ITM 9832-K10

Annual Project Report - 2000

THE IMPORTANCE OF CARBON BALANCE AND ROOT ACTIVITY IN CREEPING BENTGRASS TOLERANCE TO SUMMER STRESSES

Bingru Huang and Jack Fry

RATIONALE AND OBJECTIVE

Creeping bentgrass (Agrostis palustris) is the most widely used cool-season turfgrass on golf greens. Loss of bentgrass is observed on most golf courses nearly every year in the transition and warm climate regions during summer months when greens receive maximum use (Lucas, 1995; Carrow, 1996). Pavur (1993) reported that some courses have lost a majority of bentgrass to the decline syndrome. Attempts to extend use of bentgrass into warmer climatic regions further accentuates the problem.

To date, it is not clear what physiological factors cause summer bentgrass decline. Understanding the cause of the decline problem will not only help to treat bentgrass decline, but also provide guidelines for developing cultural practices to prevent decline. Identification of physiological factors that could be incorporated into new germplasm through genetic breeding approaches to develop cultivars tolerant to close mowing and high temperatures will reduce the overhead costs for intensive management of bentgrass greens during summer.

It was proposed that imbalanced photosynthesis and respiration process and carbohydrate depletion could be a major or primary physiological factor contributing to bentgrass quality decline under high temperature and close mowing conditions. The overall objective of the project was to test this hypothesis in creeping bentgrass cultivars grown under close mowing and high shoot/root-zone temperatures.

RESEARCH METHODOLOGY

To address the hypothesis, we initiated the two-year field study in 1999 to examine whether seasonal changes in turf quality or summer quality decline are related to changes in carbohydrate metabolism and partitioning patterns during the growing season (May, August and October) under changing temperature and close mowing conditions. The study was repeated in 2000.

The study was conducted on an USGA-specification green at the Rocky Ford Turfgrass Research Center at Manhattan, KS. Crenshaw, Penncross, and L-93 were mowed at two mowing heights throughout the growing season: a) 5/32 inch (3.8 mm) and b) 1/8 inch (3.1 mm) height. Four replicates were used for each treatment.

Turf was measured weekly with a multispectral radiometer. The radiometer measures reflected light in the near infrared (800 to 1100 nm) and red (600 to 700 nm) regions which is a good indicator of plant canopy cover or leaf area index, and canopy color. Turf quality was visually rated. Plants from four plots in each treatment were destructively sampled monthly. Total nonstructural carbohydrate content in shoots and roots were measured. Carbon allocation pattern was determined using ^{14}C labeling technique. Nitrogen uptake capacity of roots were examined by applying stable isotope tracer ($Na^{15}NO_3$) at 5 cm soil depth.

PROGRESS - 2000

Turf and root growth

Turf quality of all three cultivars was highest in May and declined to the lowest level in September and recovered in October (Fig. 1). This growth pattern was true when either mowed at 1/8 inch or 5/32 inch. The difference in turf quality between the two mowing height was not apparent. From June to late August, L-93 had the highest quality, Penncross the lowest, and Crenshaw was intermediate. Shoot clipping yield showed the same seasonal and cultivar variation as turf quality (Fig. 2), but the decline in the summer was more severe than turf quality decline.

Electrolyte leakage of leaves for all three cultivars increased dramatically in August and September, suggesting that heat damage to leaves occurred in the summer months (Fig. 3). Heat injury was more severe for grasses mowed at 1/8 inch than that mowed at 5/32 inch in September.

Seasonal changes in root dry weight and followed the similar pattern as turf quality for all three cultivars (Fig. 4). L-93 had higher root dry weight than Penncross and Crenshaw. Grasses mowed at 1/8 inch had lower root dry weight than those mowed at 5/32 inch for all three cultivars.

Root images were recorded monthly and will be analyzed for rooting depth, root mortality rate and root length.

Nitrogen uptake capacity of roots was evaluated by ^{15}N tracing technique. About 200 shoot and root samples were collected and stored for ^{15}N analysis. The analysis is currently being conducted, but have not been completed.

