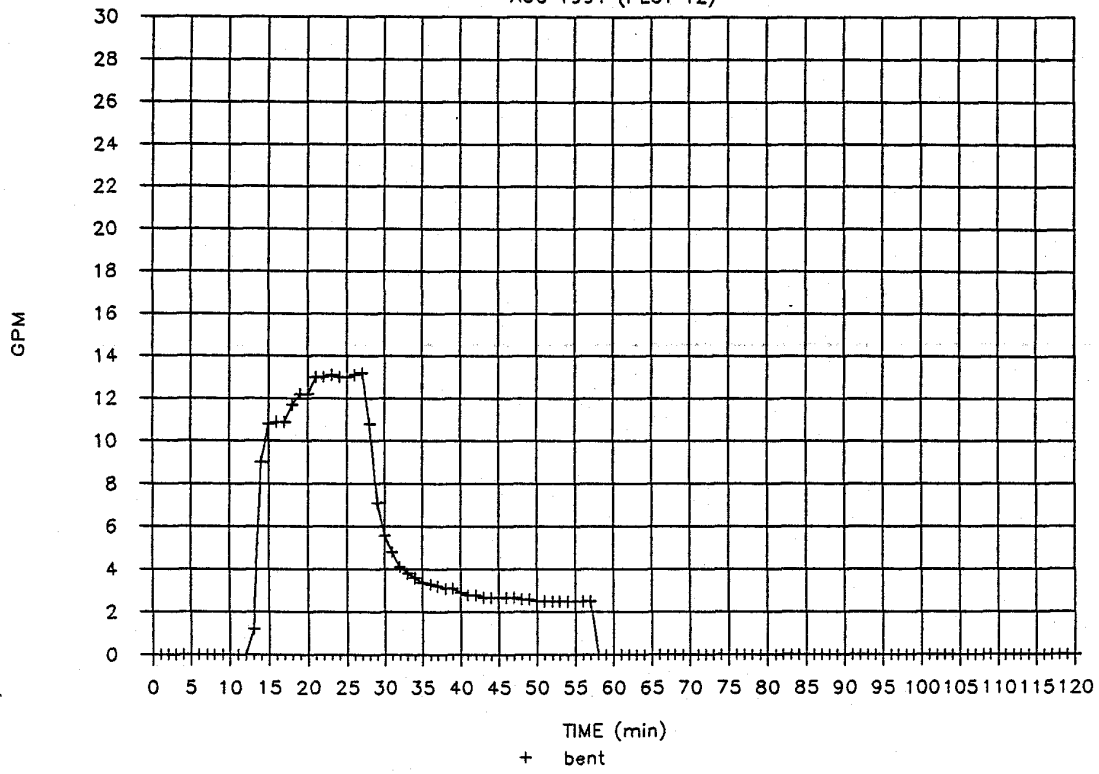
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00135

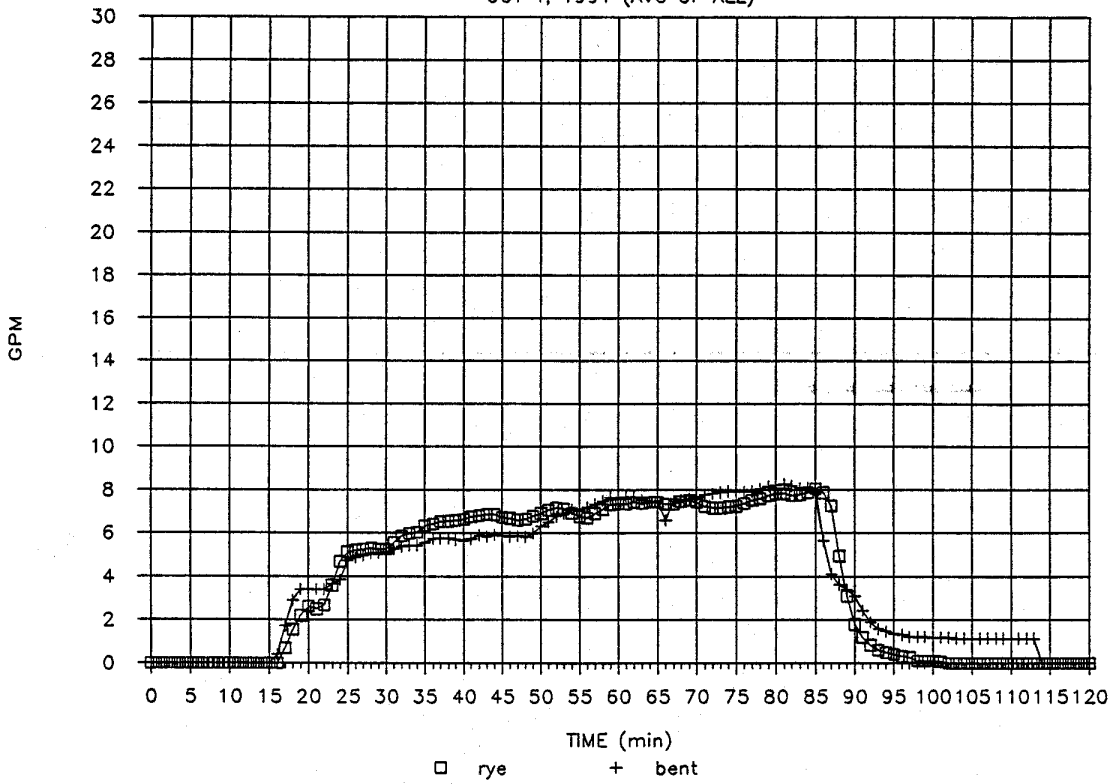
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AUG 1991 (PLOT 12)



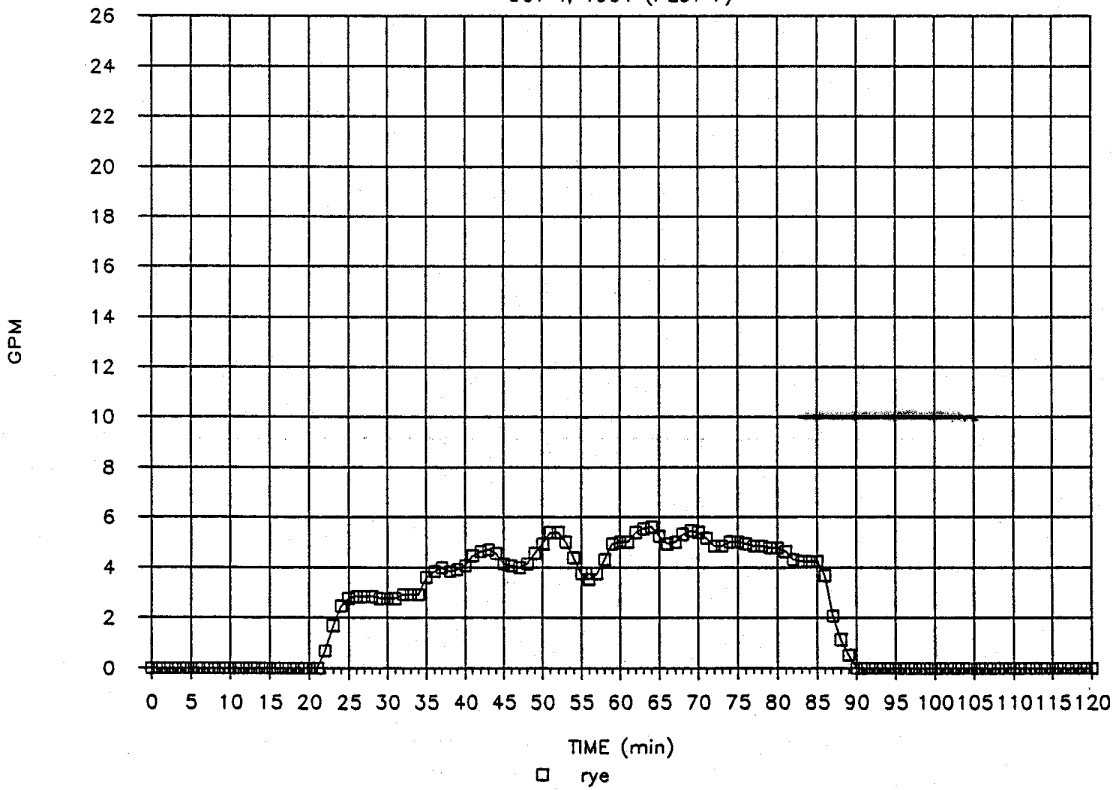
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OCT 4, 1991 (AVG OF ALL)



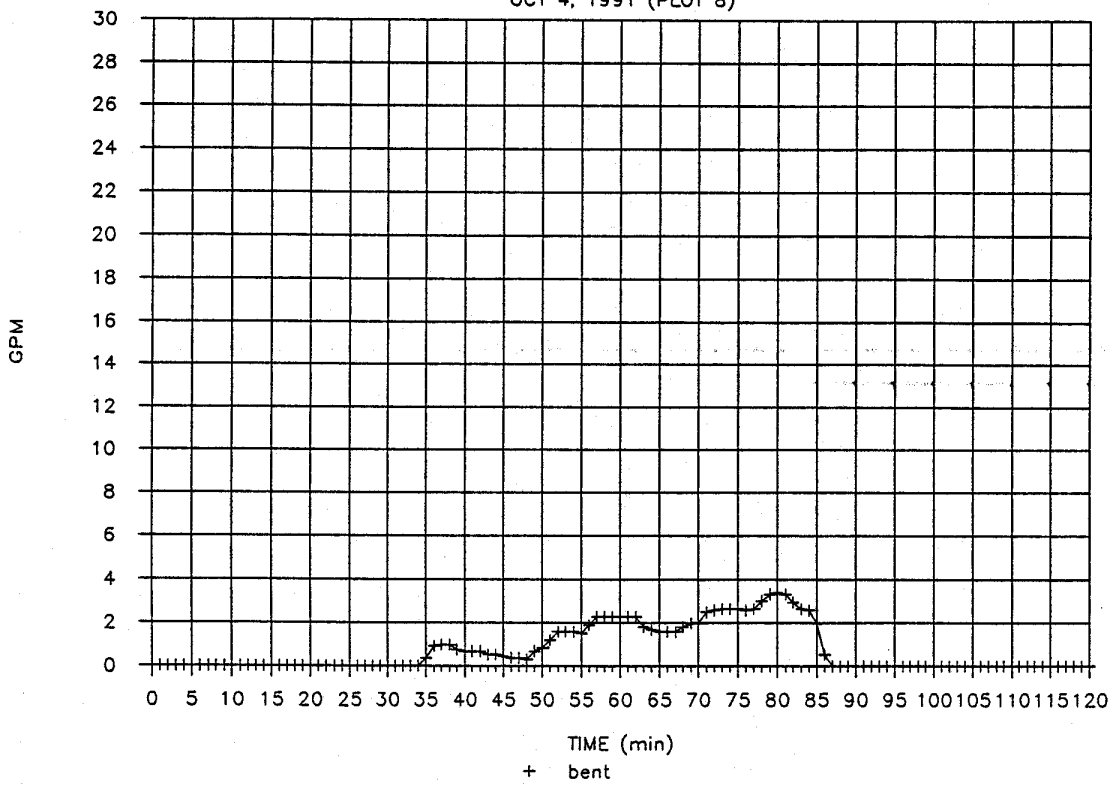
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OCT 4, 1991 (PLOT 7)



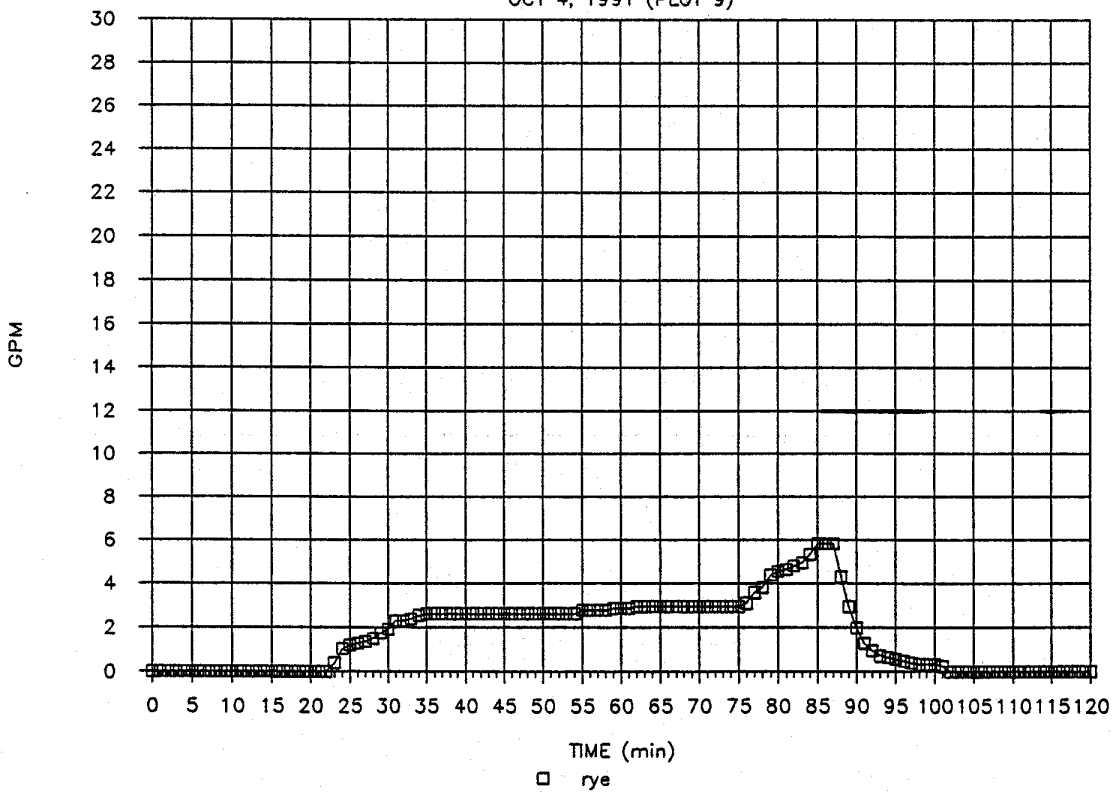
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OCT 4, 1991 (PLOT 8)



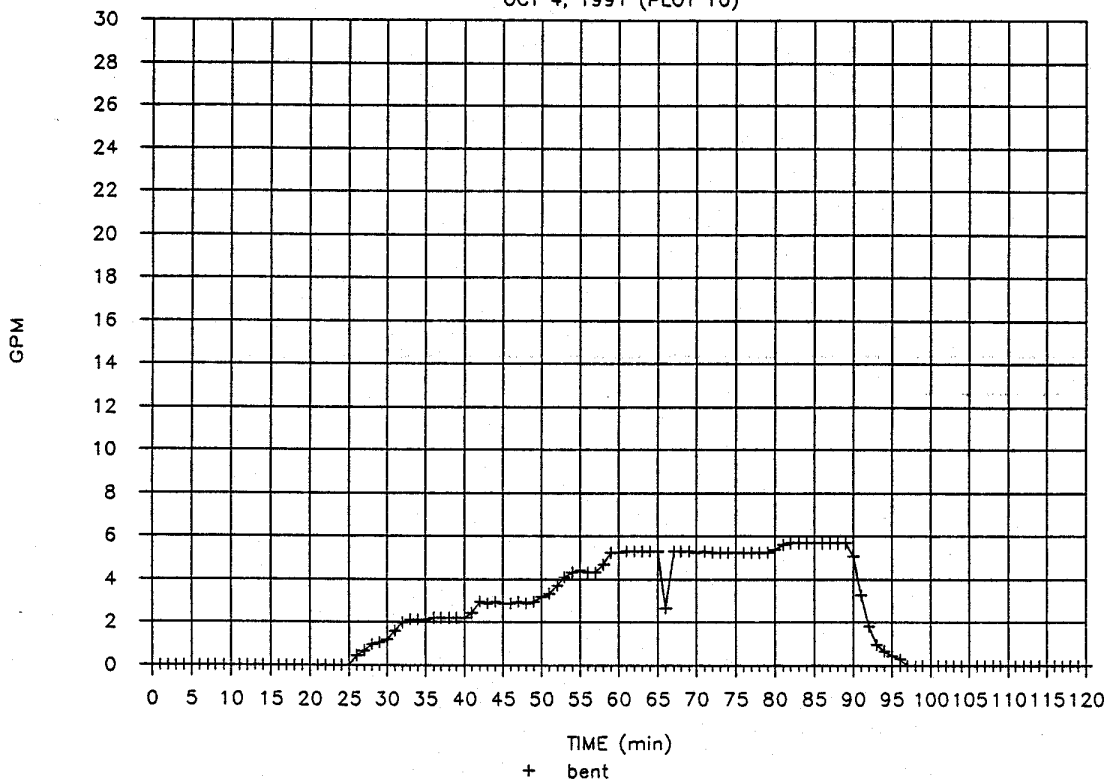
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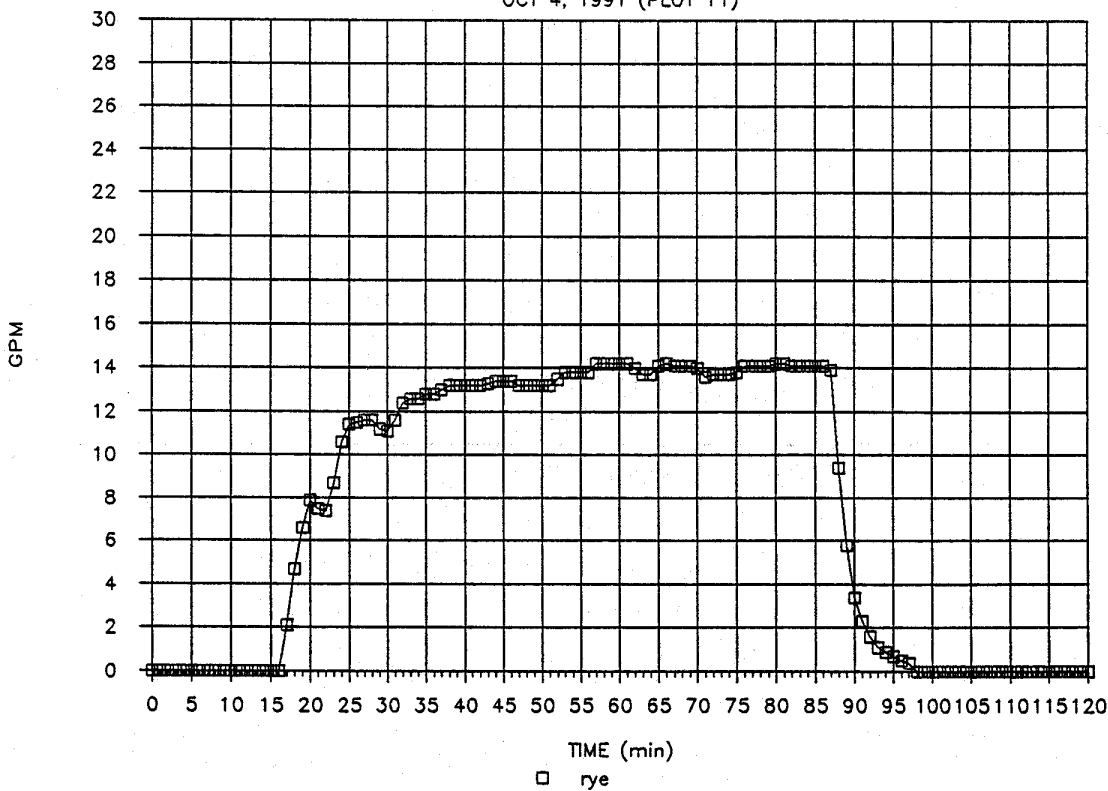
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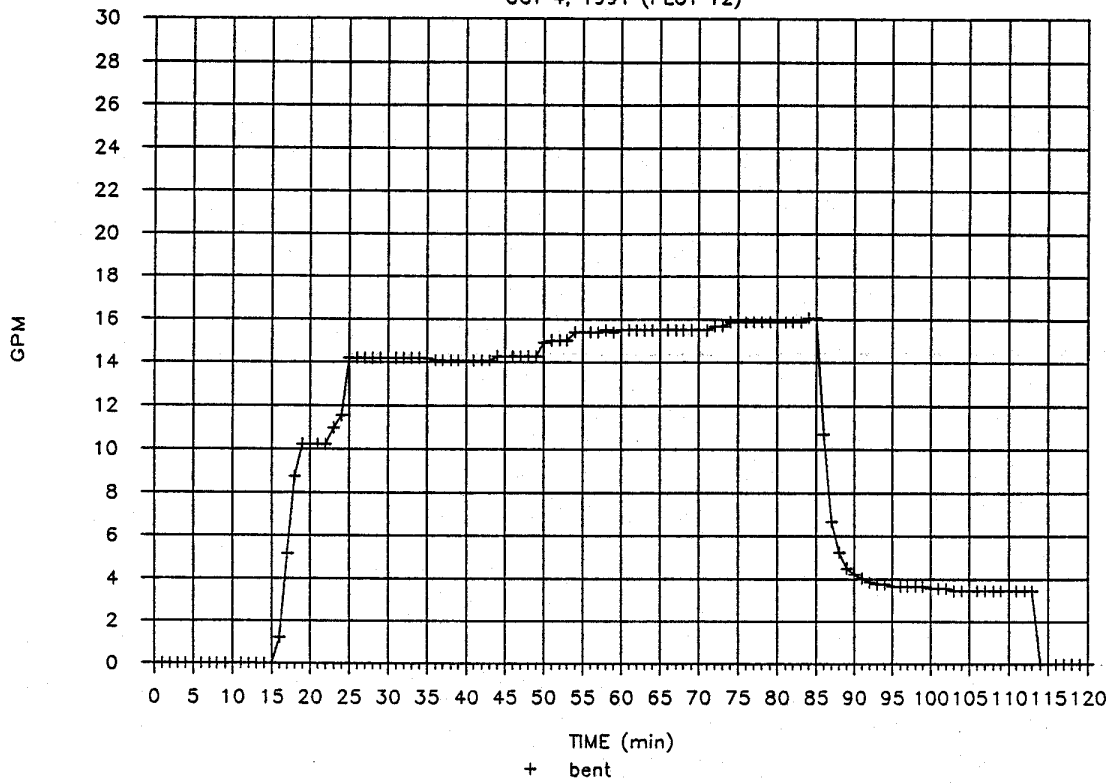
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OCT 4, 1991 (PLOT 11)



USGA EVENT #1 (CORRECTED)

OCT 4, 1991 (PLOT 12)