Antioxidant enzyme analysis

The activities of antioxidant enzymes including superoxide dismutase (SOD) (Fig. 5), catalase (CAT) (Fig. 6), peroxidase (POD) (Fig. 7), and ascorbate peroxidase (AP) (Fig. 8), increased in the early summer and decreased dramatically in the middle of the summer. The activities of antioxidant enzymes recovered gradually when air temperature decreased in October. No significant difference in the activities of the antioxidant enzymes was found between L-93 and Penncross under either mowing height. Raising mowing height from 1/8 inch to 5/32 inch increased enzyme activities only in early July.

Turf quality decline during high temperature periods in summer was associated with changes in the activities of antioxidant enzymes, indicating summer bentgrass decline could involve oxidative stress. Increasing antioxidant enzyme activities could help improve turf quality of creeping bentgrass during summer.

Carbohydrate accumulation and allocation

Leaves and roots were collected monthly from May to October. Samples have been dried and stored for analysis. The content of total nonstructural carbohydrate, fructans, starch, glucose and sucrose will be analyzed this winter.

Seasonal changes in carbon allocation pattern was examined by radioactivity ^{14}C labeling technique. About 400 shoot and root samples were collected during the entire growing season. Samples have been grounded and stored for ^{14}C analysis. The analysis is underway.

PUBLICATIONS

Xu, Q. and B. Huang. 2000. Growth and physiological responses of creeping bentgrass to root-zone temperature modification. Crop Sci. 40:1363-1368.

Xu, Q. and B. Huang. 2000. Carbohydrate metabolism of creeping bentgrass in responses to high shoot and root temperatures. Crop Sci. 40:1368-1374.

Huang, B. and Q. Xu. 2000. Root growth and nutrient status of creeping bentgrass cultivars differing in heat tolerance as influenced by supraoptimal shoot and root temperatures. Journal of Plant Nutrition. 23:979-990.

Liu, X. and B. Huang. 2000. Carbohydrate accumulation in relation to heat tolerance in two creeping bentgrass cultivars. Am. J. Hort Sci. 125:442-447.

Liu, X. and B. Huang. 2000. Heat stress injury of creeping bentgrass in relation to membrane lipid peroxidation. Crop Sci. 40:503-510.

Huang, B, X, Liu, and Q. Xu. 2001. Supraoptimal soil temperature induced oxidative stress in creeping bentgrass. 41: (in press).

Xu, Q., and B. Huang. 2001. Morphological and physiological characteristics associated with heat tolerance in creeping bentgrass. Crop Sci. 40: (in press).

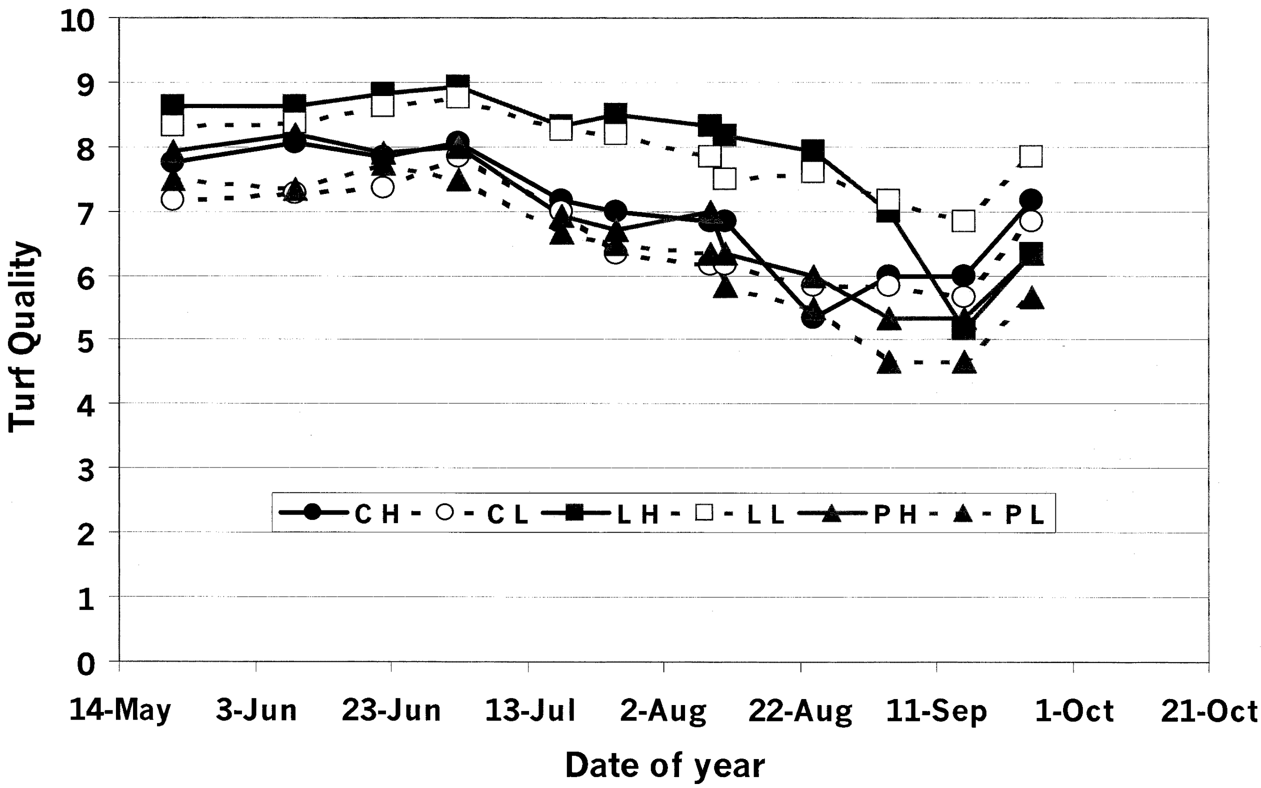
WORK PLANNED FOR THE COMING YEAR

Processing root images

Analysis of carbohydrates in shoots and roots

Analysis of radio active carbon activity in shoots and roots

Analysis of ^{15}N uptake in shoots and roots



10
9
8
7
6
5
4
3
2
1
0
Turf Quality
CH
CL
LH
LL
PH
PL
14-May
3-Jun
23-Jun
13-Jul
2-Aug
22-Aug
11-Sep
1-Oct
21-Oct
Date of year