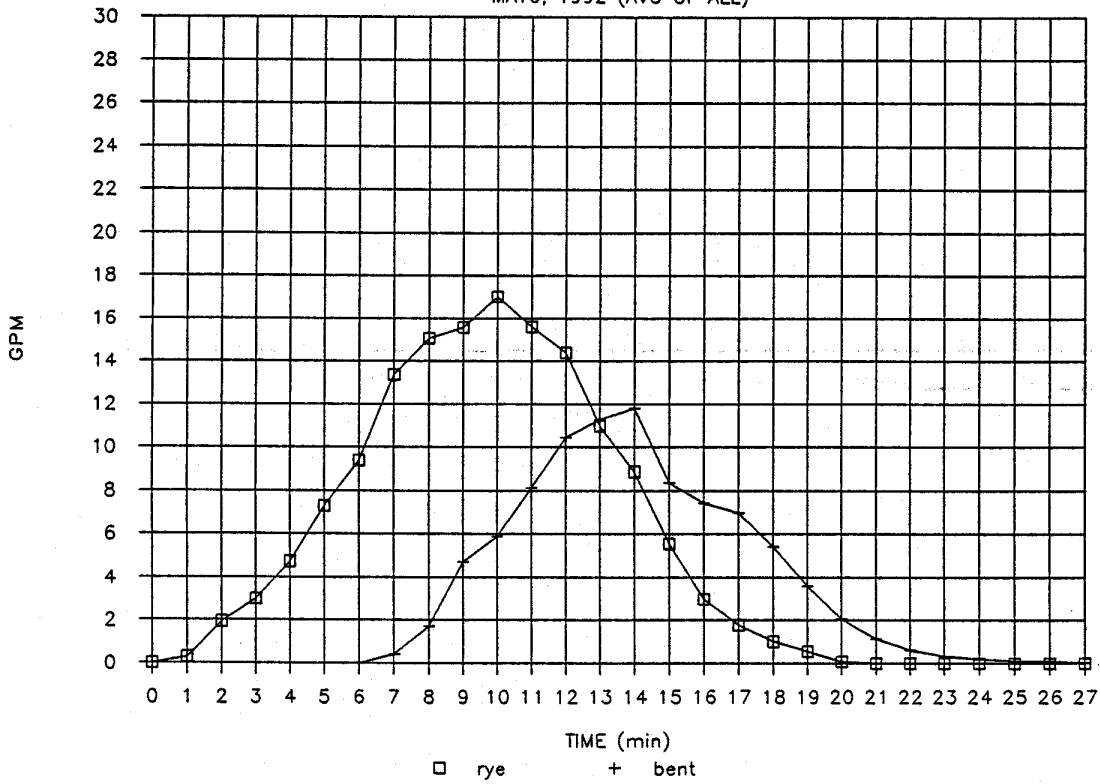


00140



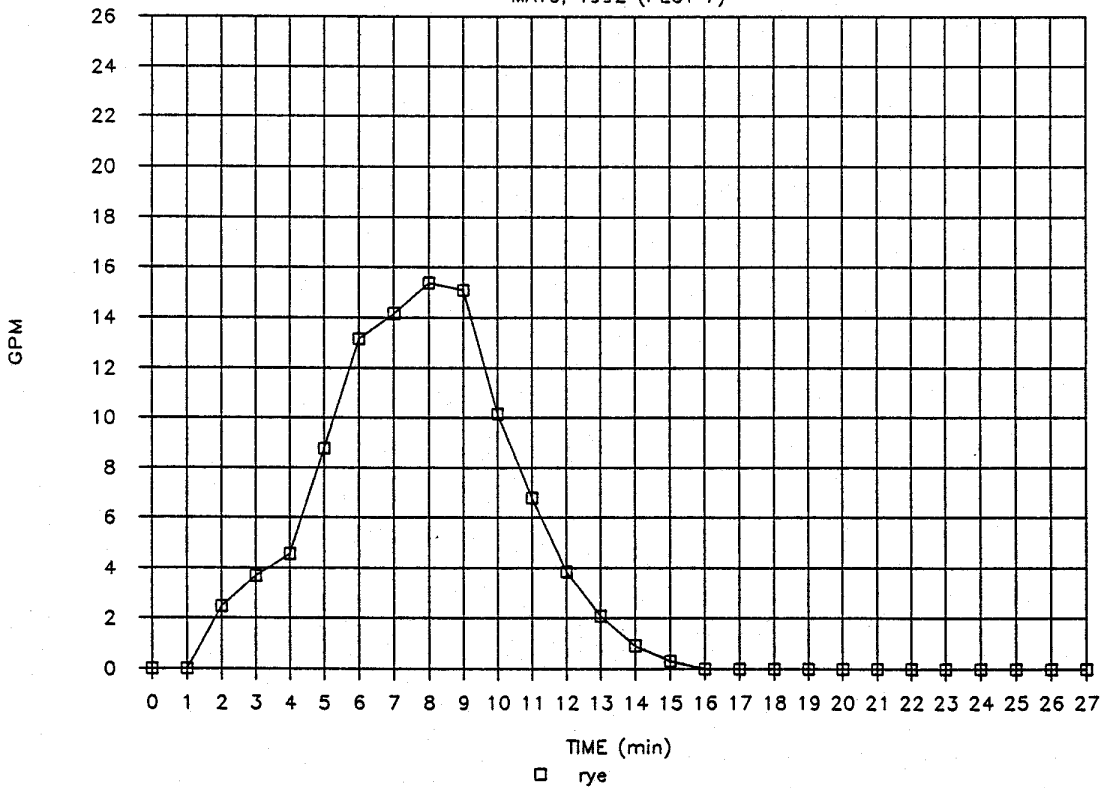
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MAY6, 1992 (AVG OF ALL)



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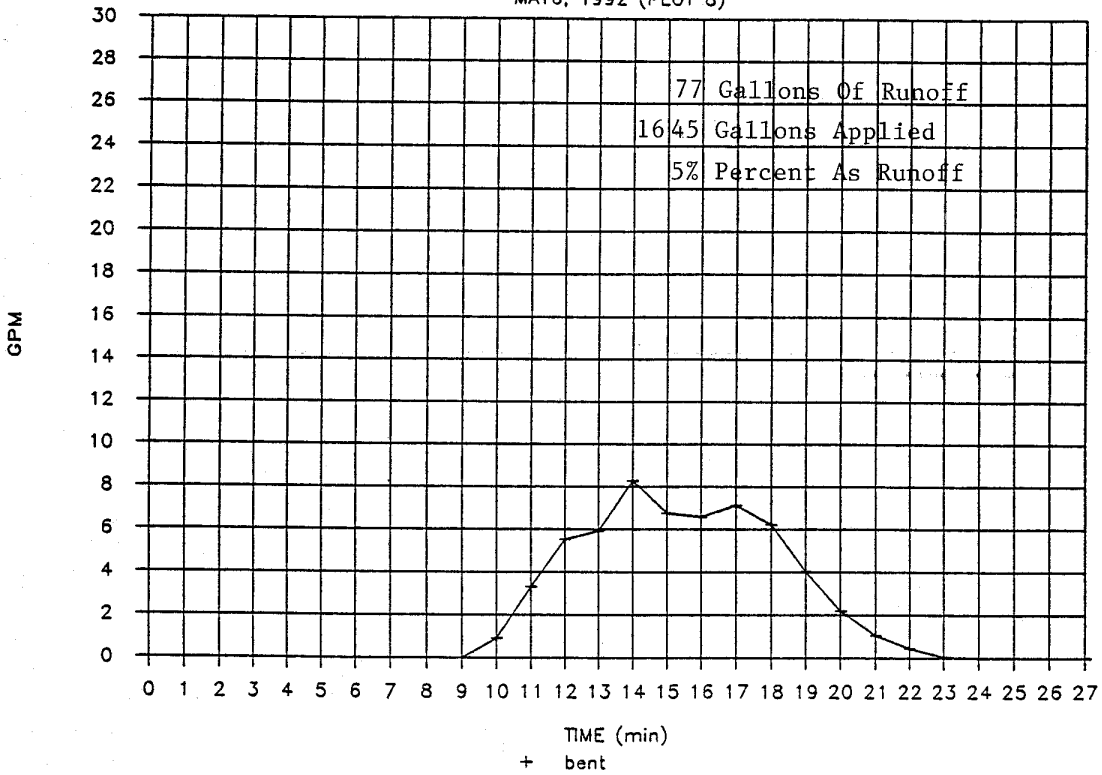
MAY6, 1992 (PLOT 7)



00141

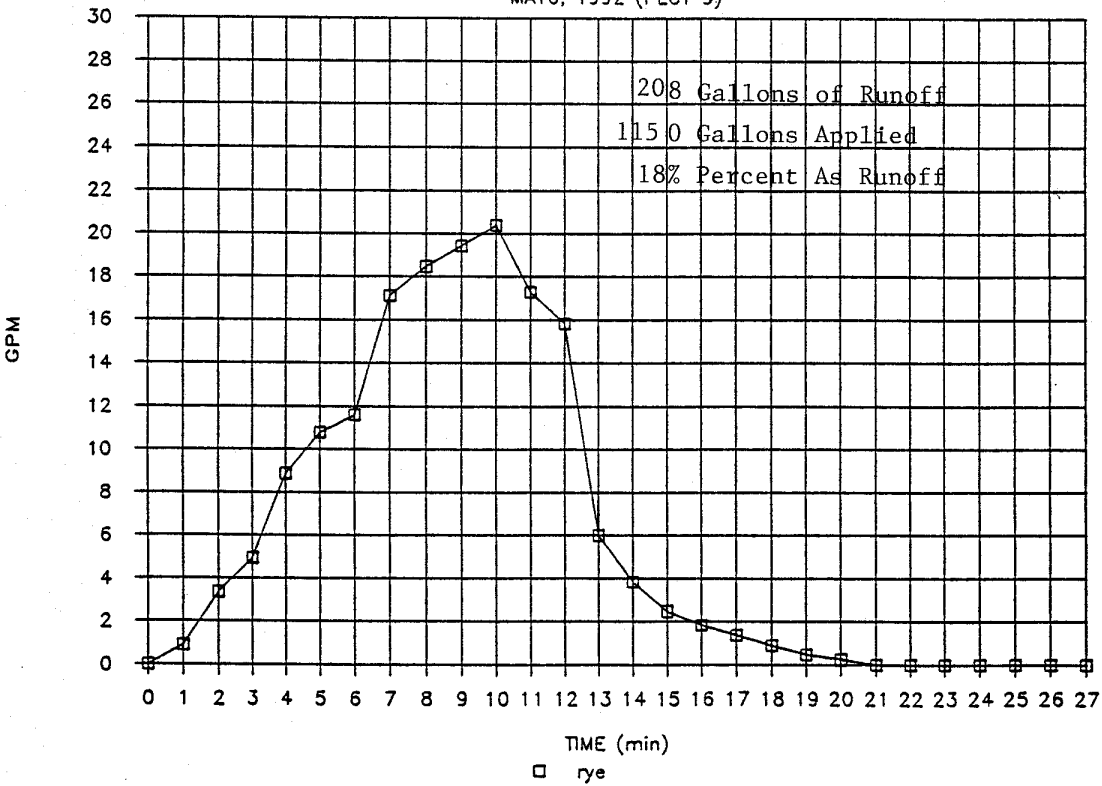
USGA EVENT #2 (CORRECTED)

MAY6, 1992 (PLOT 8)



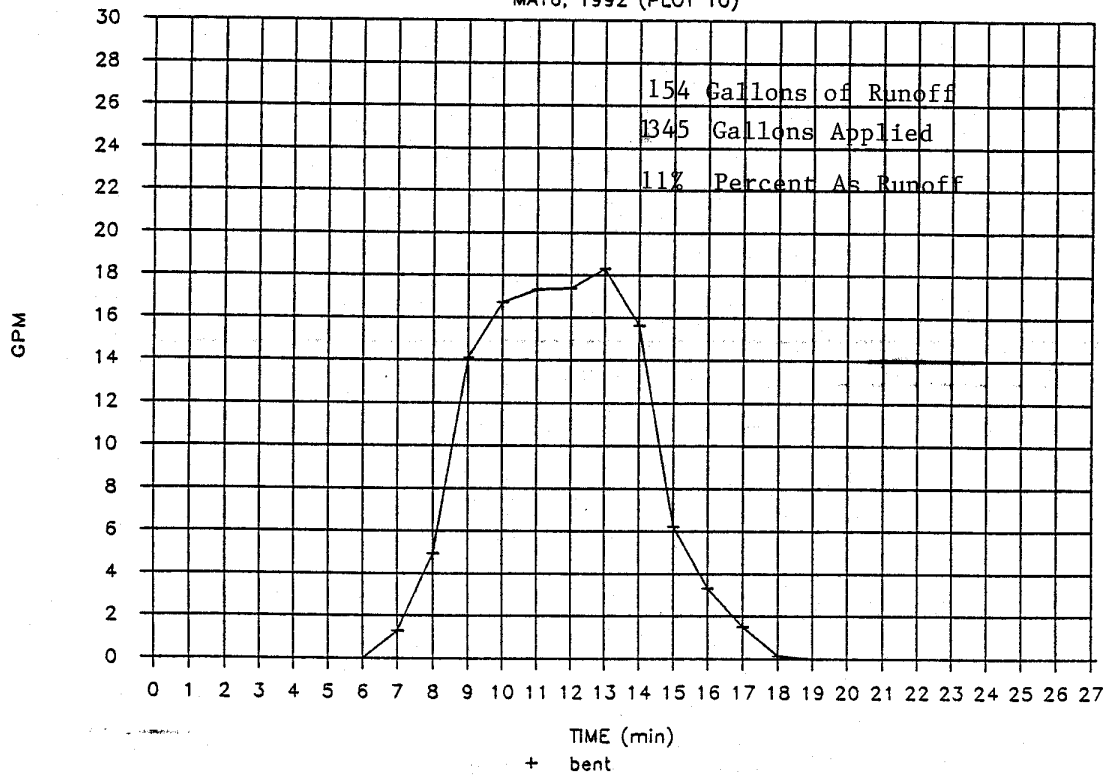
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MAY6, 1992 (PLOT 9)



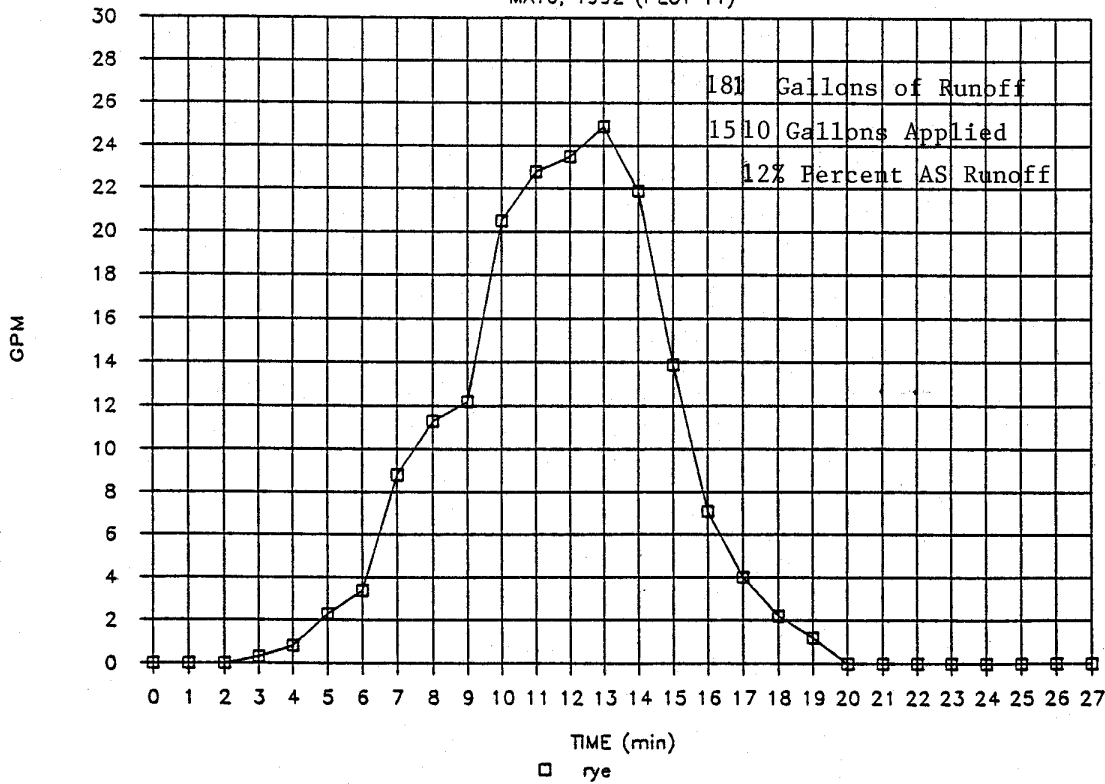
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MAY6, 1992 (PLOT 10)



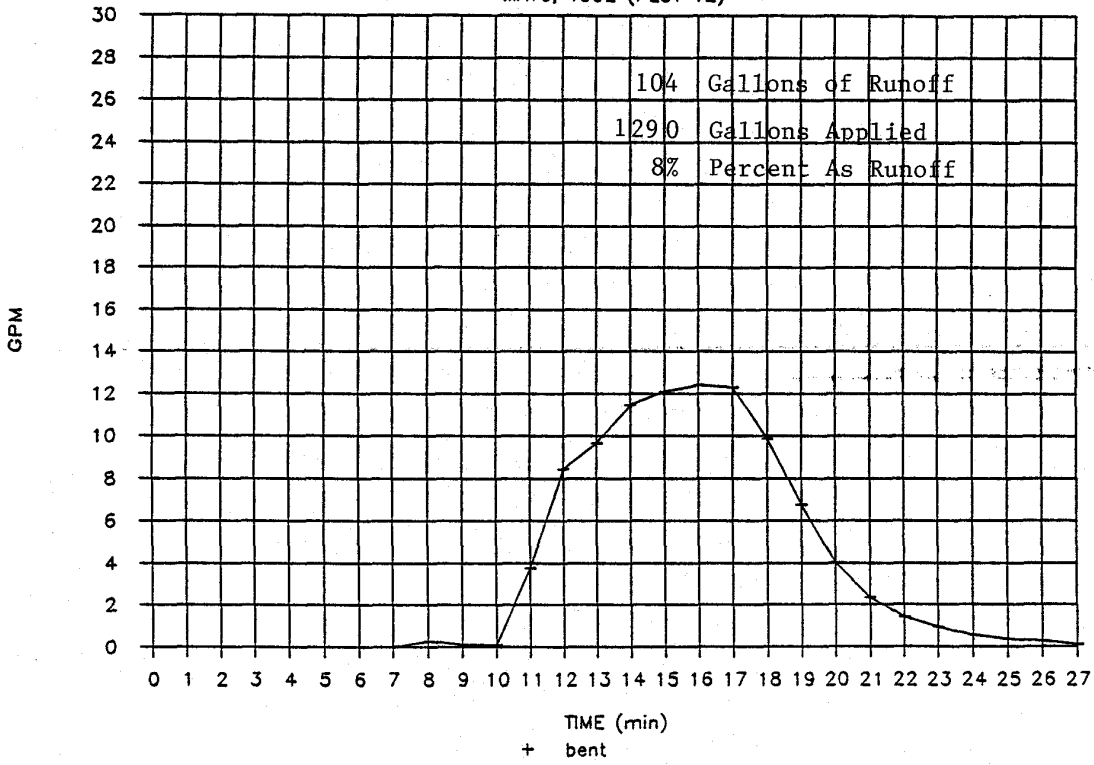
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MAY6, 1992 (PLOT 11)



USGA EVENT #2 (CORRECTED)

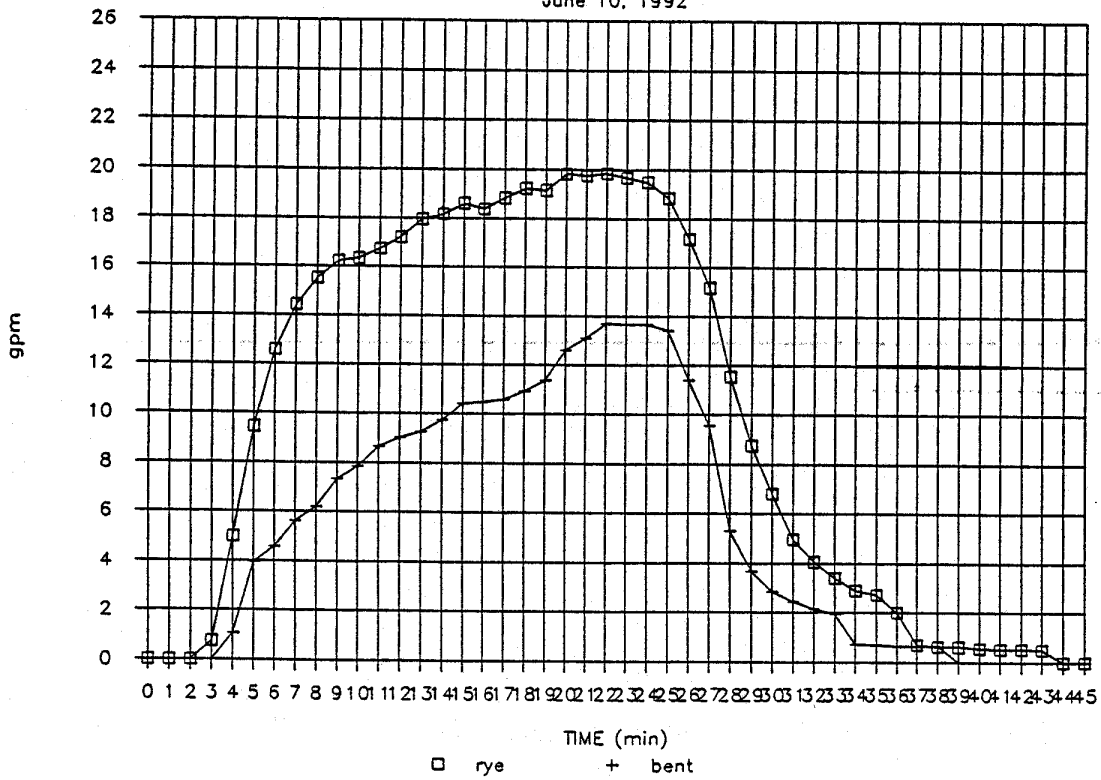
MAY6, 1992 (PLOT 12)