Fig.1

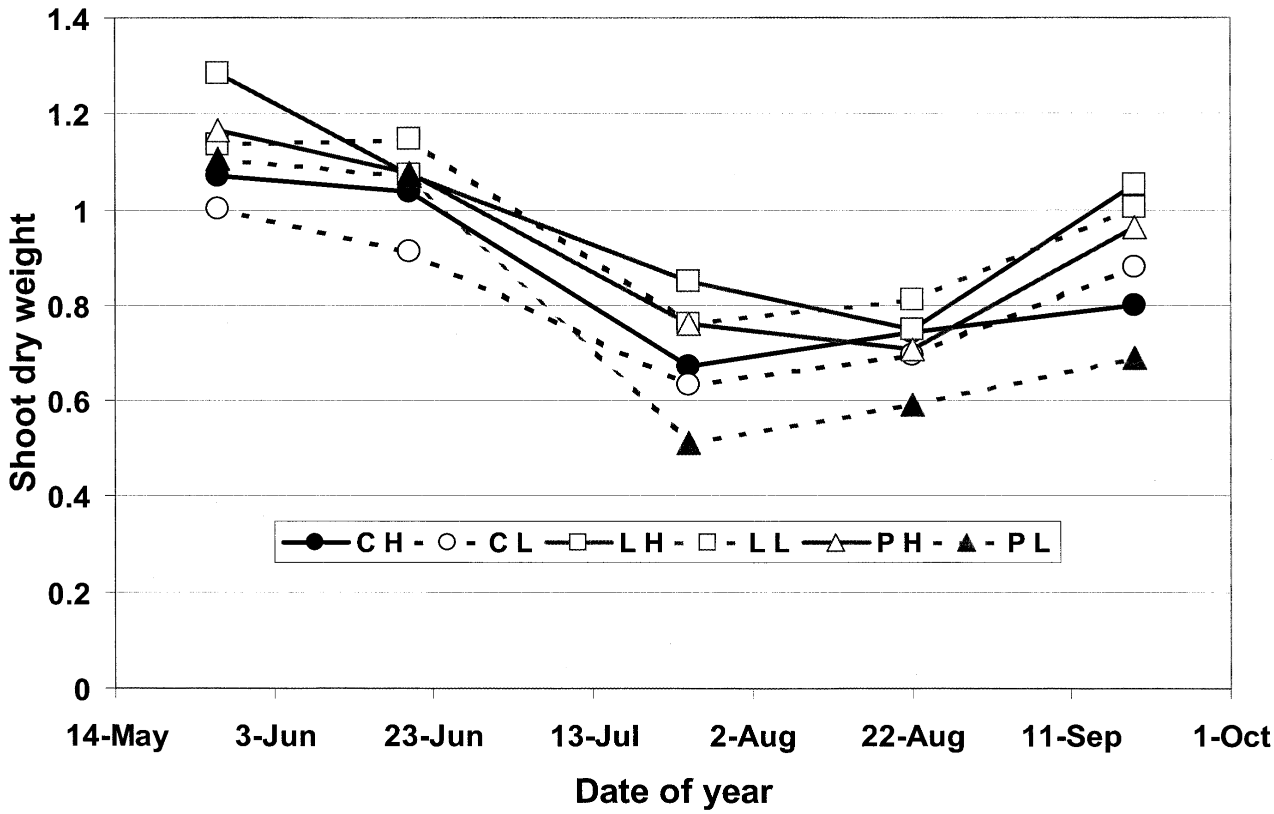
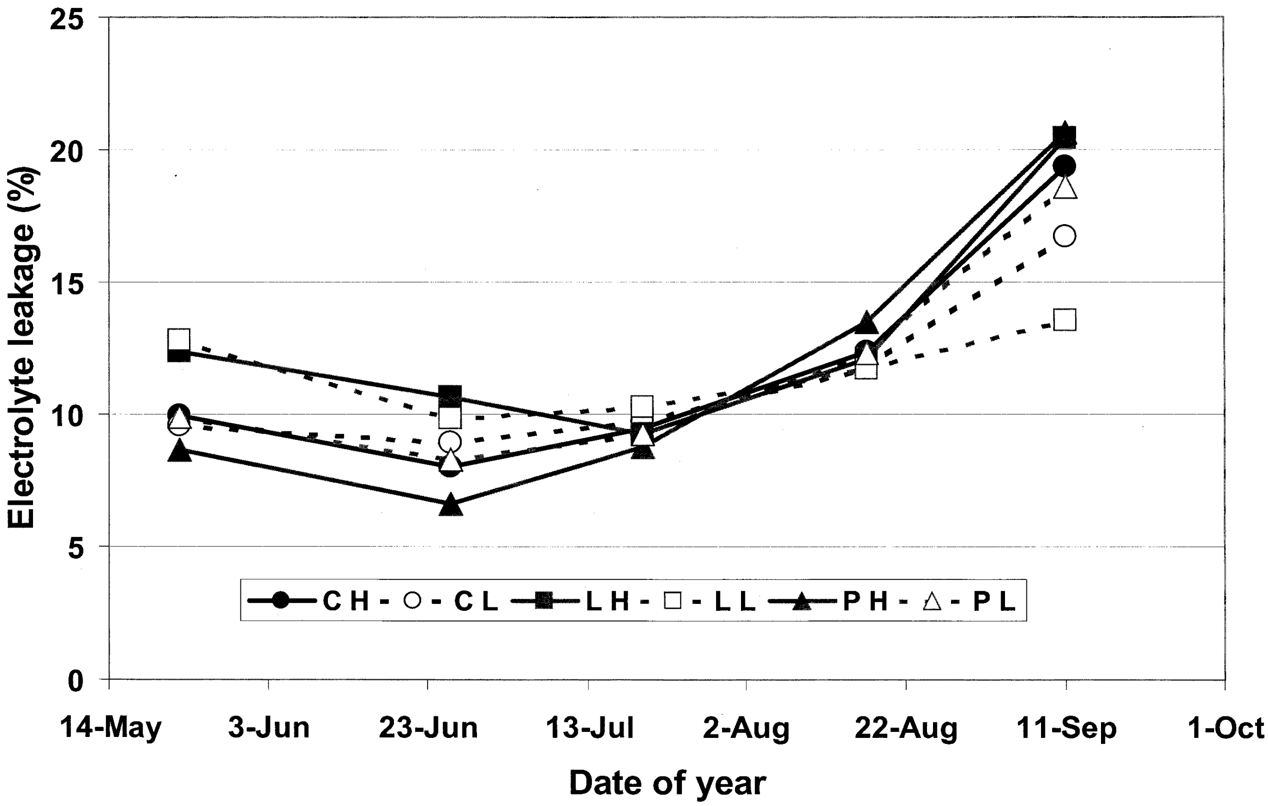