00144

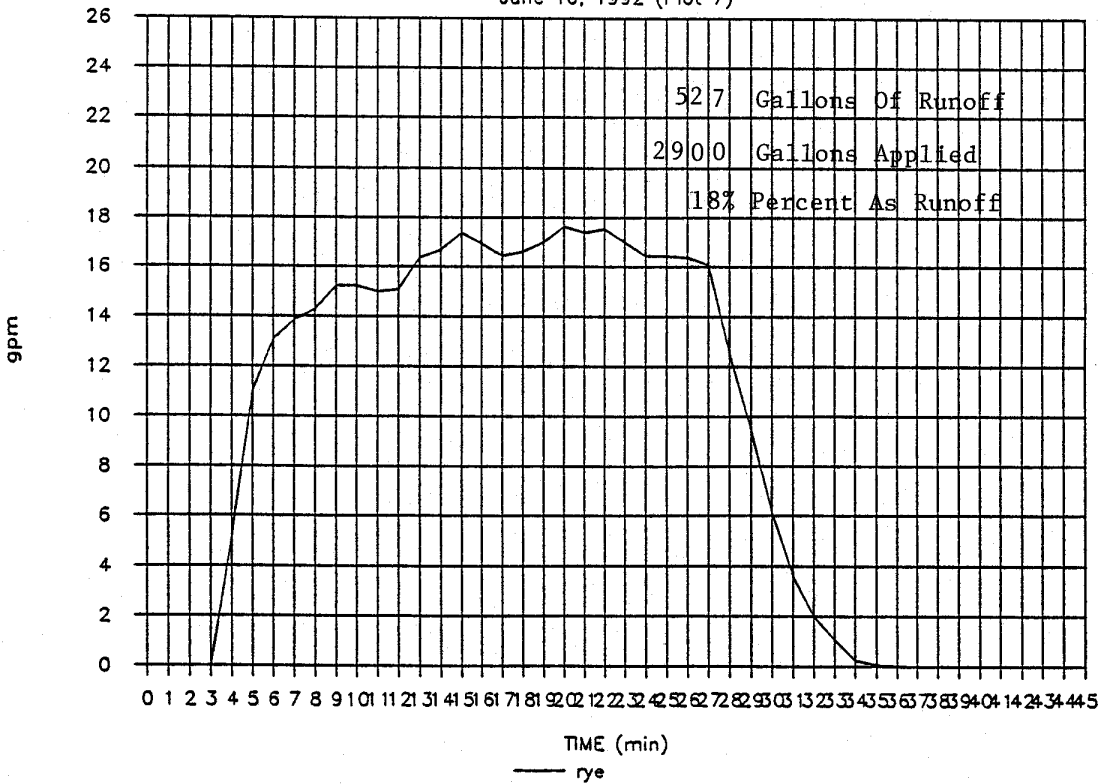
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June 10, 1992



# USGA EVENT #4 (CORRECTED)

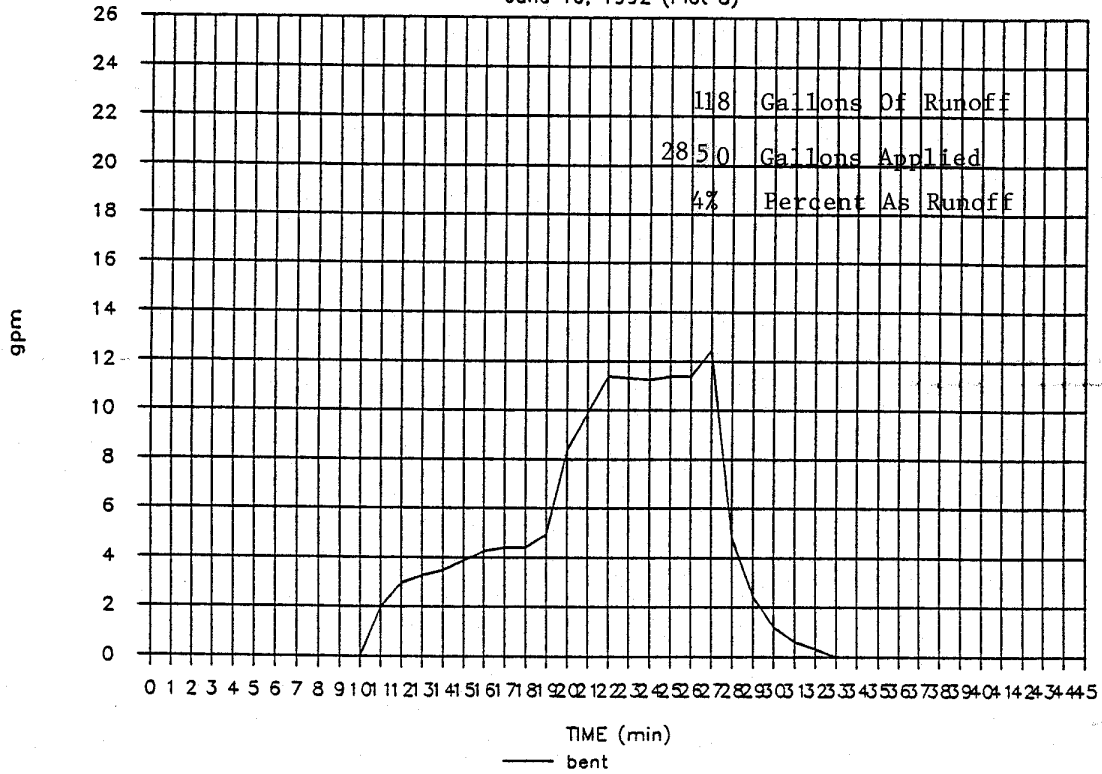
June 10, 1992 (Plot 7)



00145

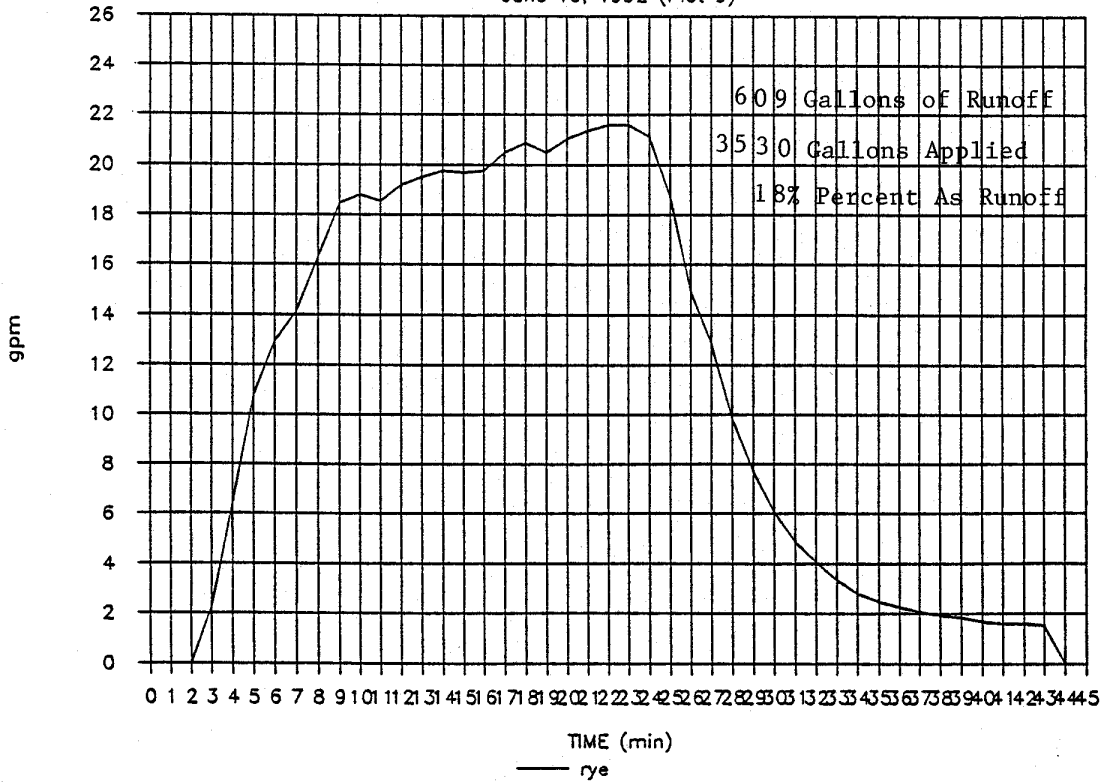
USGA EVENT #4 (CORRECTED)

June 10, 1992 (Plot 8)



USGA EVENT #4 (CORRECTED)

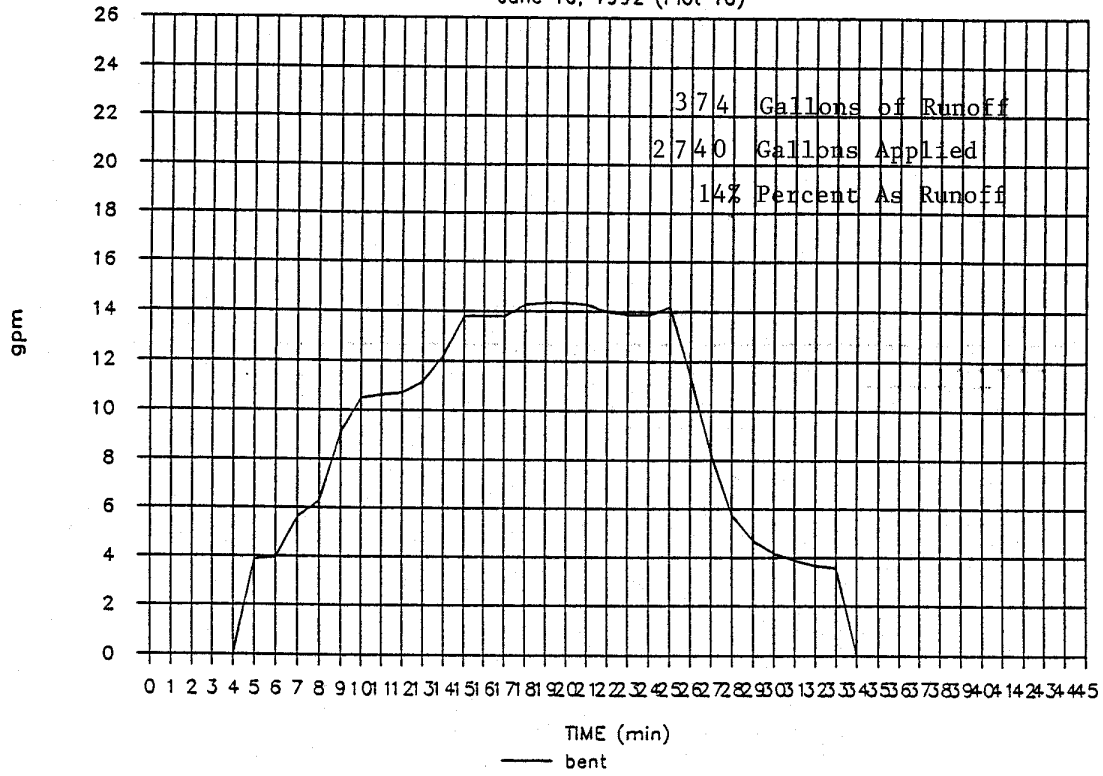
June 10, 1992 (Plot 9)



00146

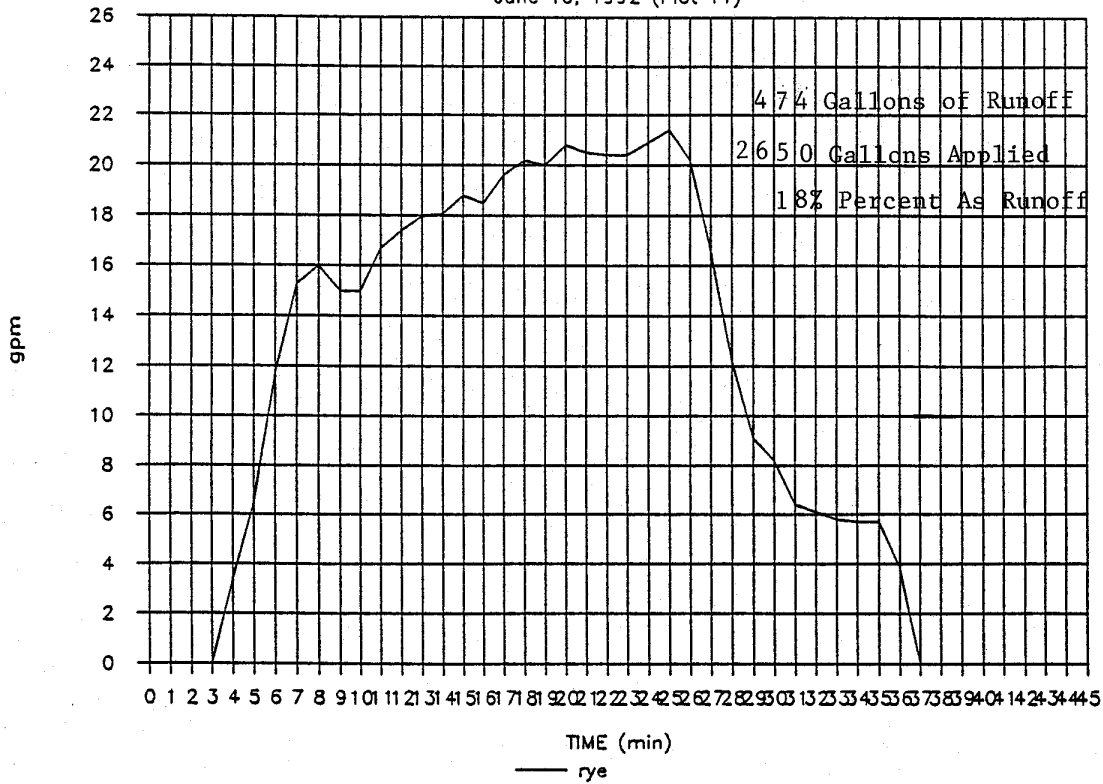
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June 10, 1992 (Plot 10)



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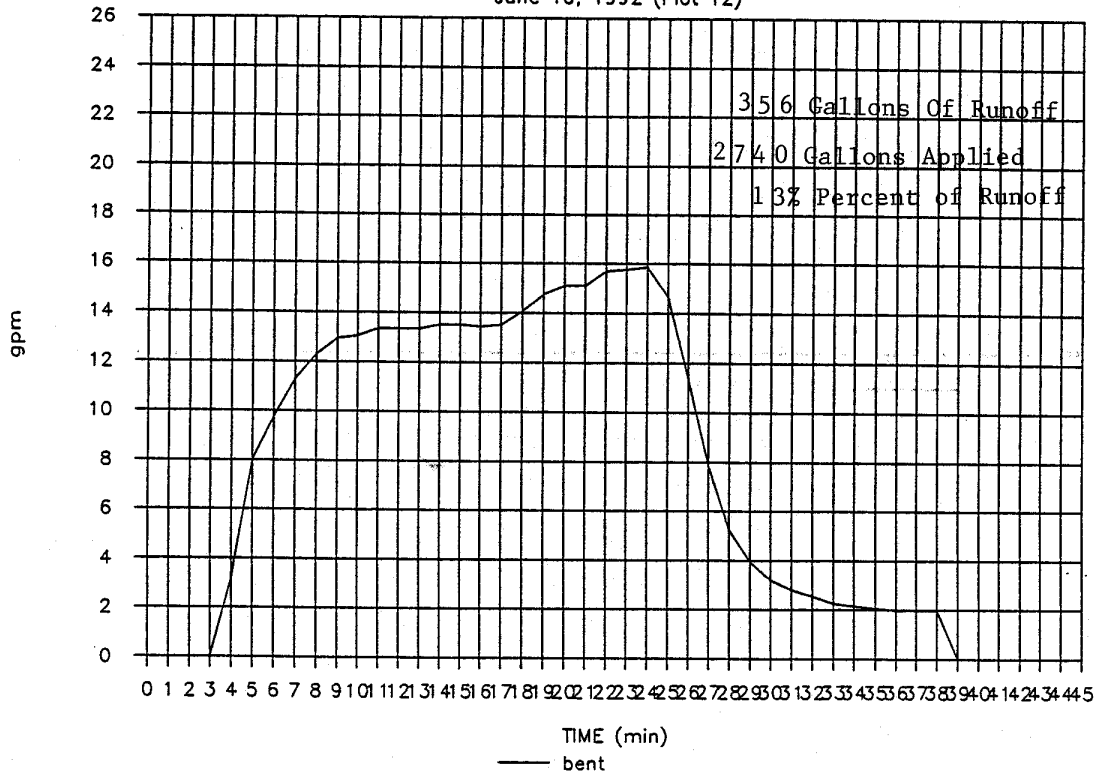
June 10, 1992 (Plot 11)



00147

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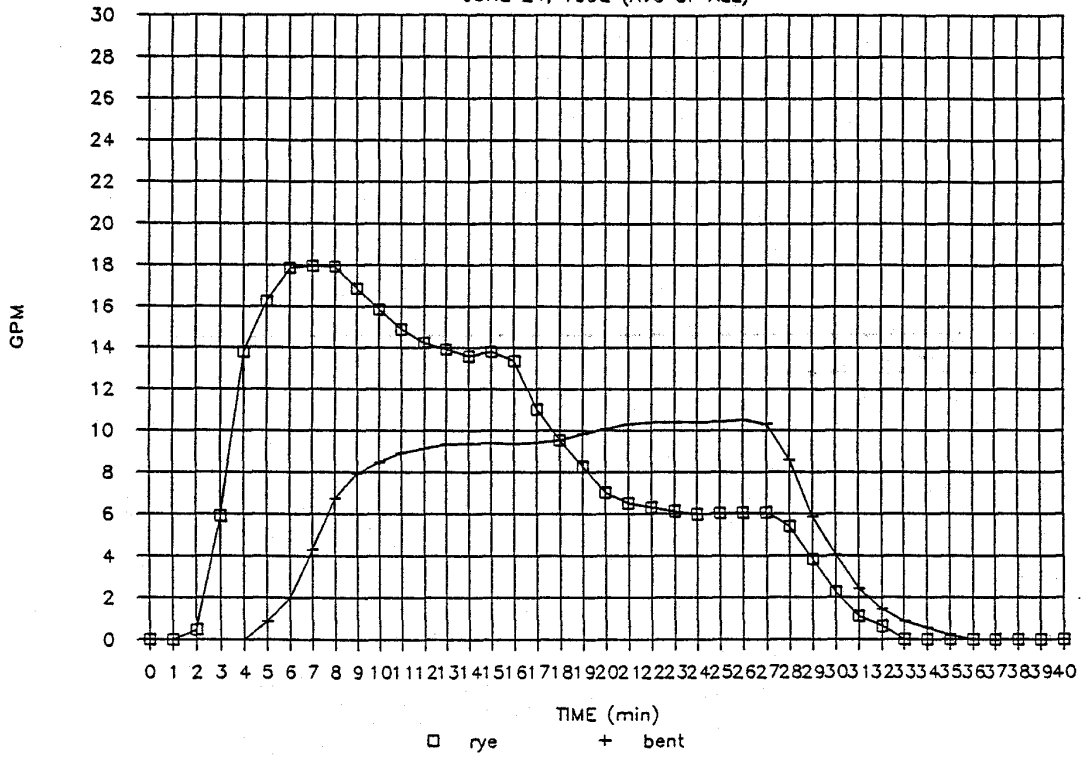


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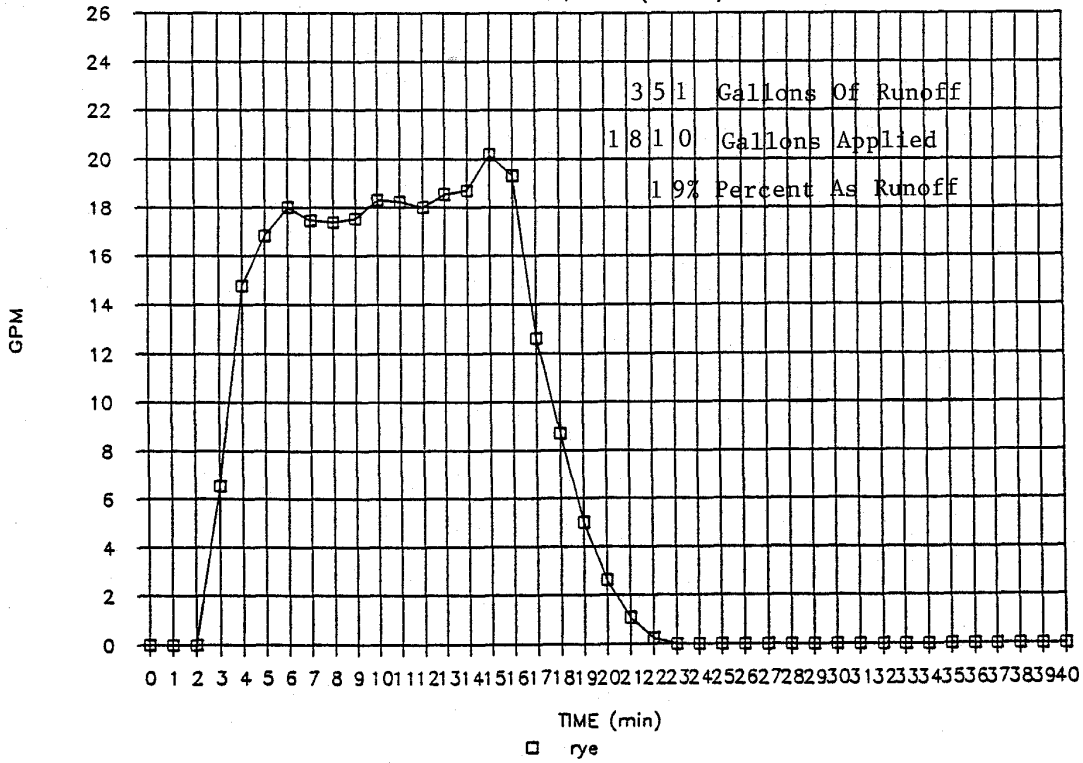
USGA EVENT #6 (CORRECTED)

JUNE 24, 1992 (AVG OF ALL)



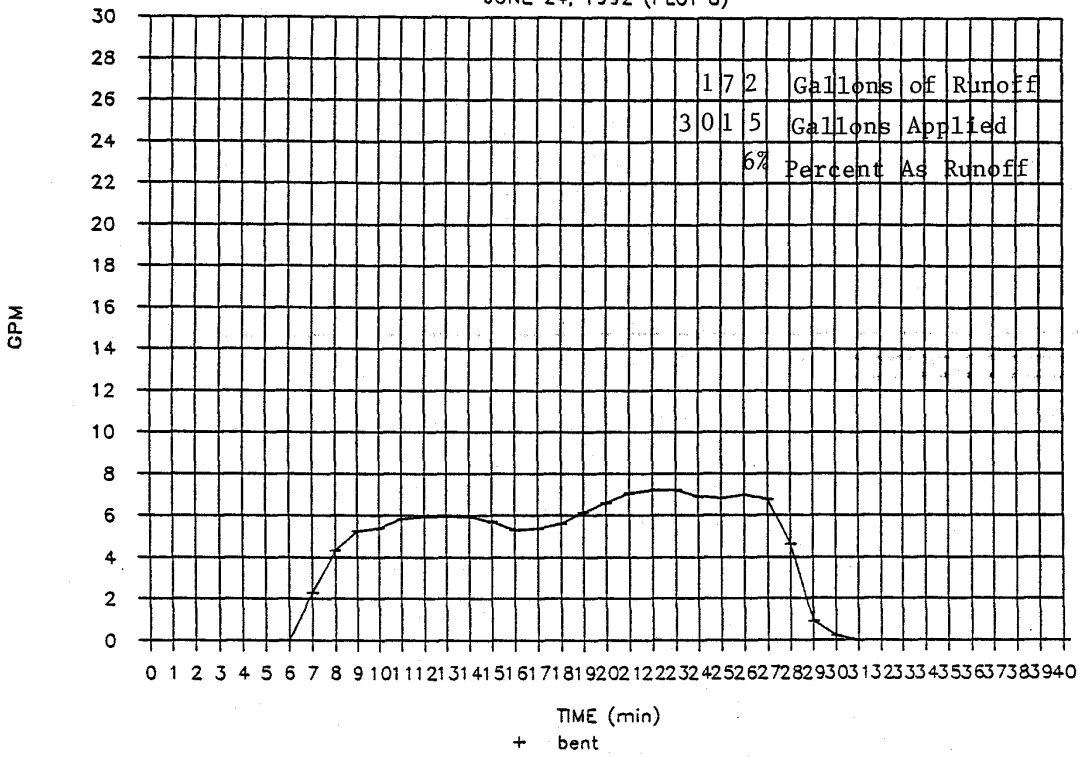
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JUNE 24, 1992 (PLOT 7)



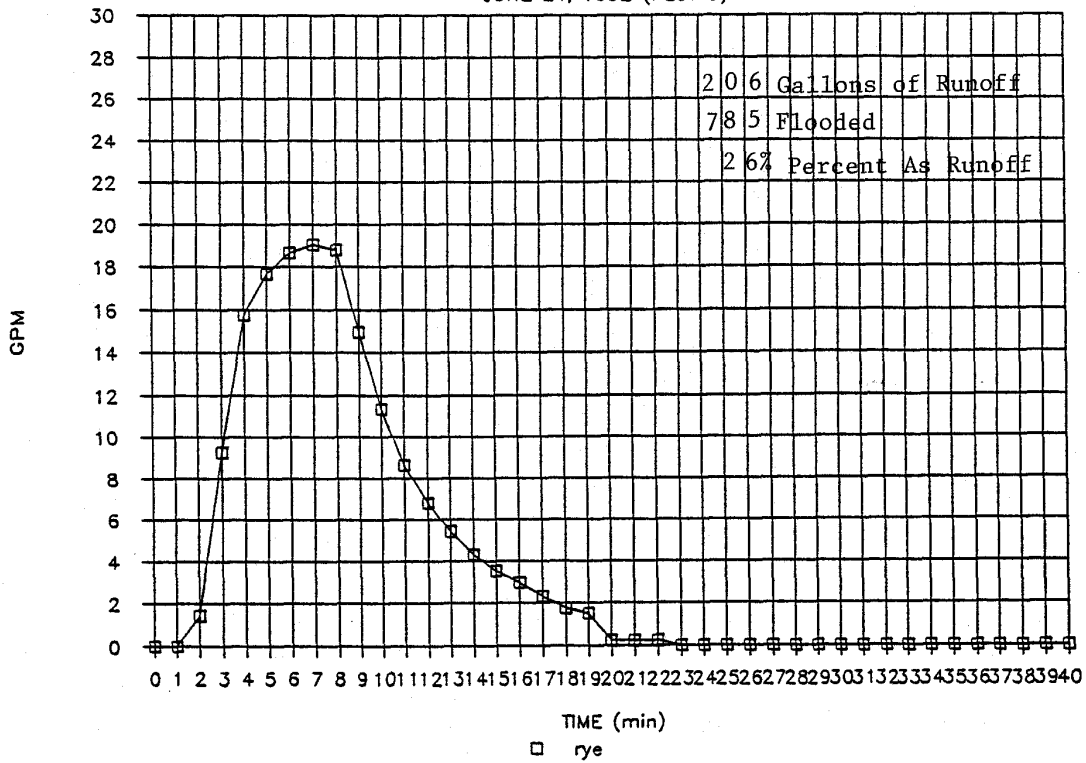
USGA EVENT #6 (CORRECTED)

JUNE 24, 1992 (PLOT 8)



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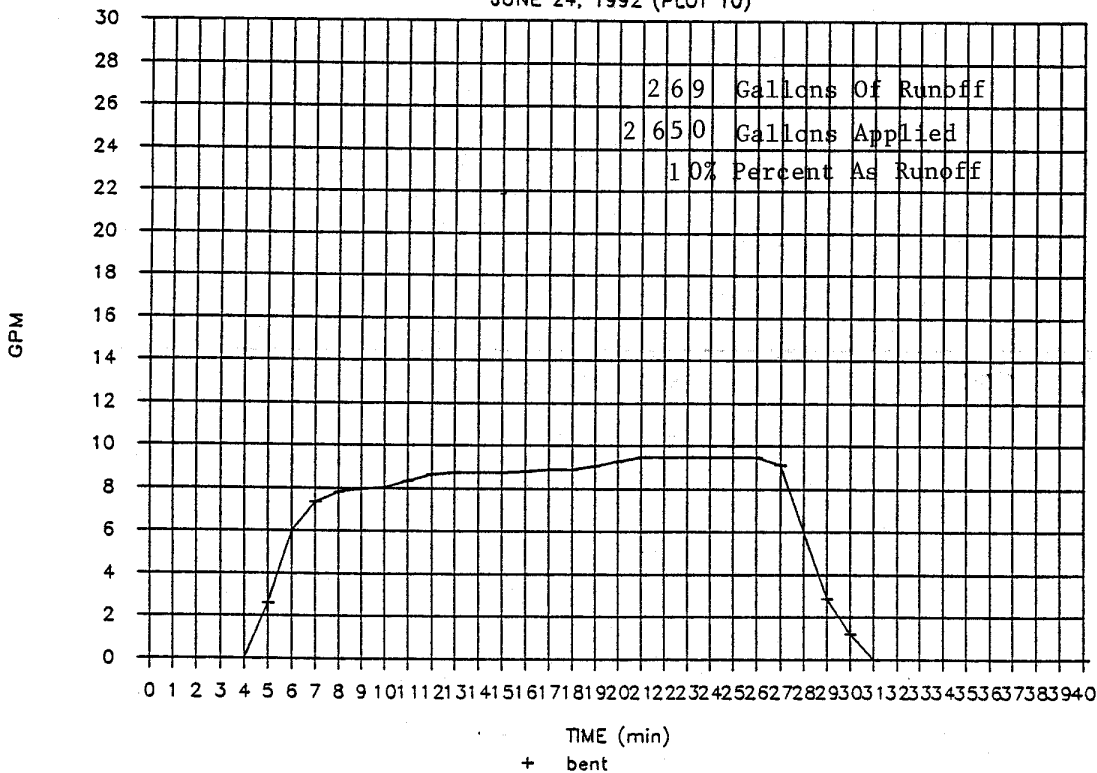
JUNE 24, 1992 (PLOT 9)



00150

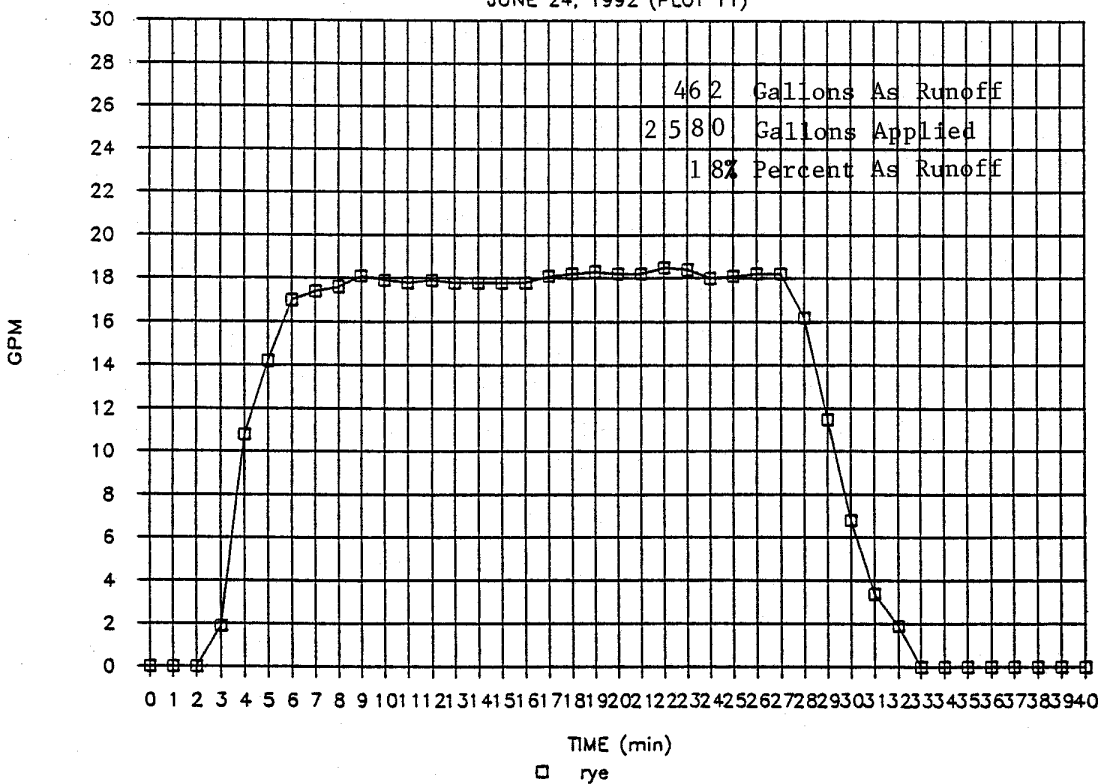
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JUNE 24, 1992 (PLOT 10)



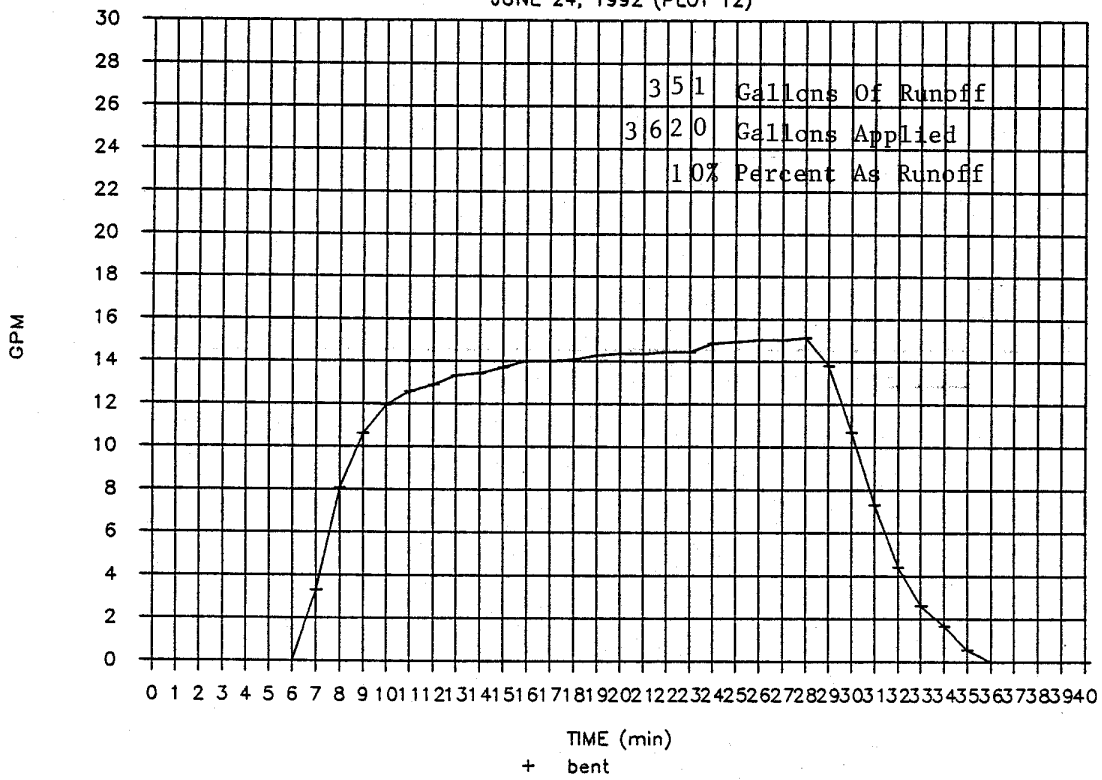
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JUNE 24, 1992 (PLOT 11)



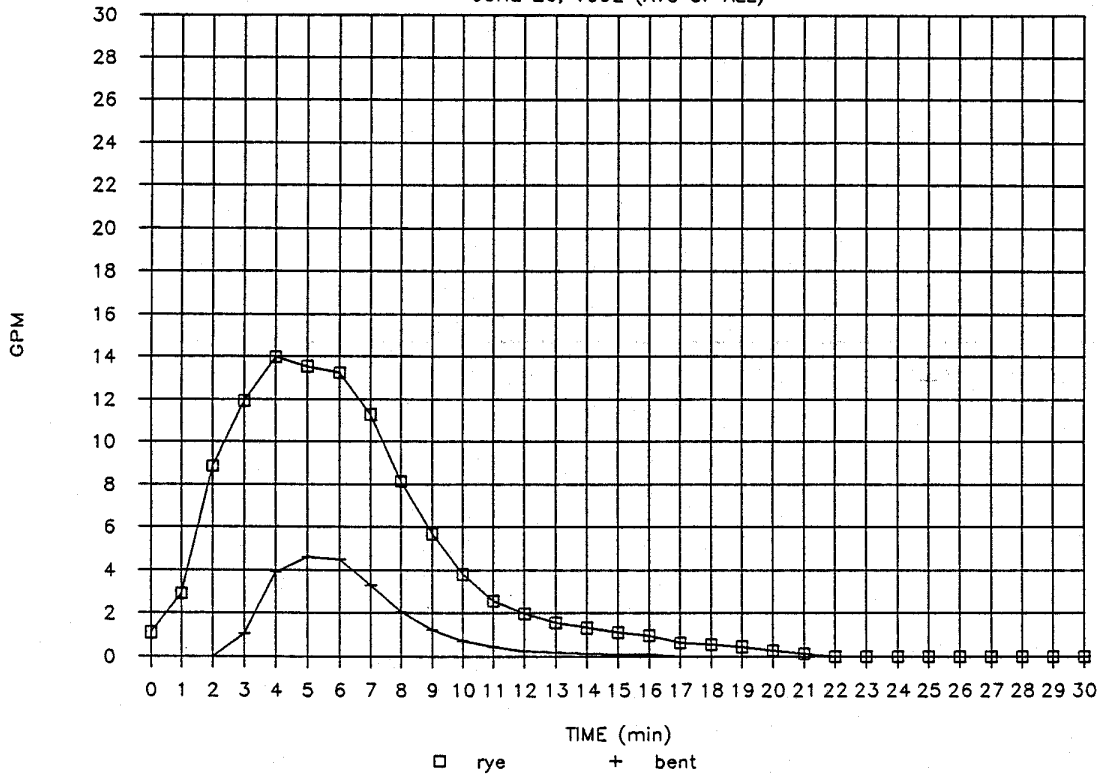
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JUNE 24, 1992 (PLOT 12)



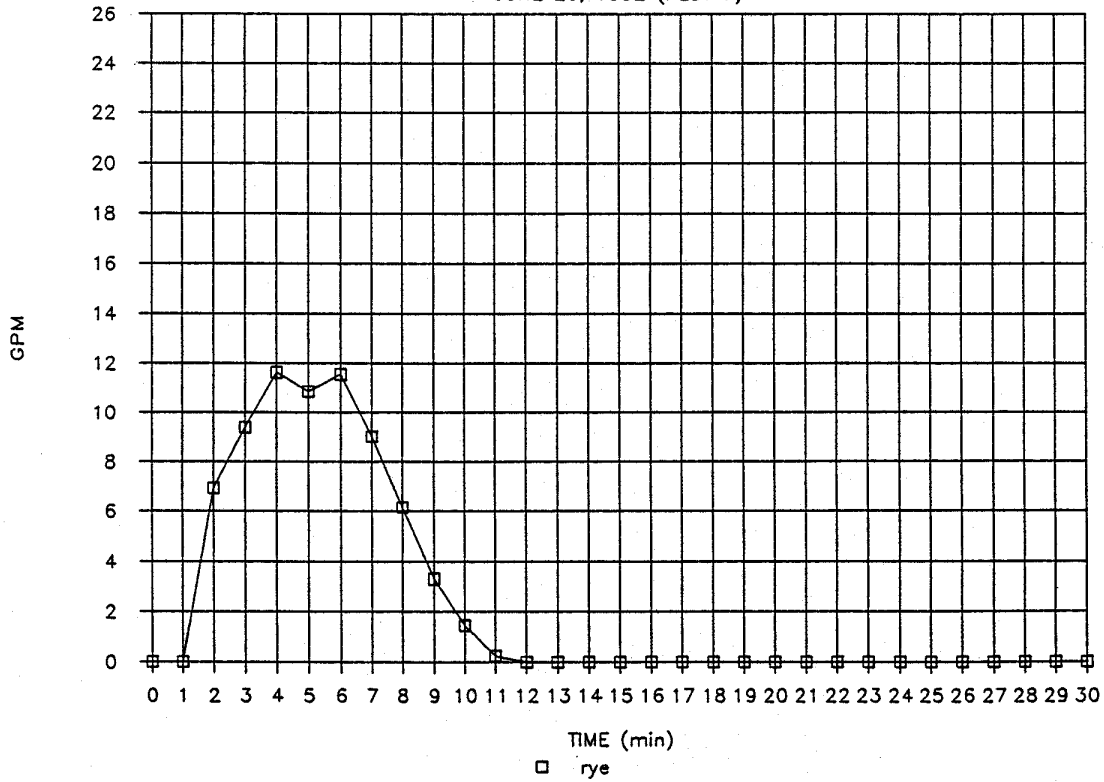
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JUNE 26, 1992 (AVG OF ALL)



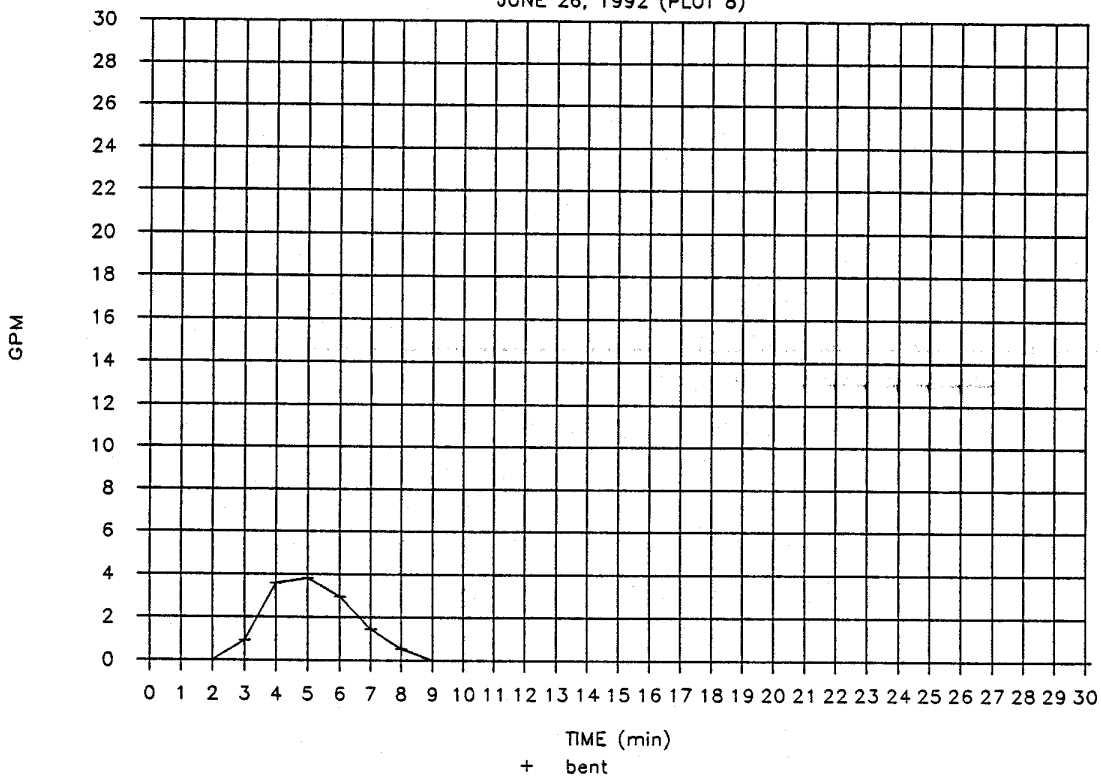
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JUNE 26, 1992 (PLOT 7)



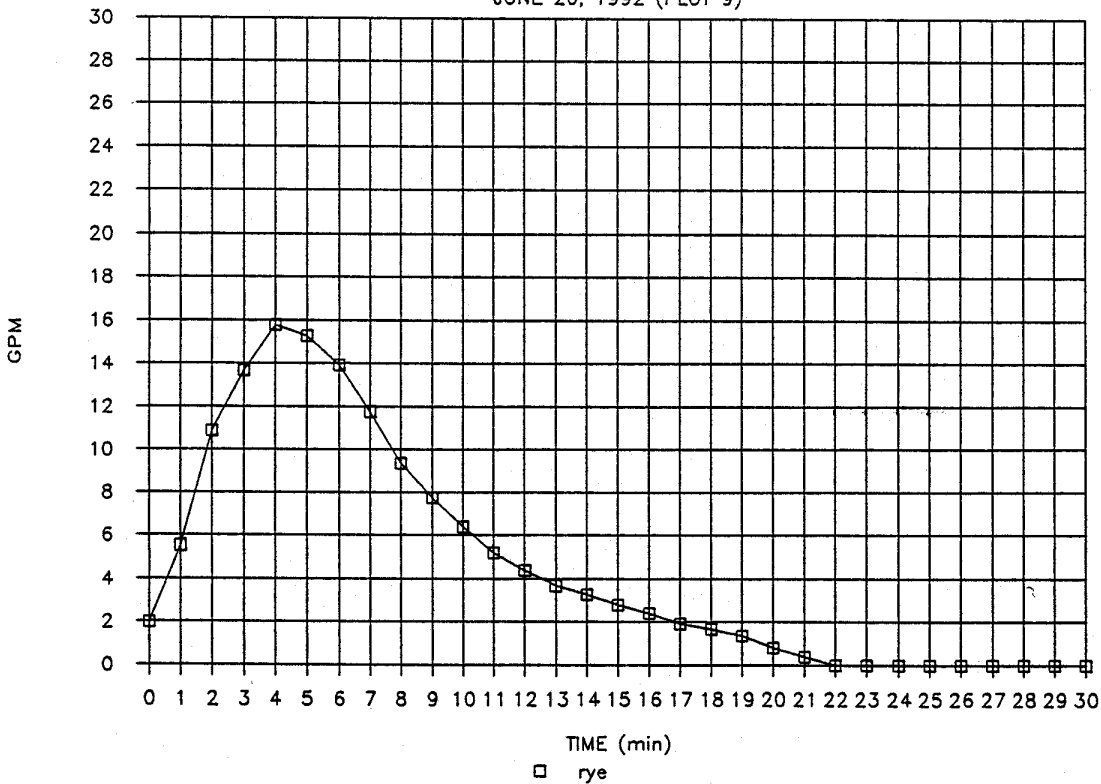
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JUNE 26, 1992 (PLOT 8)