1.4
1.2
1
0.8
0.6
0.4
0.2
0
Shoot dry weight
C H
C L
L H
L L
P H
P L
14-May
3-Jun
23-Jun
13-Jul
2-Aug
22-Aug
11-Sep
1-Oct
Date of year

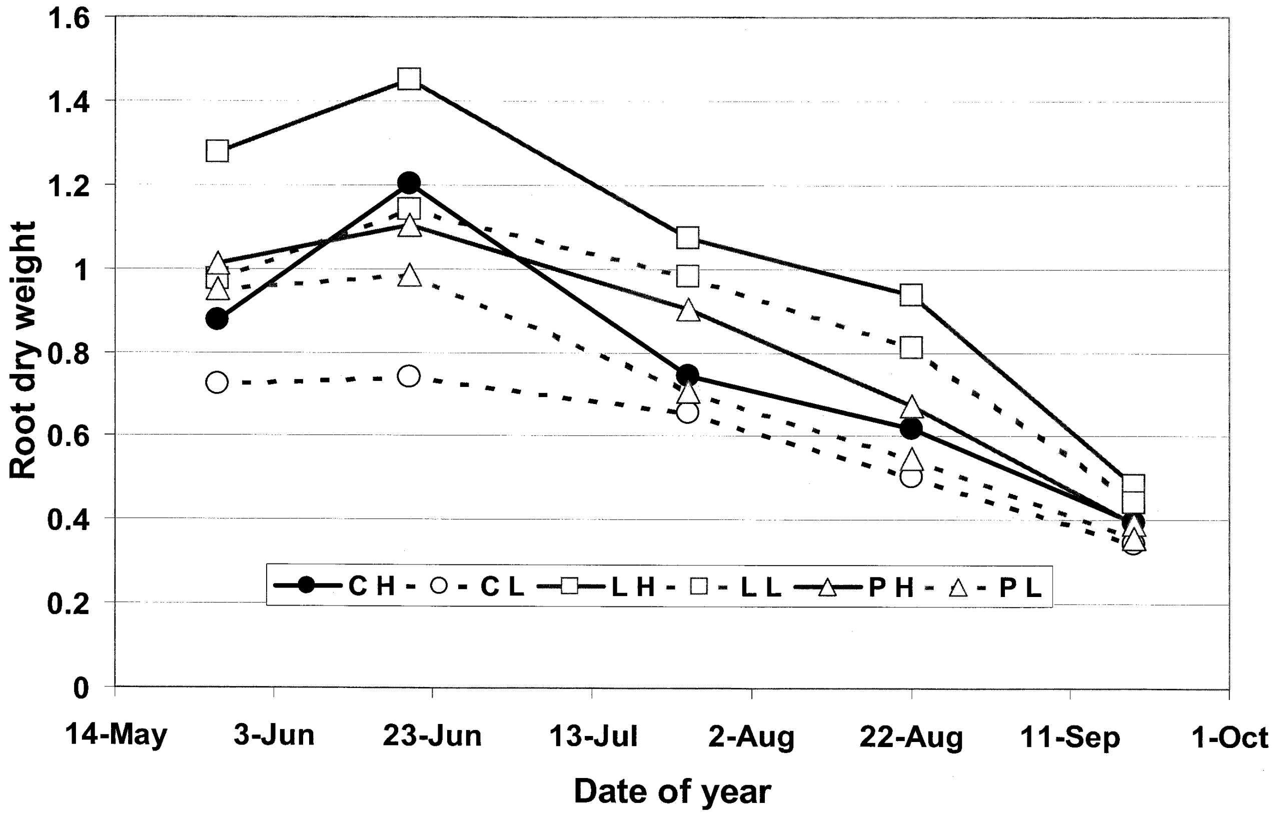
Fig. 2



25
20
15
10
5
0
Electrolyte leakage (%)
CH
CL
LH
LL
PH
PL
14-May
3-Jun
23-Jun
13-Jul
2-Aug
22-Aug
11-Sep
1-Oct
Date of year

Fig. 3

650



1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
Root dry weight
C H
C L
L H
L L
P H
P L
14-May
3-Jun
23-Jun
13-Jul
2-Aug
22-Aug
11-Sep
1-Oct
Date of year