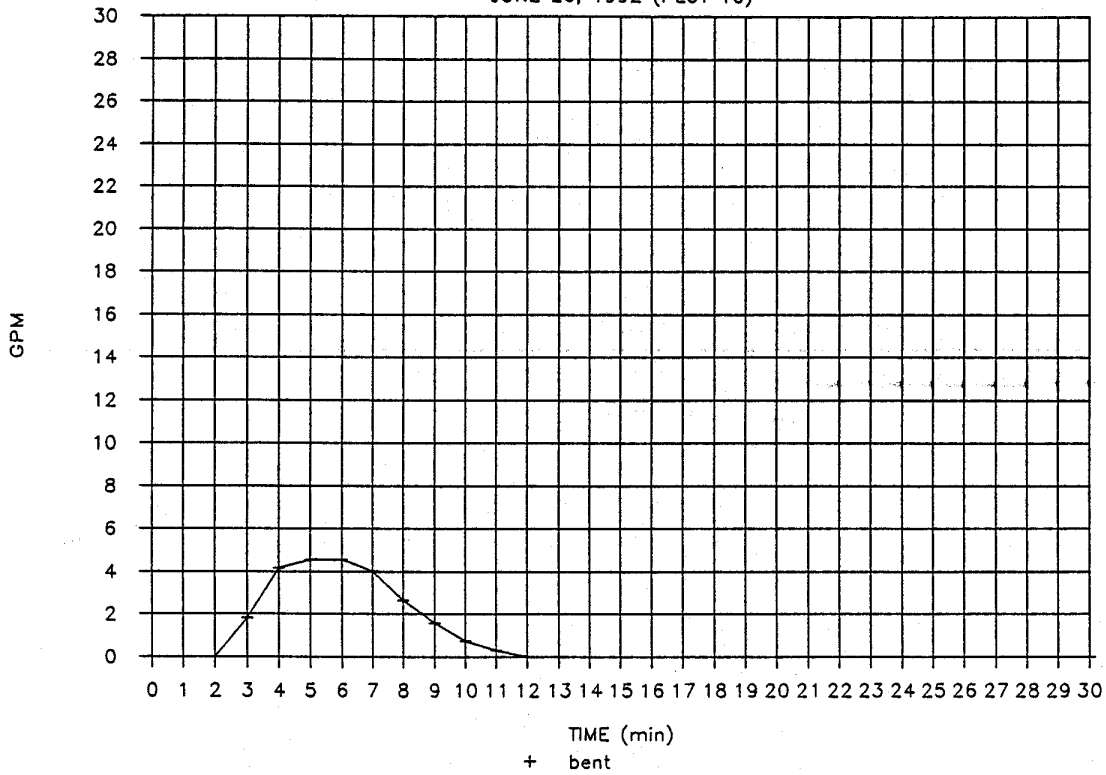
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JUNE 26, 1992 (PLOT 9)



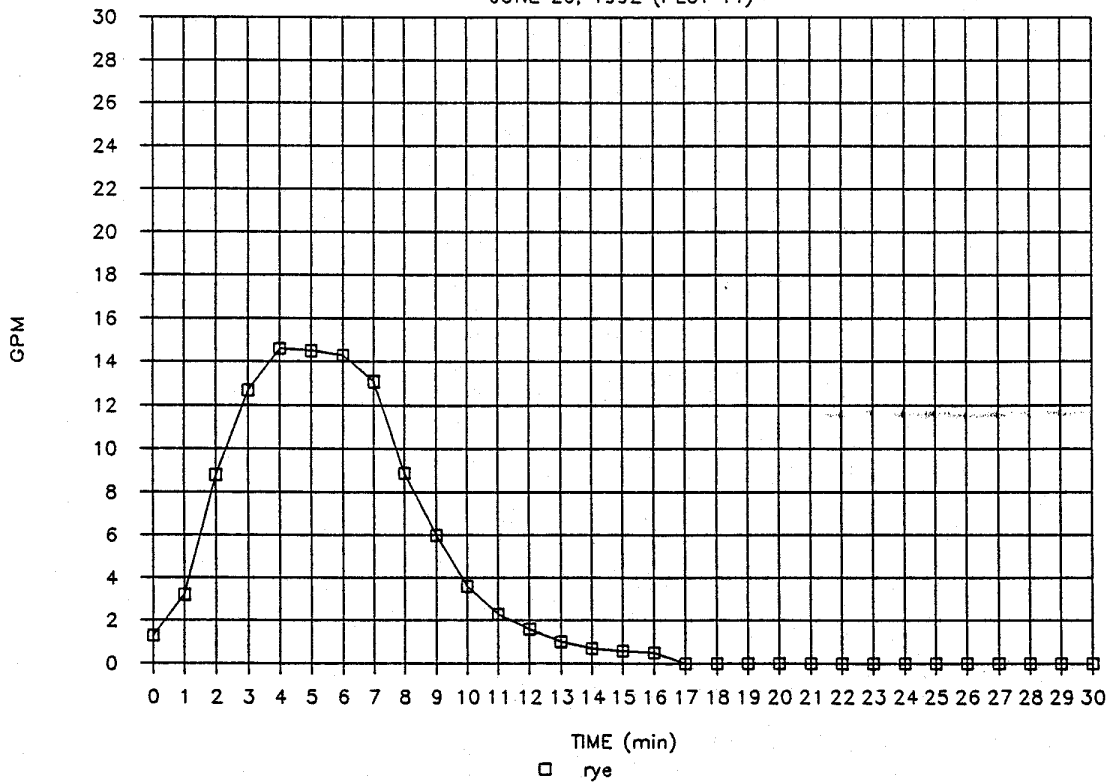
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JUNE 26, 1992 (PLOT 10)



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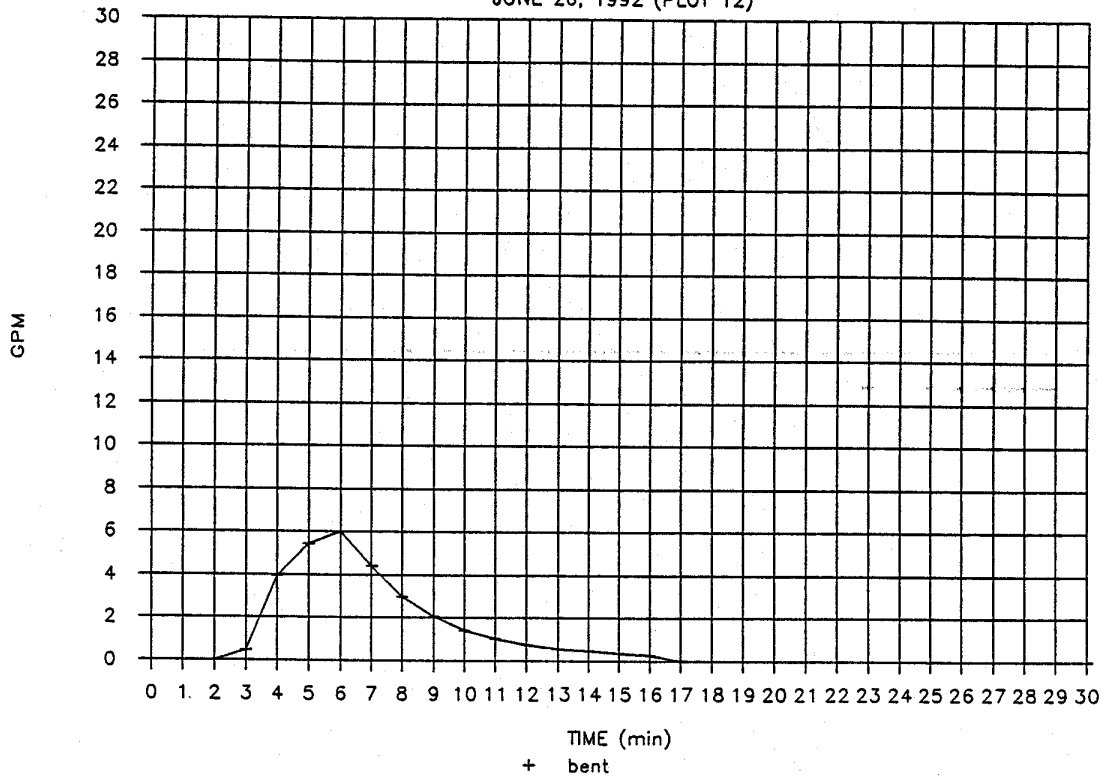
JUNE 26, 1992 (PLOT 11)



00155

USGA EVENT #7 NATURAL (CORRECTED)

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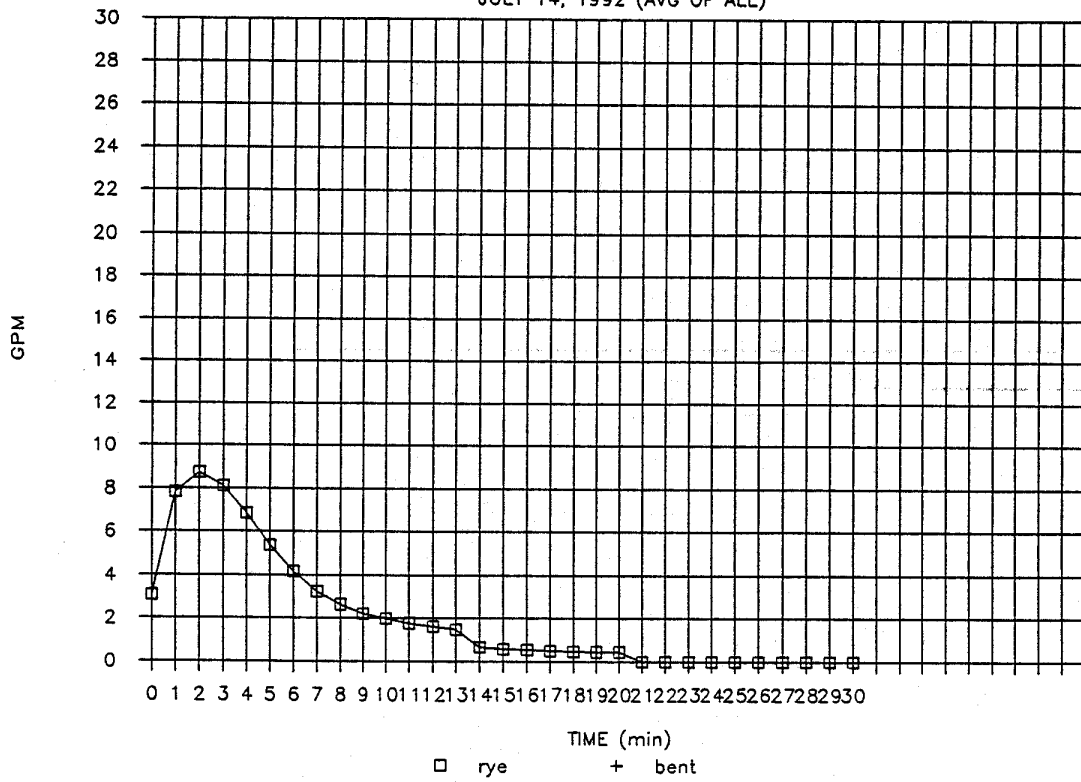


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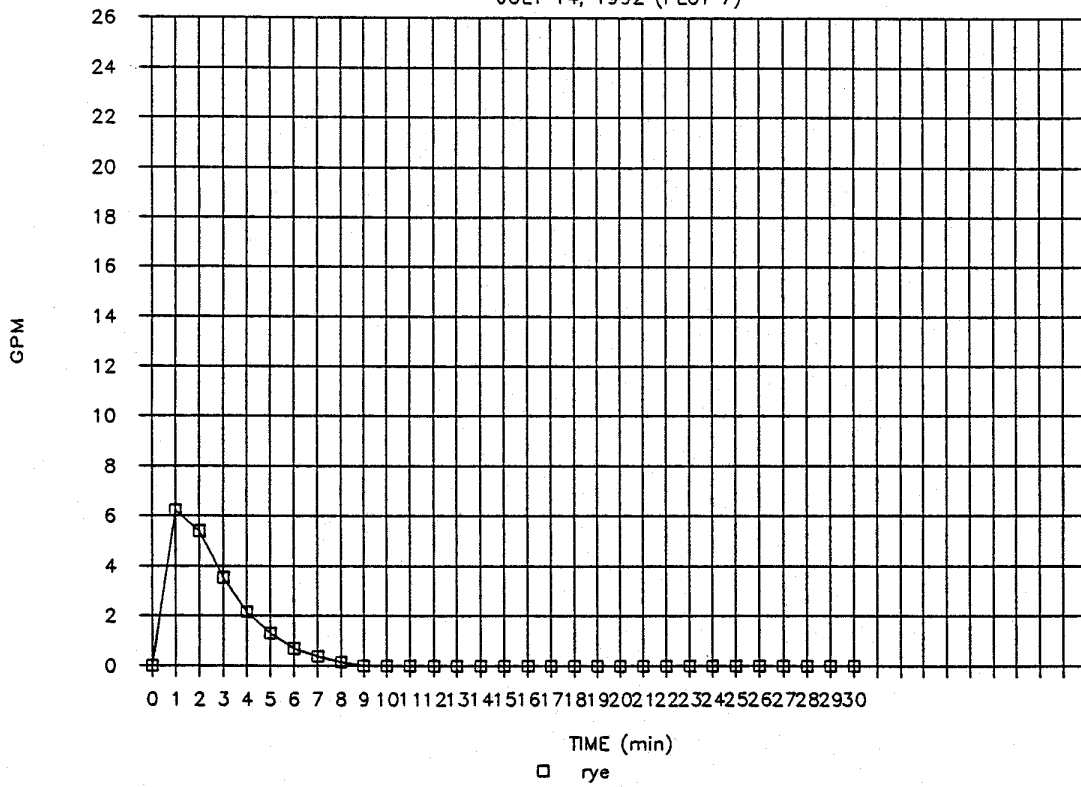
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JULY 14, 1992 (AVG OF ALL)



# USGA EVENT #8 (CORRECTED)

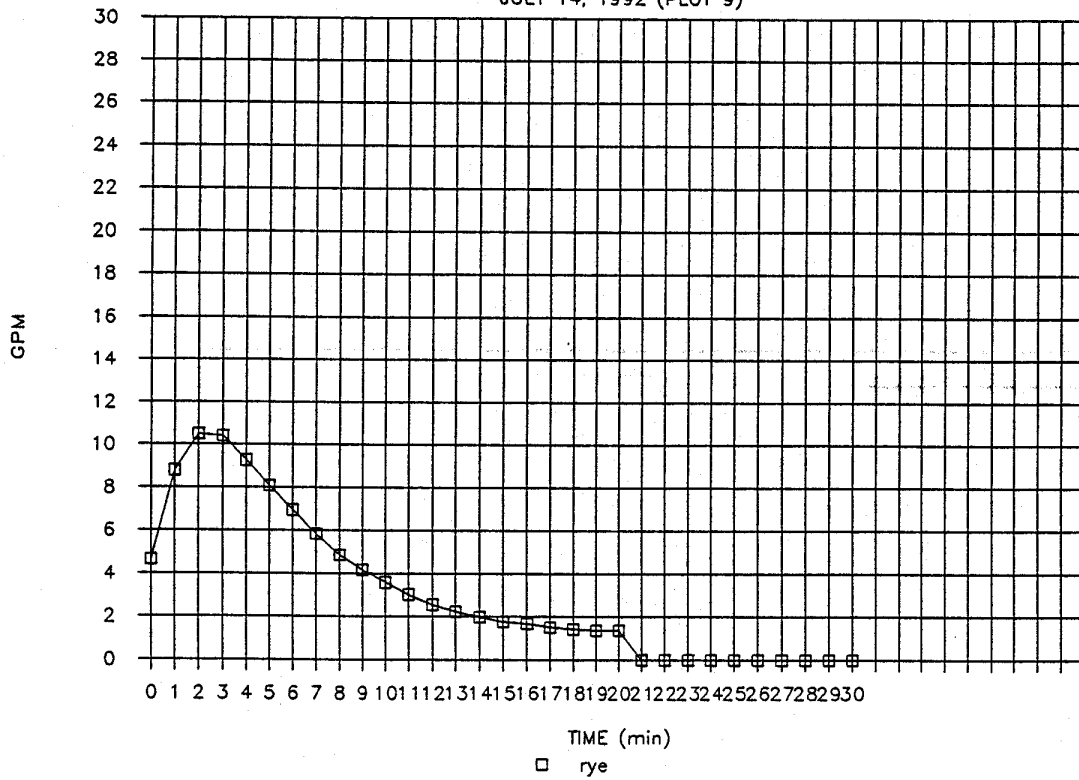
JULY 14, 1992 (PLOT 7)



00157

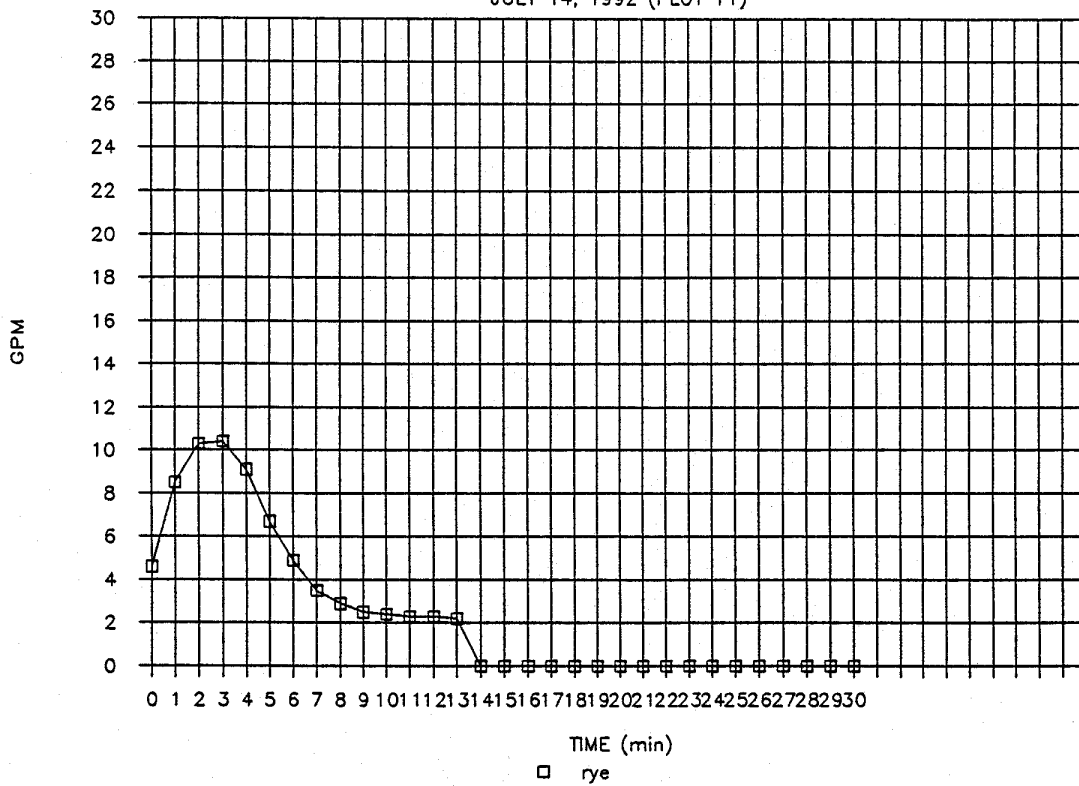
USGA EVENT #8 (CORRECTED)

JULY 14, 1992 (PLOT 9)



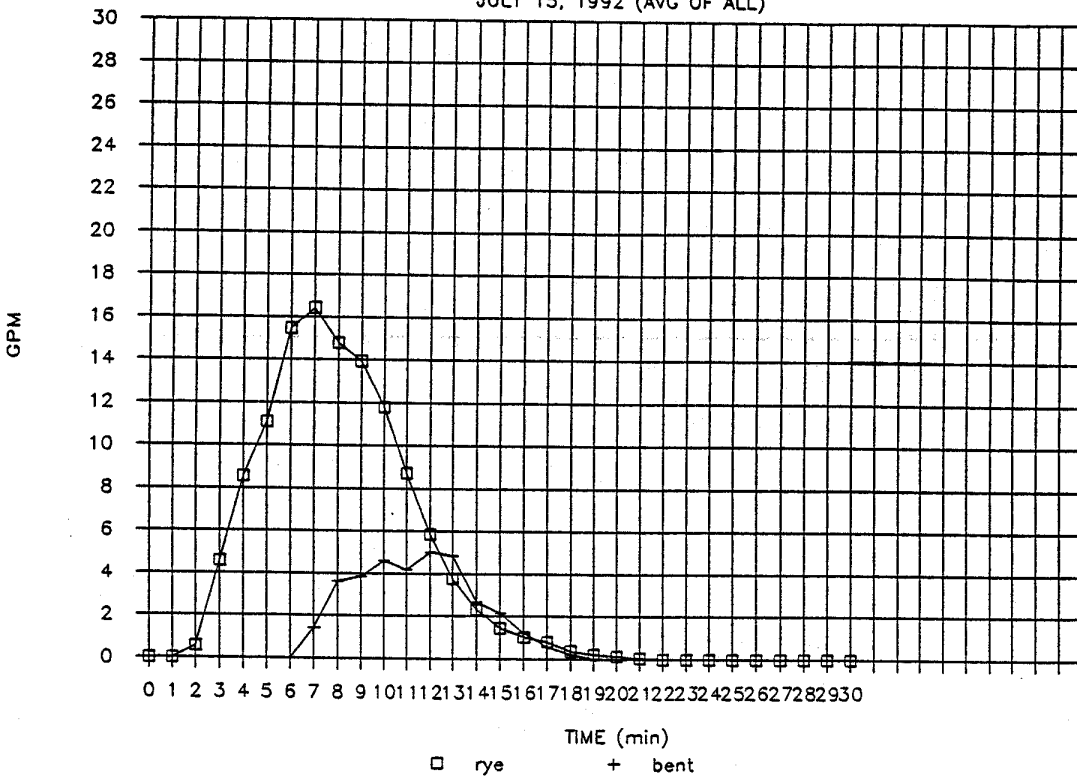
USGA EVENT #8 (CORRECTED)

JULY 14, 1992 (PLOT 11)



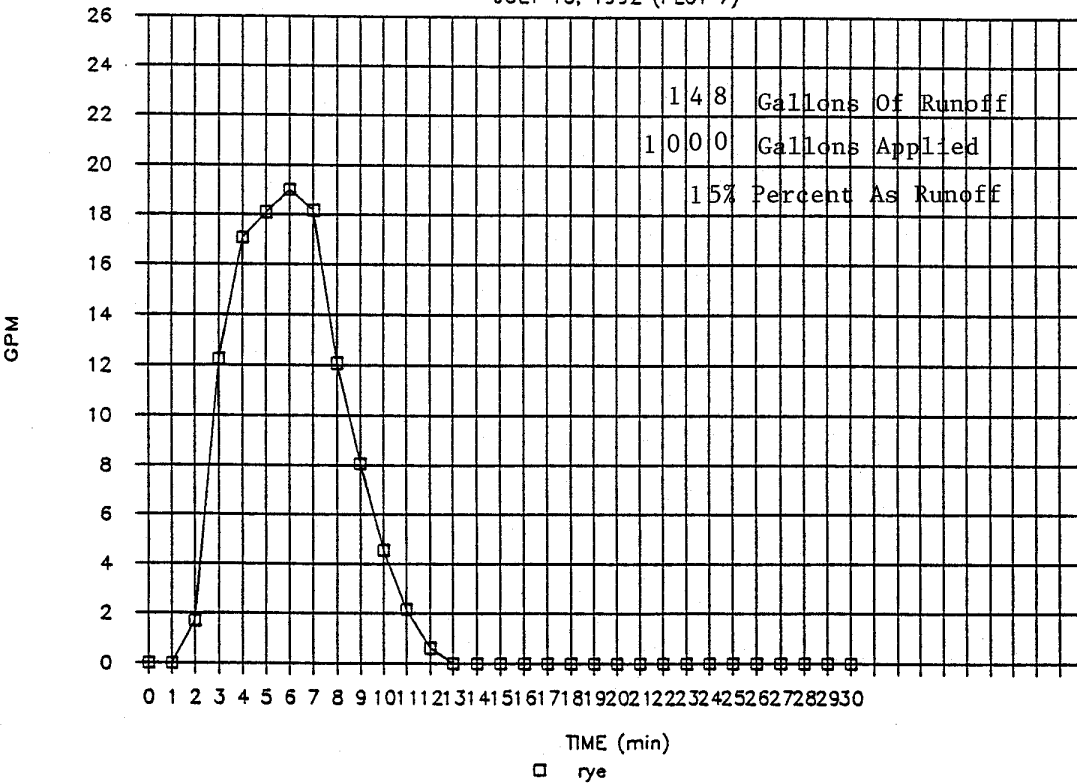
USGA EVENT #9 (CORRECTED)

JULY 15, 1992 (AVG OF ALL)



USGA EVENT #9 (CORRECTED)

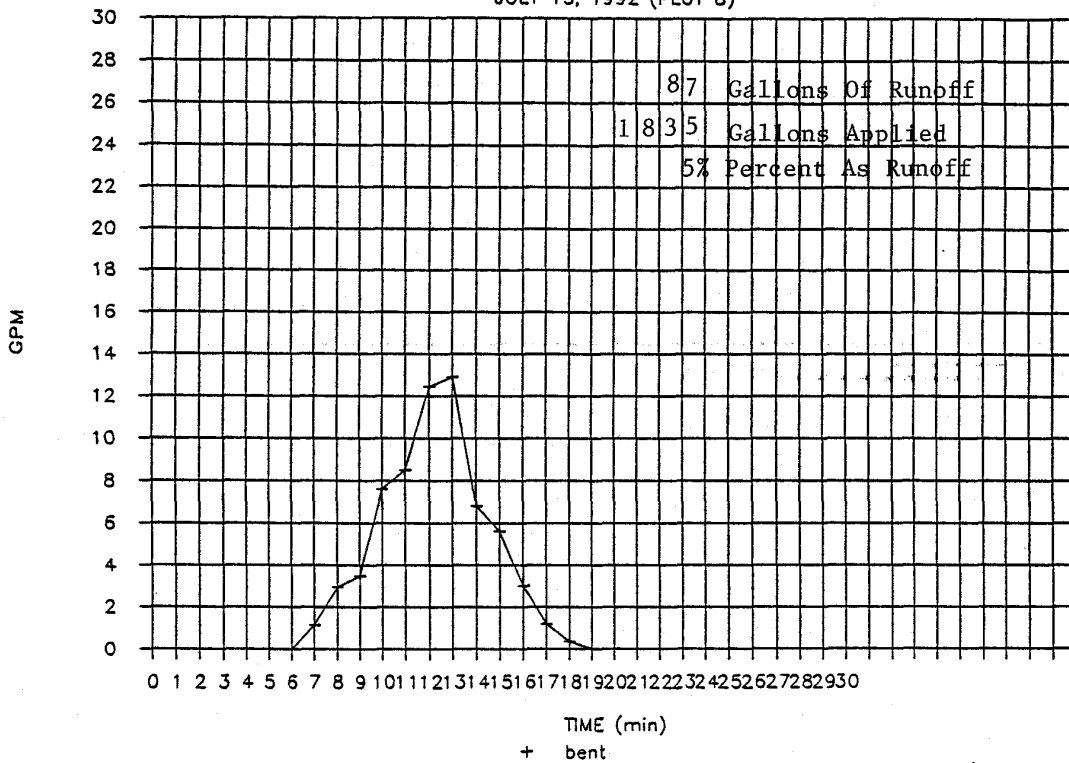
JULY 15, 1992 (PLOT 7)



00159

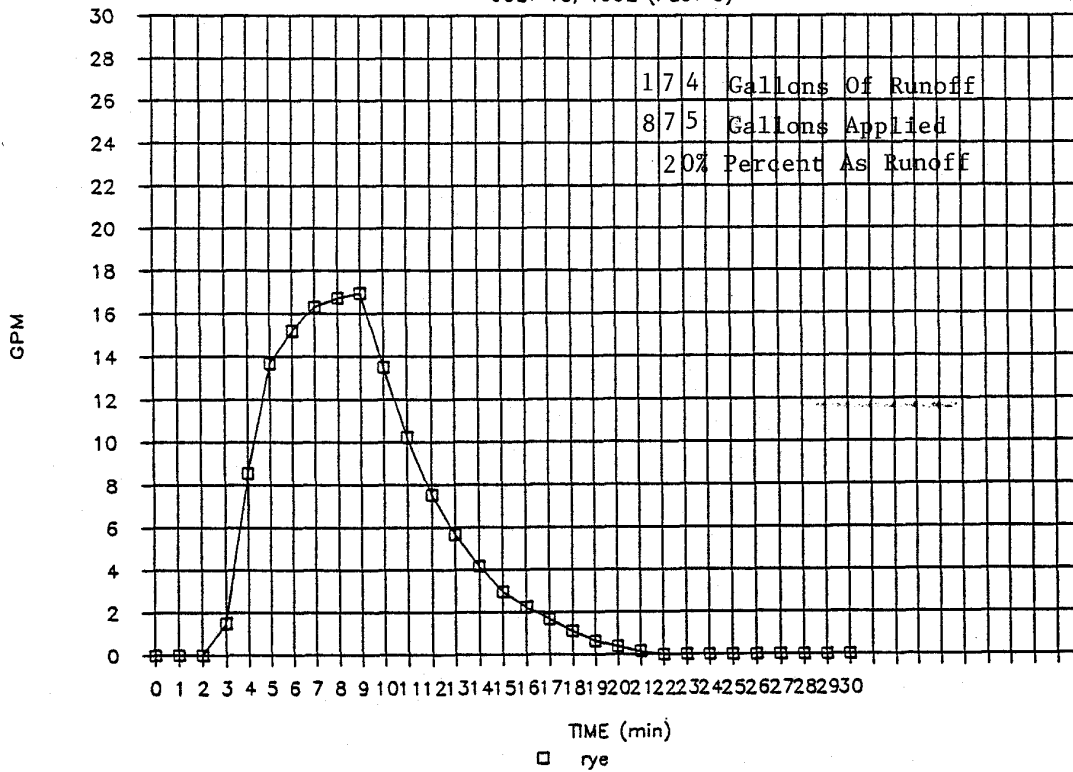
USGA EVENT #9 (CORRECTED)

JULY 15, 1992 (PLOT 8)



USGA EVENT #9 (CORRECTED)

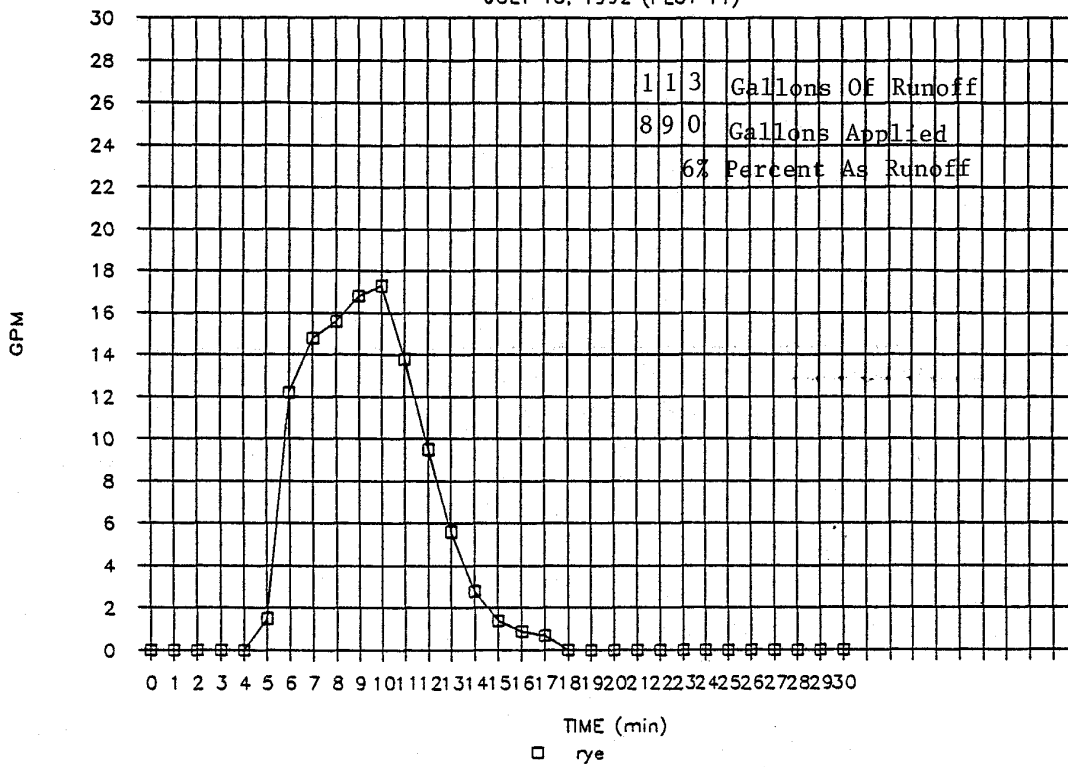
JULY 15, 1992 (PLOT 9)



00160

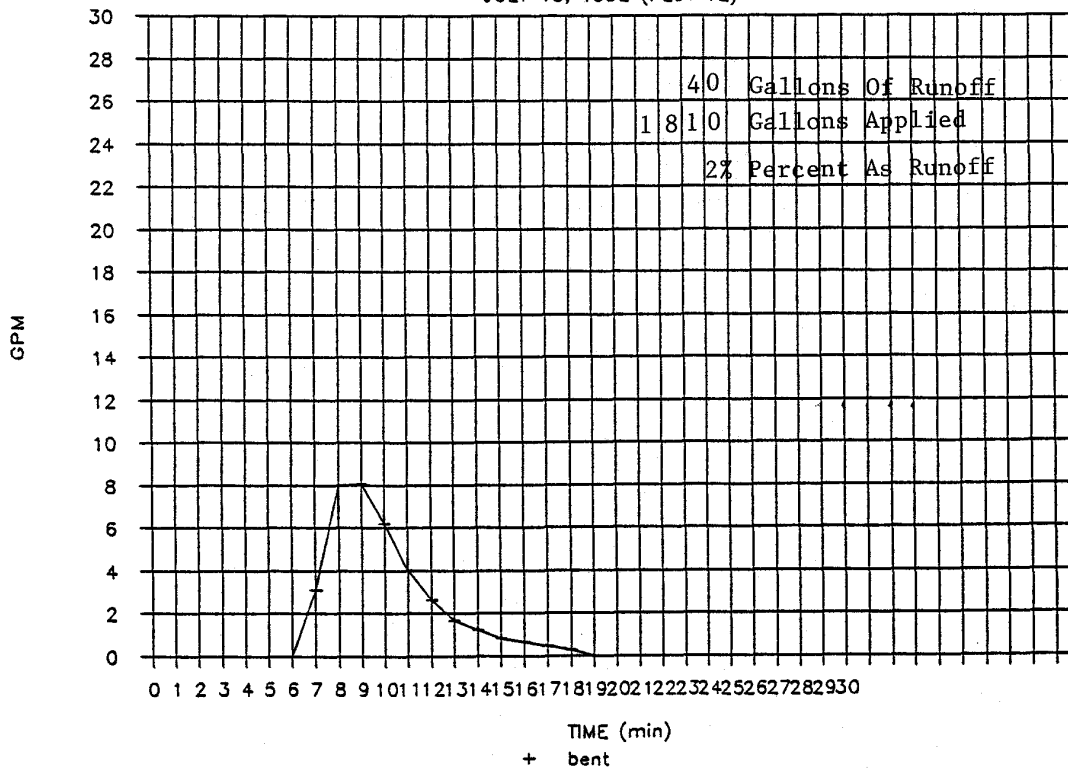
USGA EVENT #9 (CORRECTED)

JULY 15, 1992 (PLOT 11)



USGA EVENT #9 (CORRECTED)

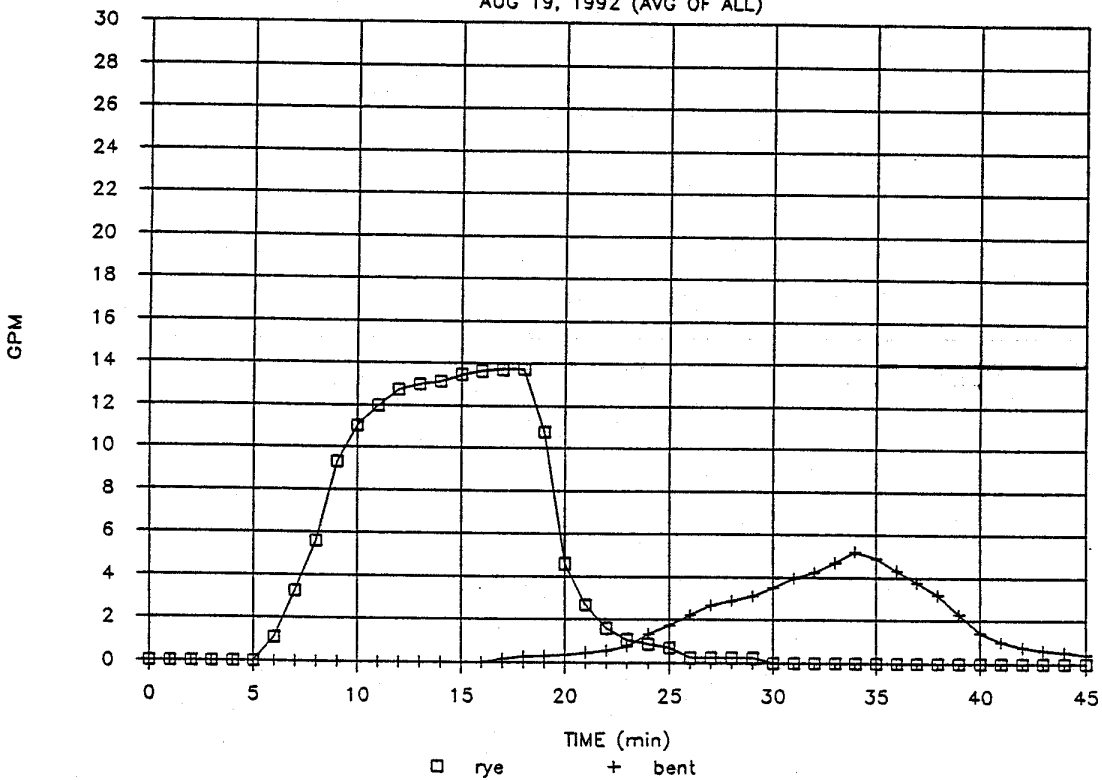
JULY 15, 1992 (PLOT 12)



00161

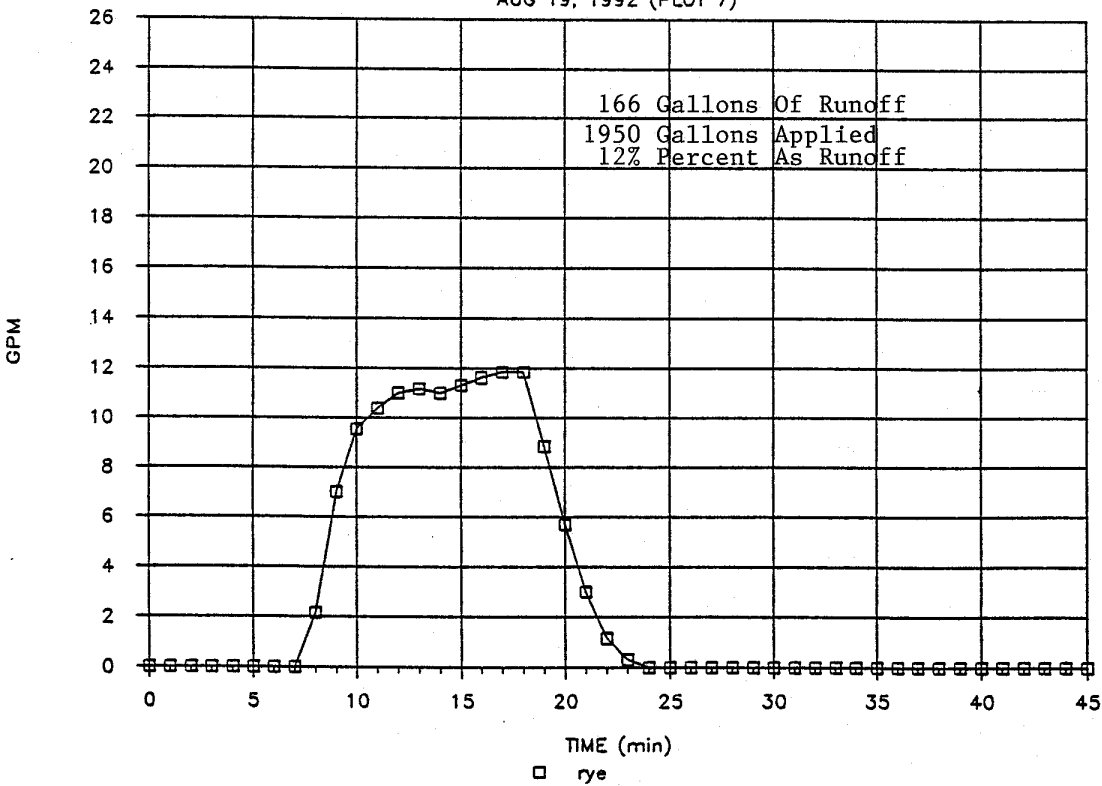
USGA EVENT #10 (CORRECTED)

AUG 19, 1992 (AVG OF ALL)



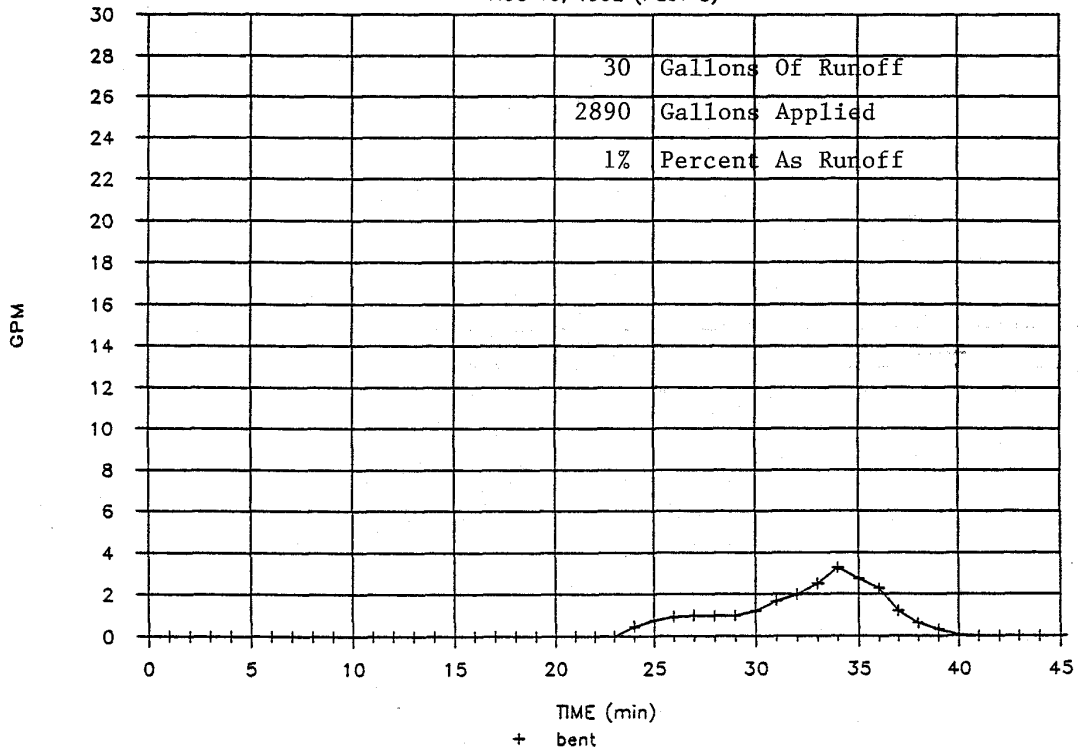
USGA EVENT #10 (CORRECTED)

AUG 19, 1992 (PLOT 7)



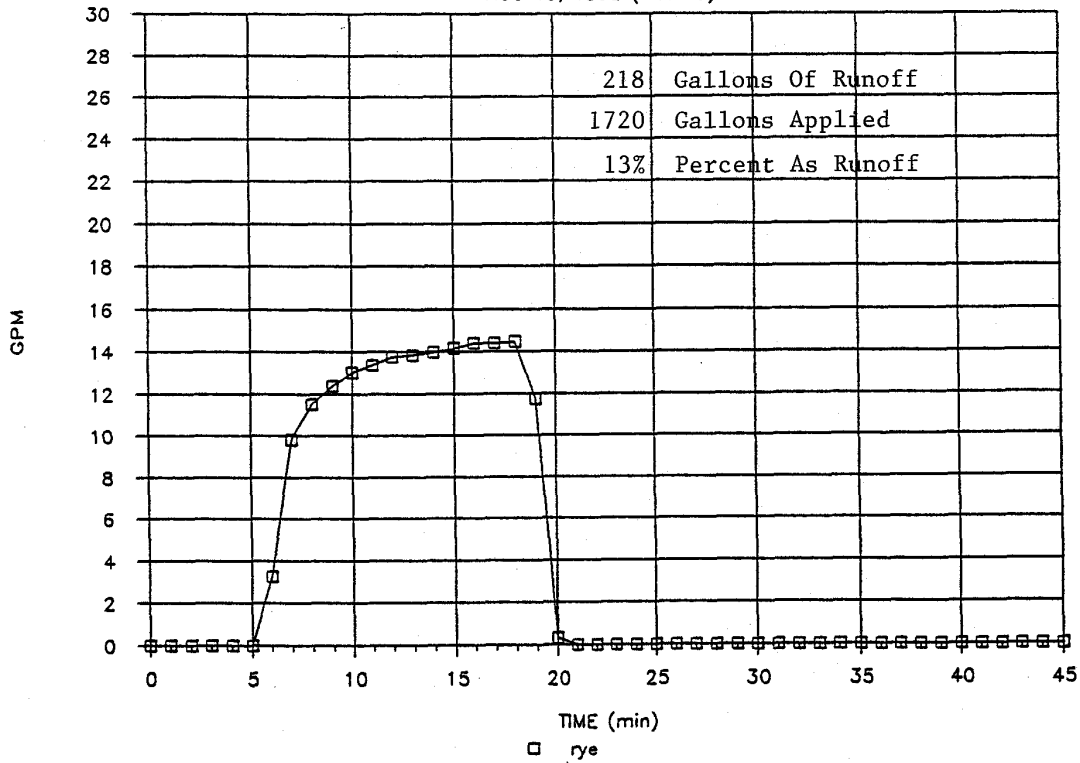
USGA EVENT #10 (CORRECTED)