Fig. 4

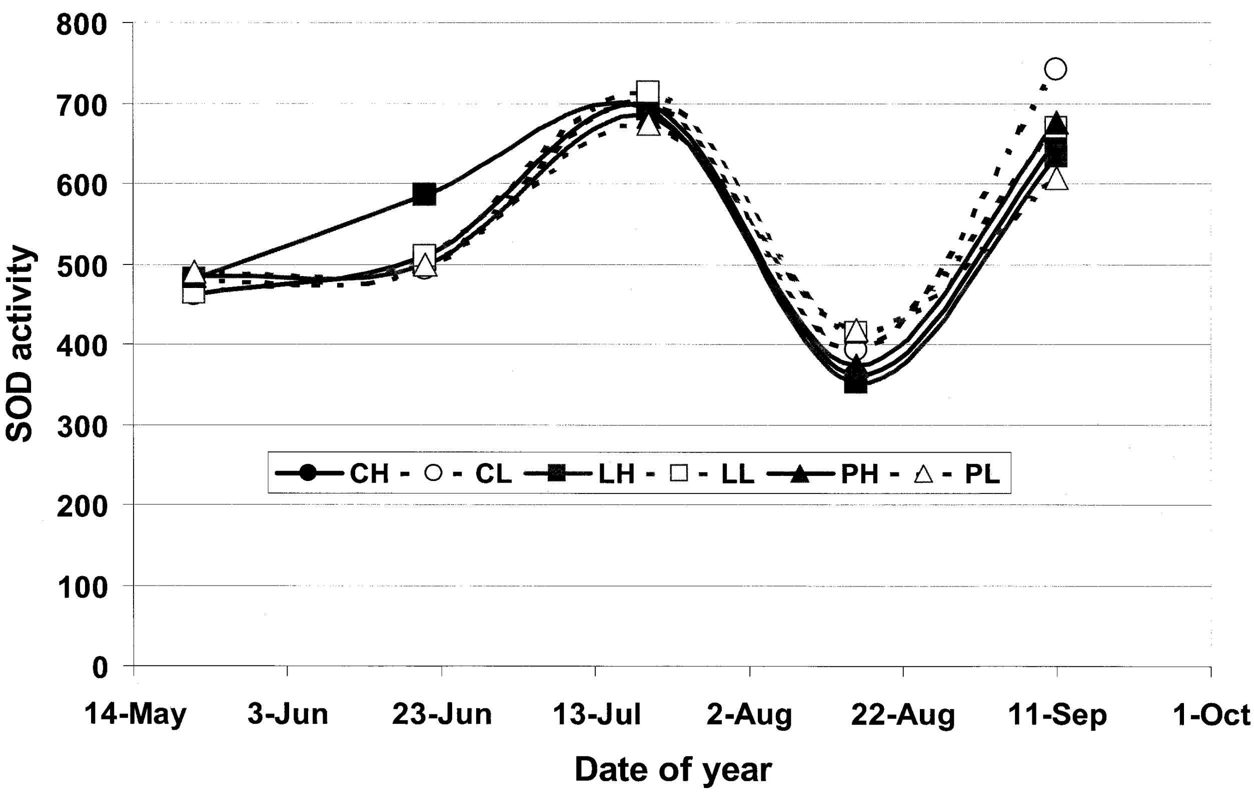

800
700
600
500
400
300
200
100
0
SOD activity
CH - CL - LH - LL - PH - PL
14-May
3-Jun
23-Jun
13-Jul
2-Aug
22-Aug
11-Sep
1-Oct
Date of year