AUG 19, 1992 (PLOT 8)



USGA EVENT #10 (CORRECTED)

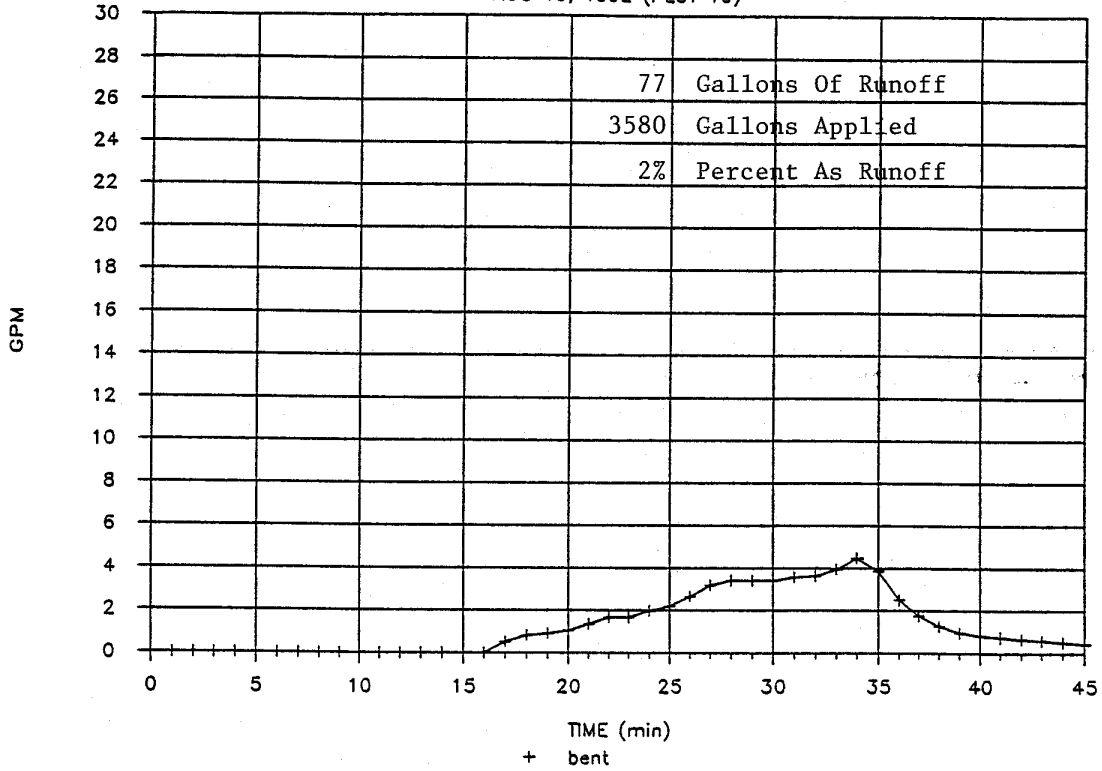
AUG 19, 1992 (PLOT 9)



00163

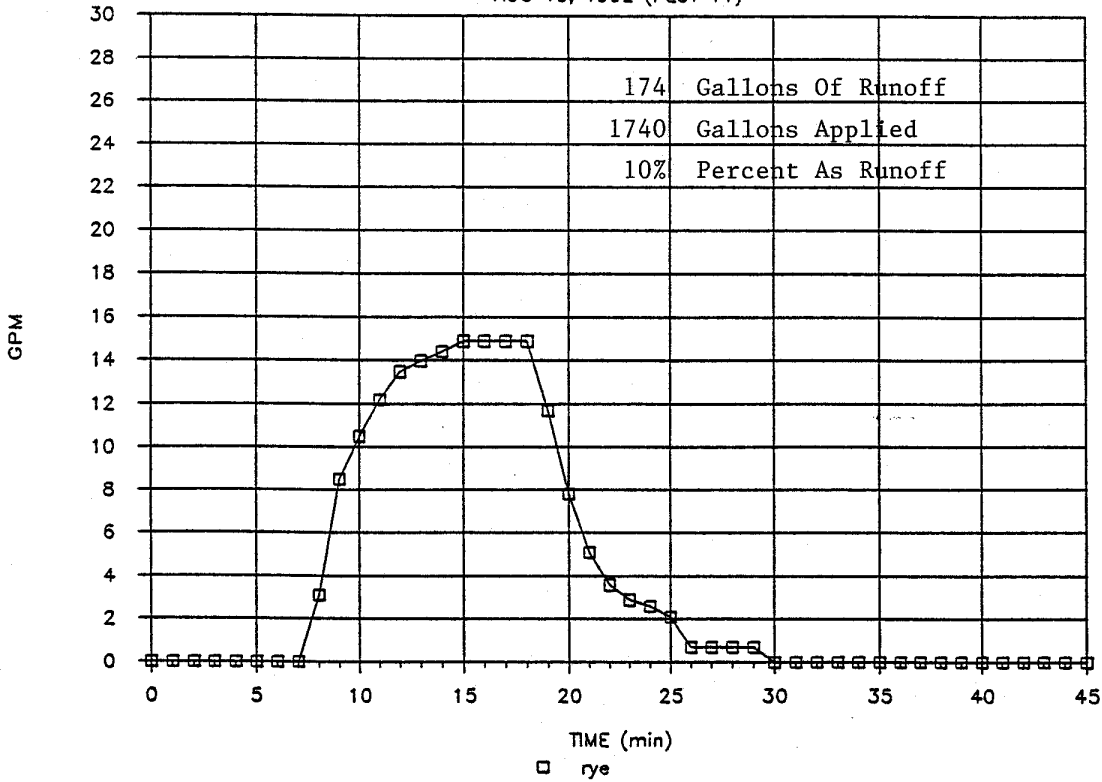
USGA EVENT #10 (CORRECTED)

AUG 19, 1992 (PLOT 10)



USGA EVENT #10 (CORRECTED)

AUG 19, 1992 (PLOT 11)

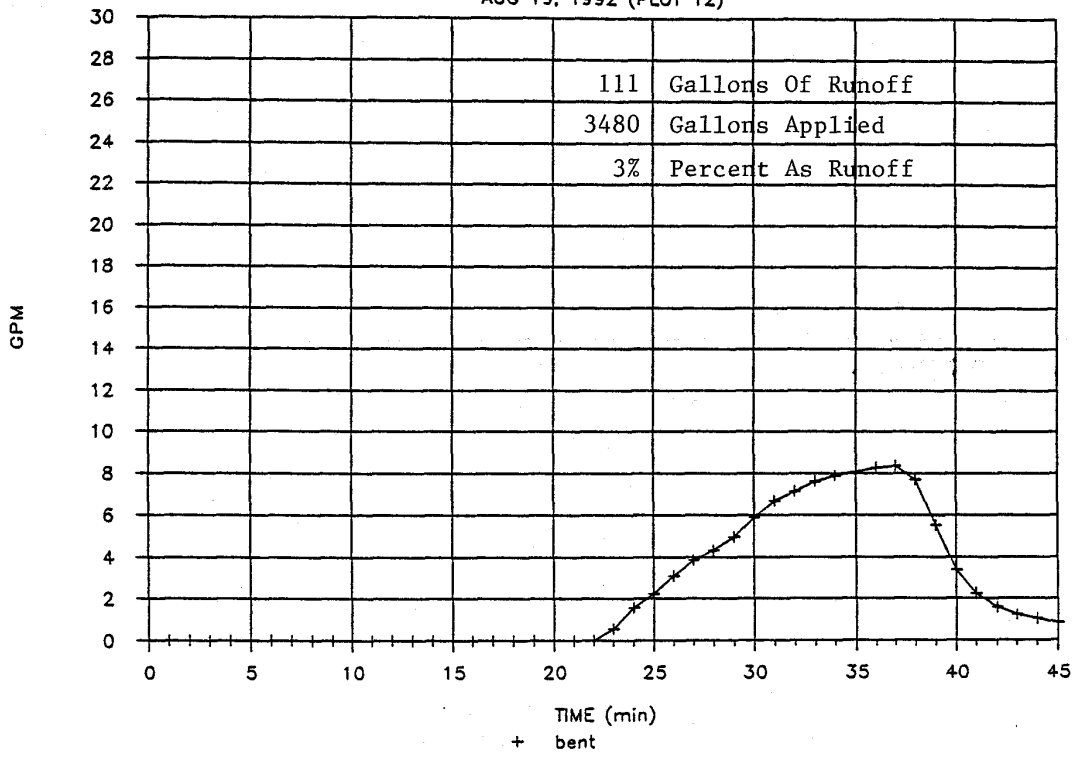


00164



USGA EVENT #10 (CORRECTED)

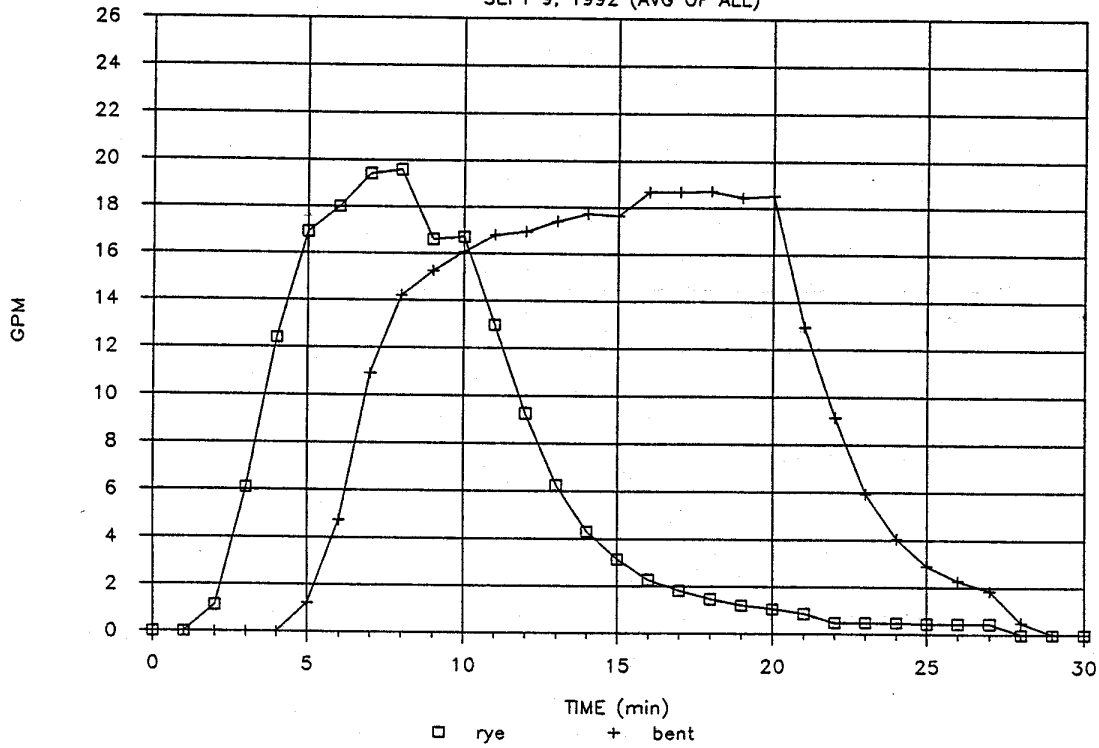
AUG 19, 1992 (PLOT 12)



00165

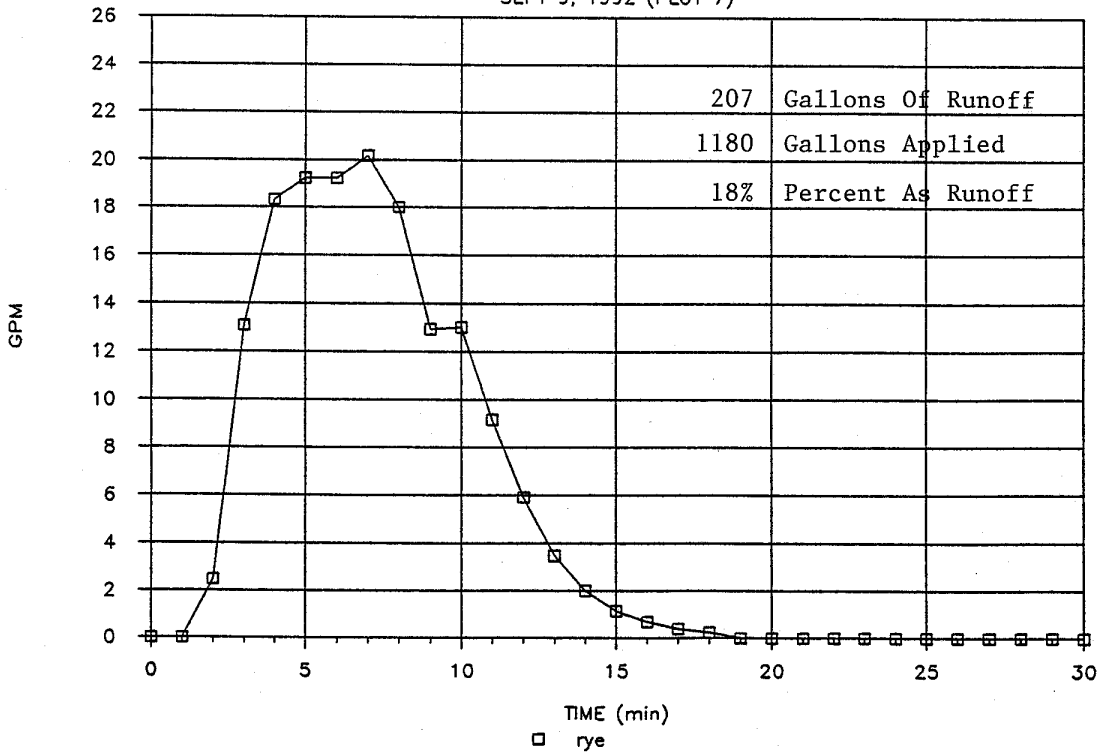
### USGA EVENT #12 (CORRECTED)

SEPT 9, 1992 (AVG OF ALL)



### USGA EVENT #12 (CORRECTED)

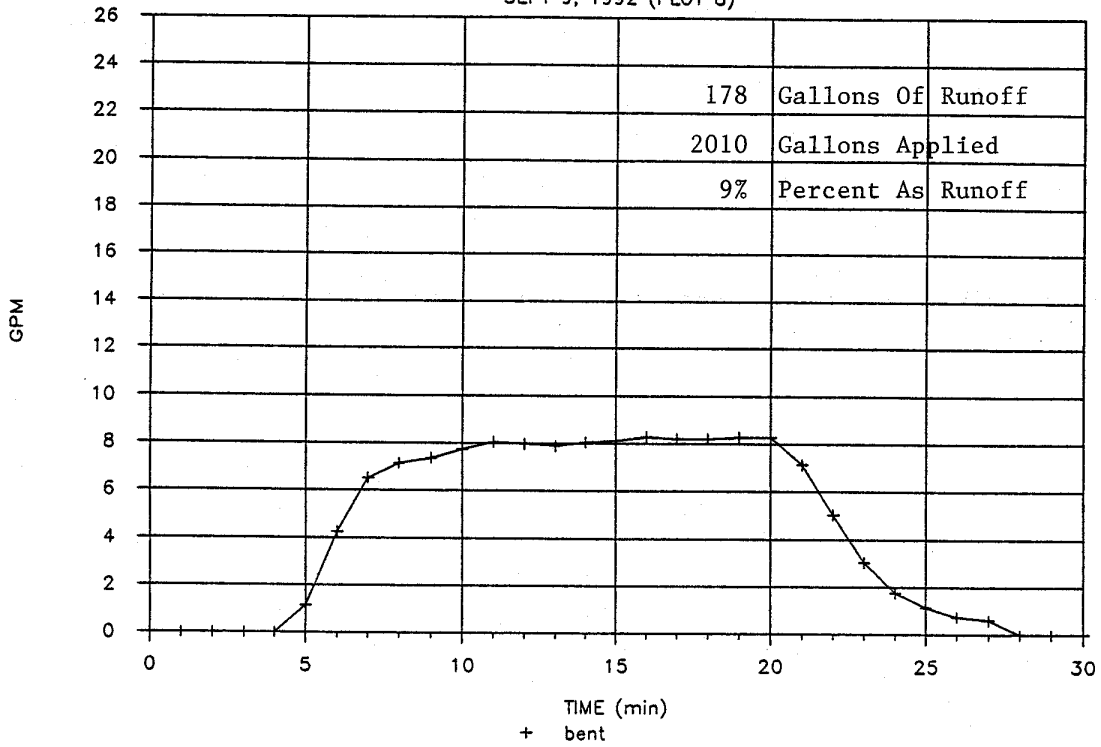
SEPT 9, 1992 (PLOT 7)



00166

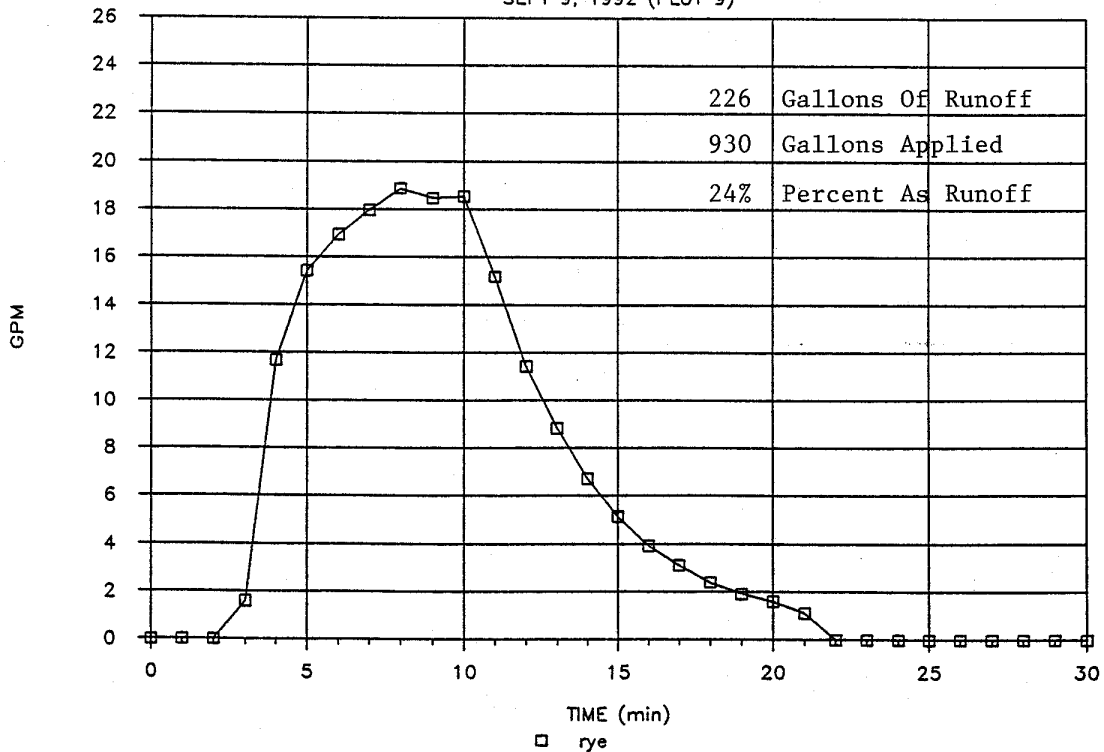
USGA EVENT #12 (CORRECTED)

SEPT 9, 1992 (PLOT 8)



USGA EVENT #12 (CORRECTED)

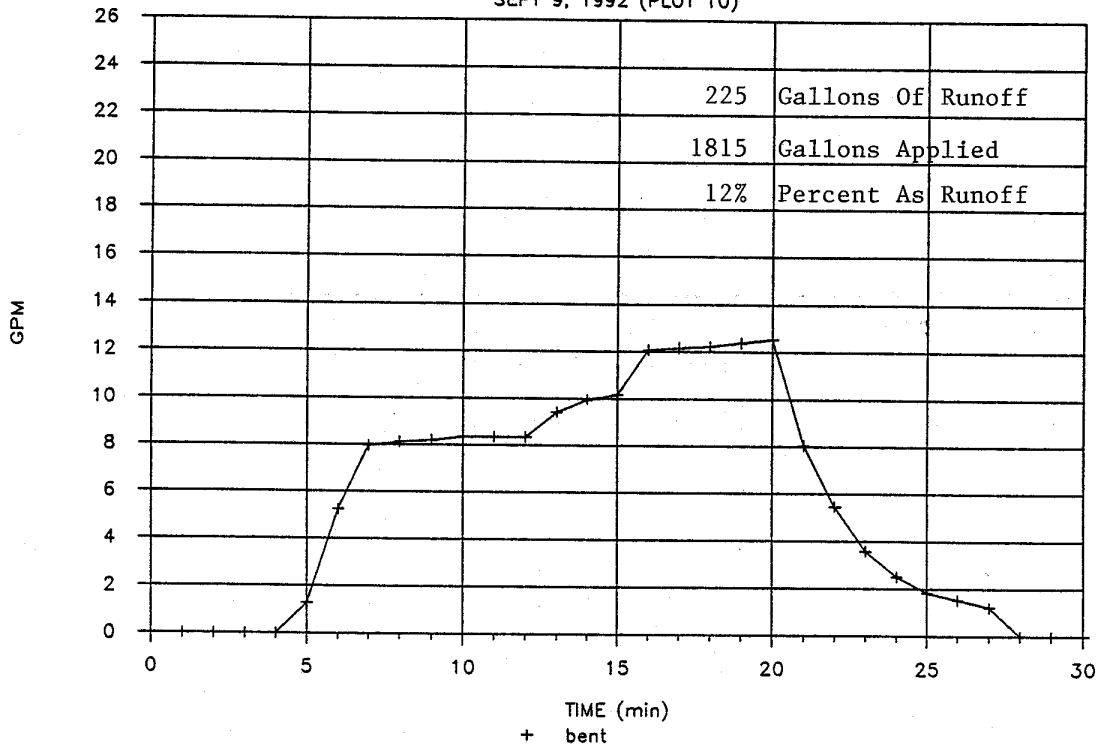
SEPT 9, 1992 (PLOT 9)



00167

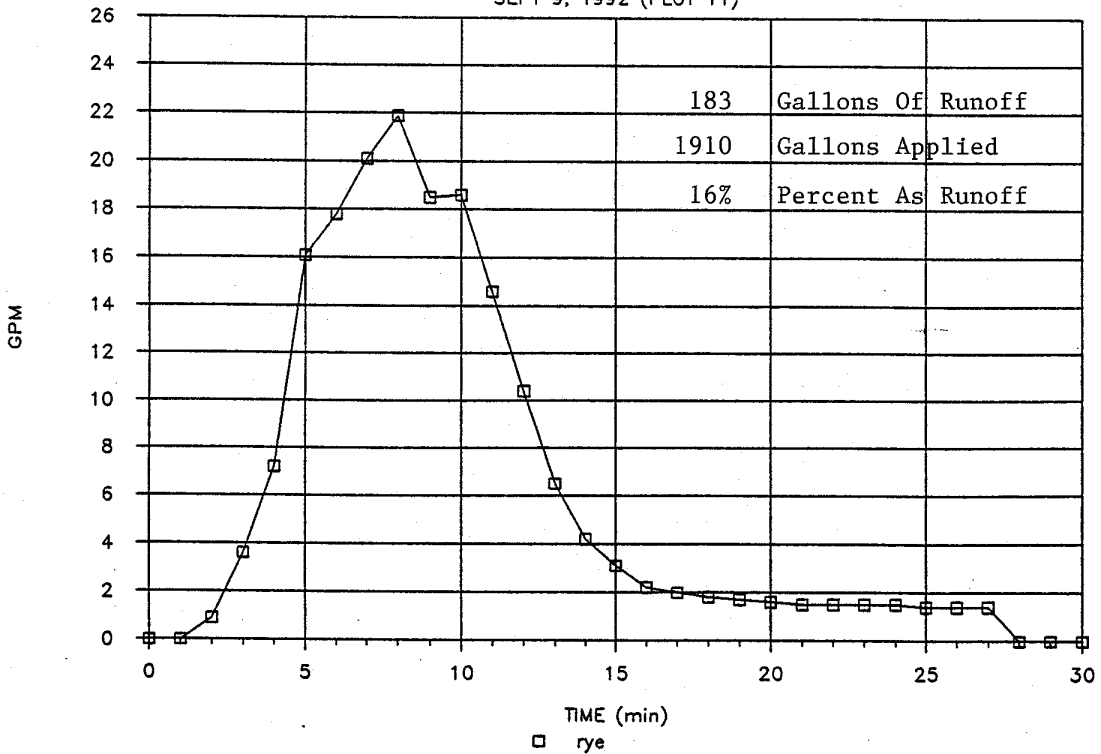
### USGA EVENT #12 (CORRECTED)

SEPT 9, 1992 (PLOT 10)



### USGA EVENT #12 (CORRECTED)

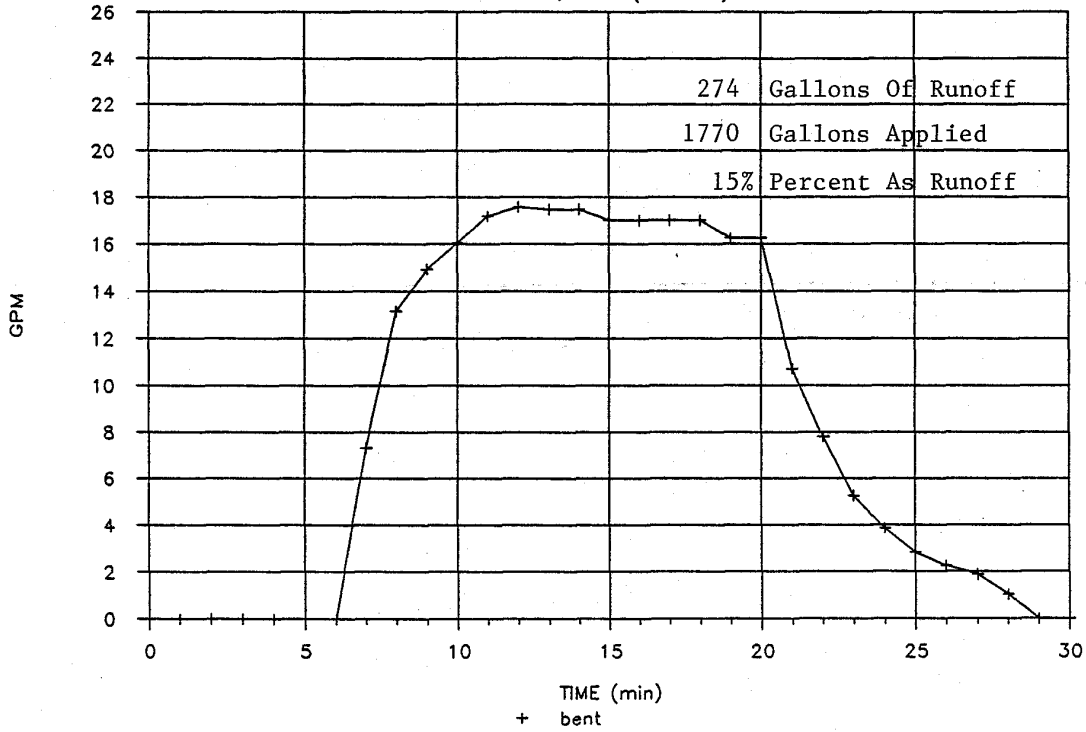
SEPT 9, 1992 (PLOT 11)



00168

USGA EVENT #12 (CORRECTED)

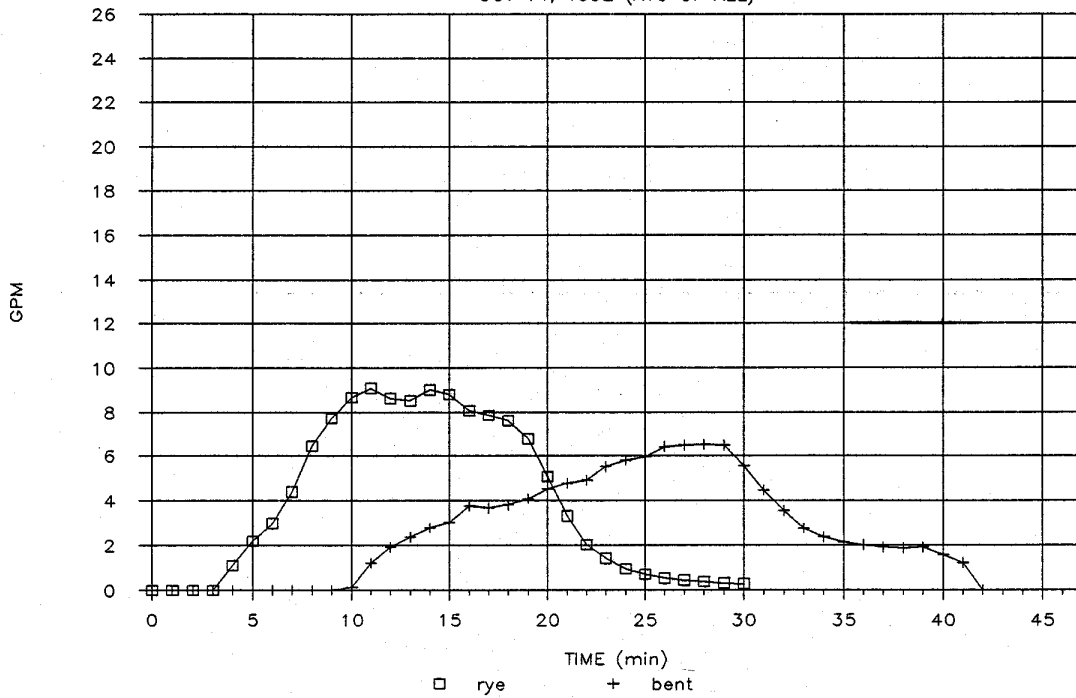
SEPT 9, 1992 (PLOT 12)



00169

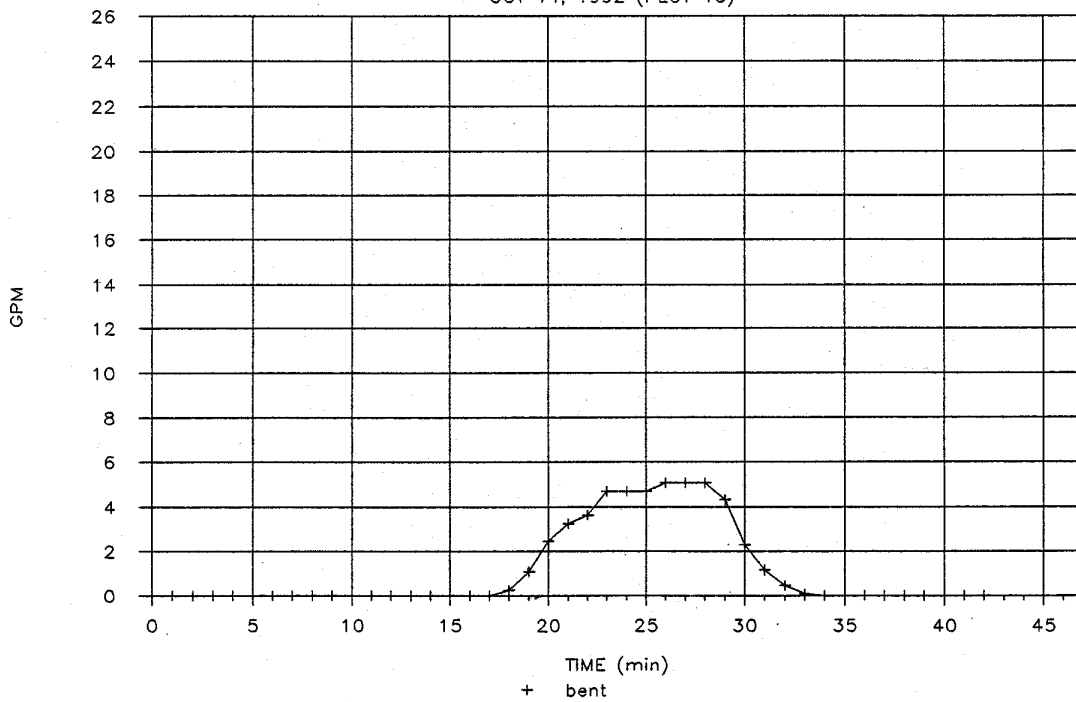
USGA EVENT #13 (CORRECTED)

OCT 14, 1992 (AVG OF ALL)



USGA EVENT #13 (CORRECTED)

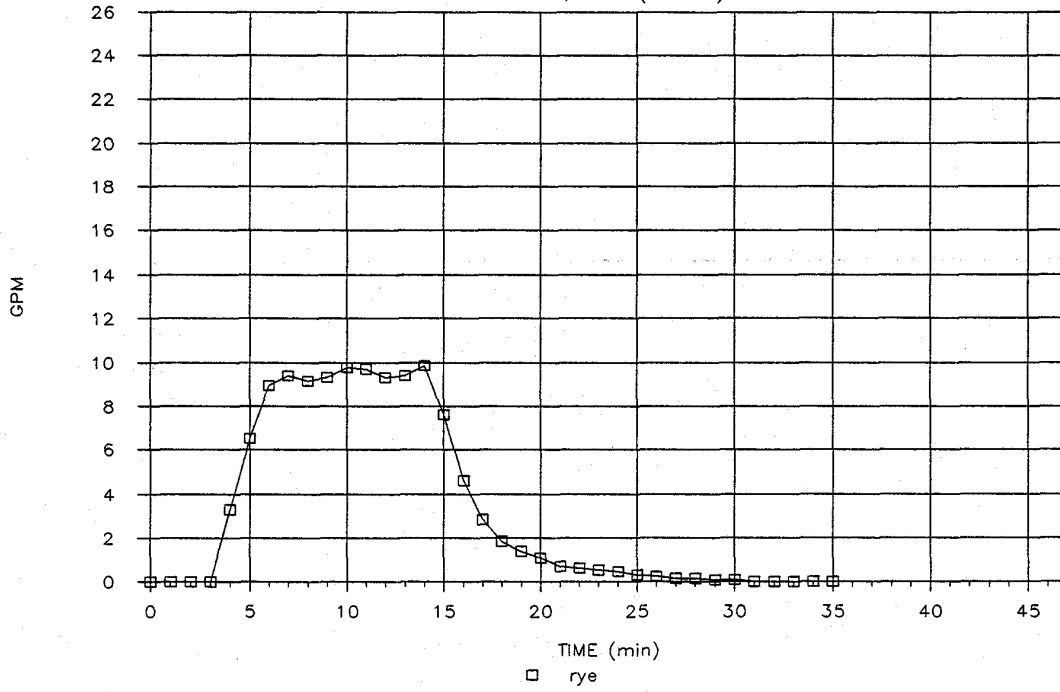
OCT 14, 1992 (PLOT 10)



00170

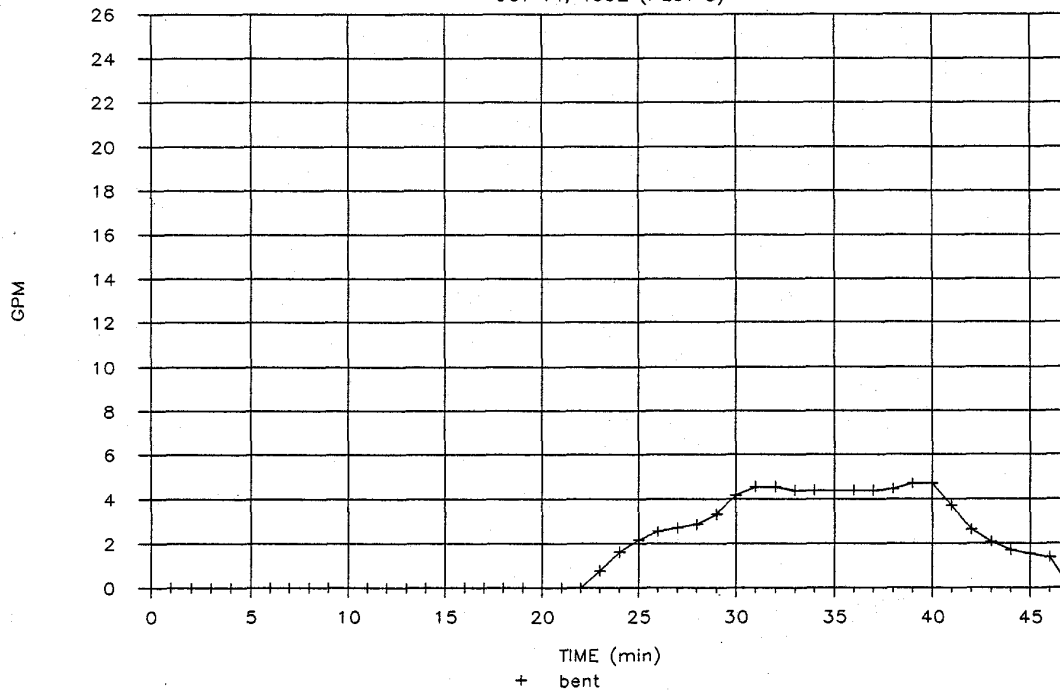
USGA EVENT #13 (CORRECTED)

OCT 14, 1992 (PLOT 7)



USGA EVENT #13 (CORRECTED)

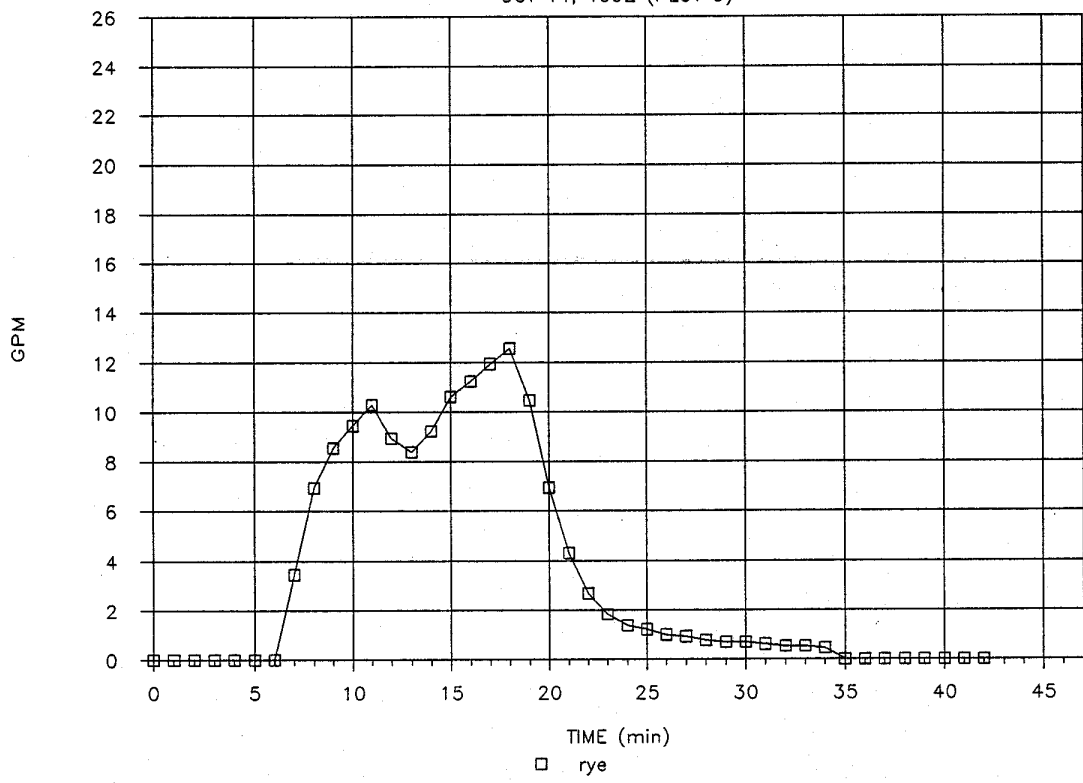
OCT 14, 1992 (PLOT 8)



00171

# USGA EVENT #13 (CORRECTED)

OCT 14, 1992 (PLOT 9)

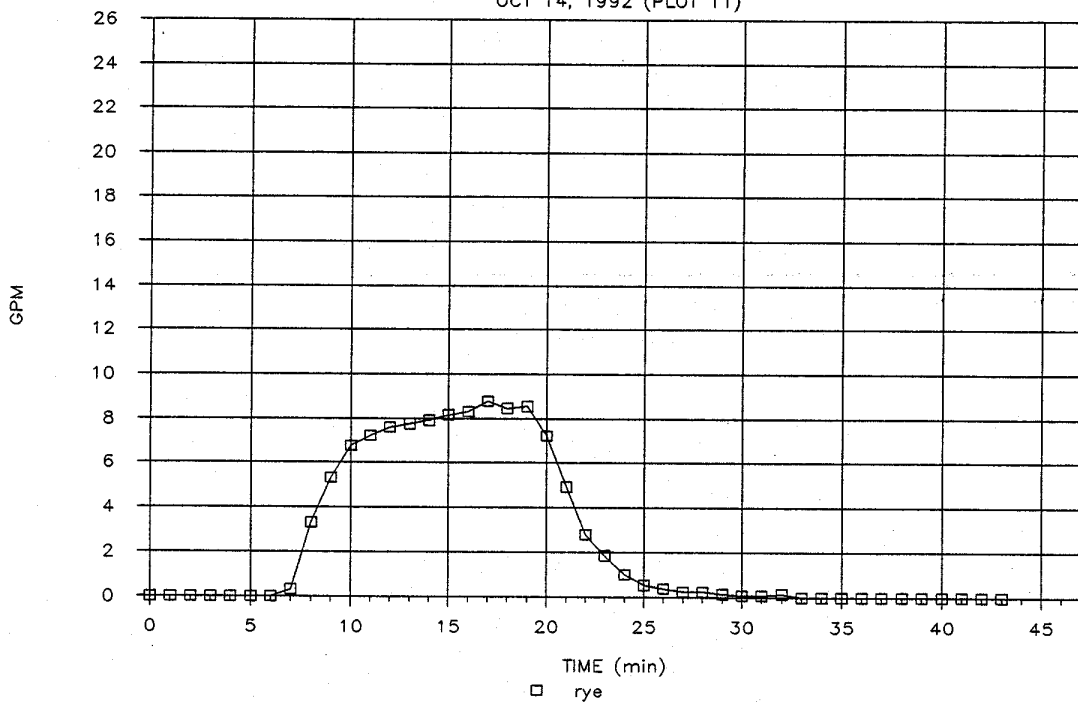


00172



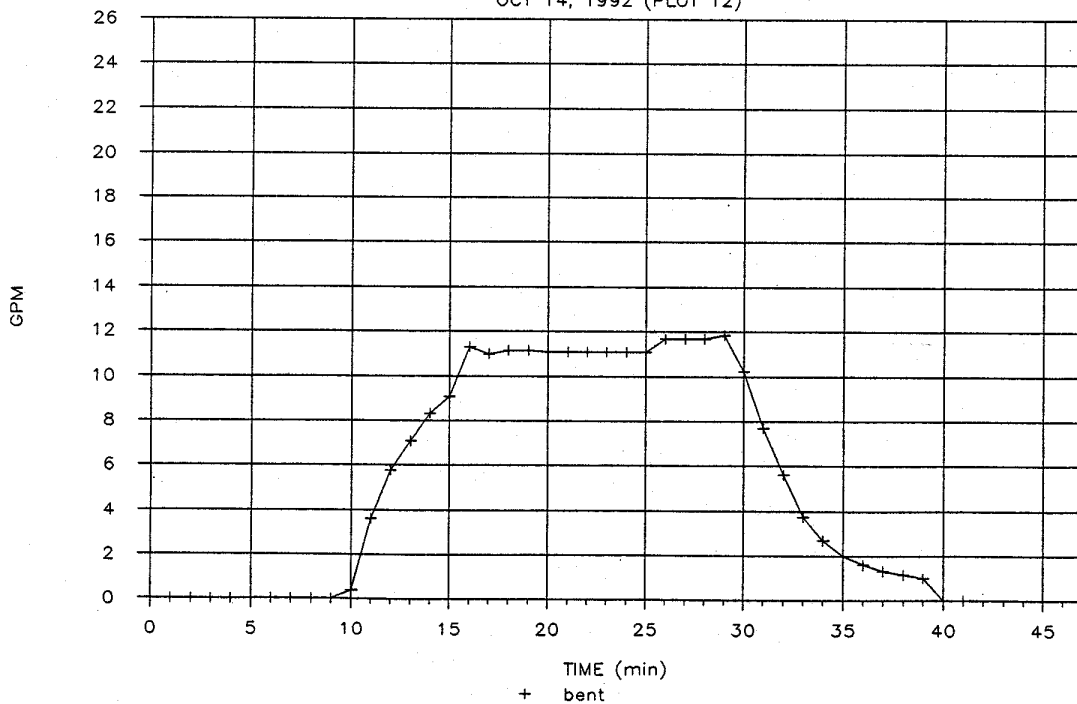
USGA EVENT #13 (CORRECTED)

OCT 14, 1992 (PLOT 11)



USGA EVENT #13 (CORRECTED)

OCT 14, 1992 (PLOT 12)



00173