Fig. 5

652

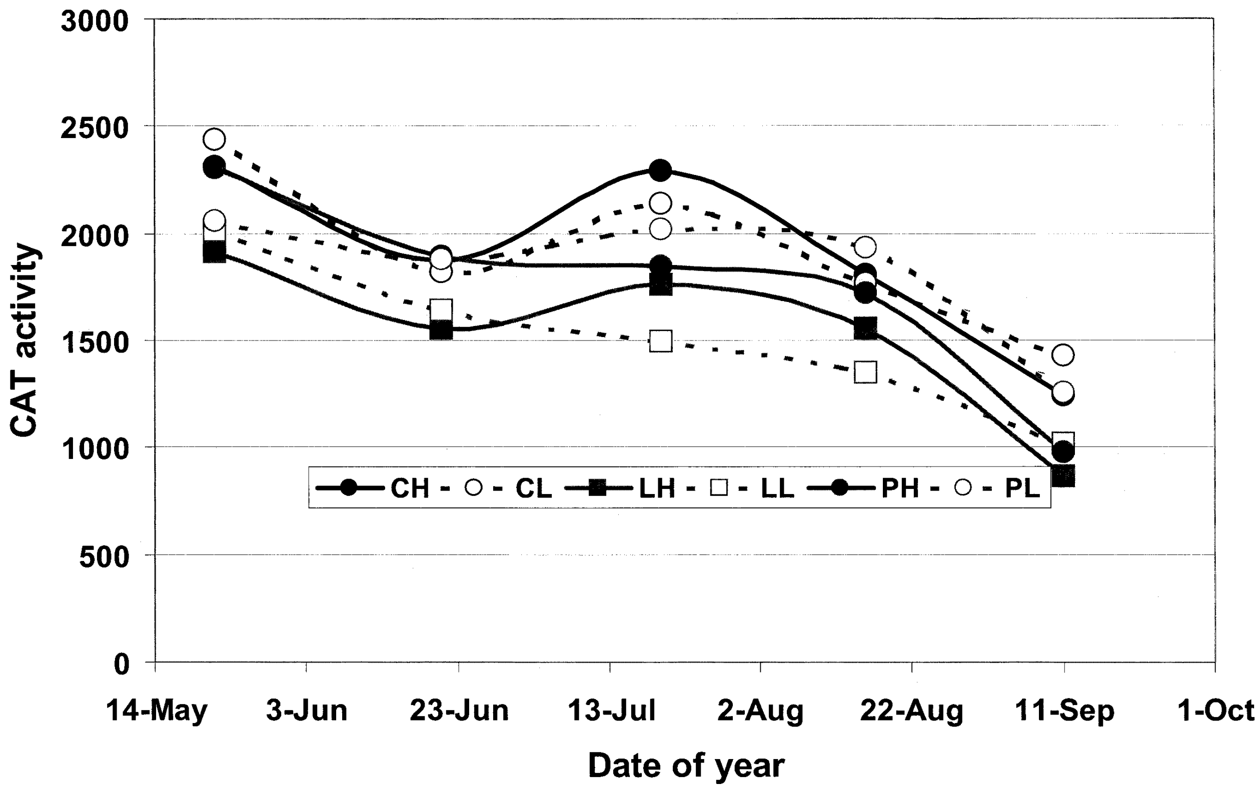
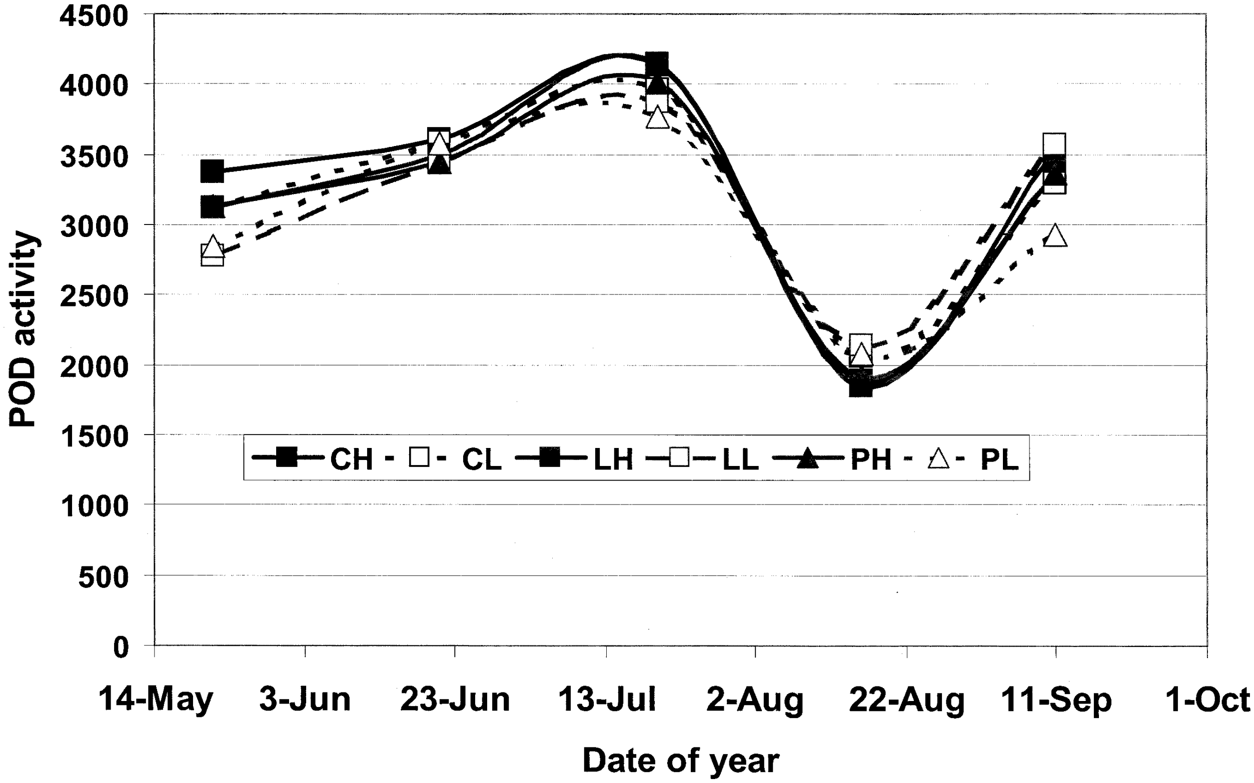

3000
2500
2000
1500
1000
500
0
CAT activity
CH
CL
LH
LL
PH
PL
14-May
3-Jun
23-Jun
13-Jul
2-Aug
22-Aug
11-Sep
1-Oct
Date of year

Fig. 6

653



4500
4000
3500
3000
2500
2000
1500
1000
500
0
POD activity
CH
CL
LH
LL
PH
PL
14-May
3-Jun
23-Jun
13-Jul
2-Aug
22-Aug
11-Sep
1-Oct
Date of year

Fig. 7

654

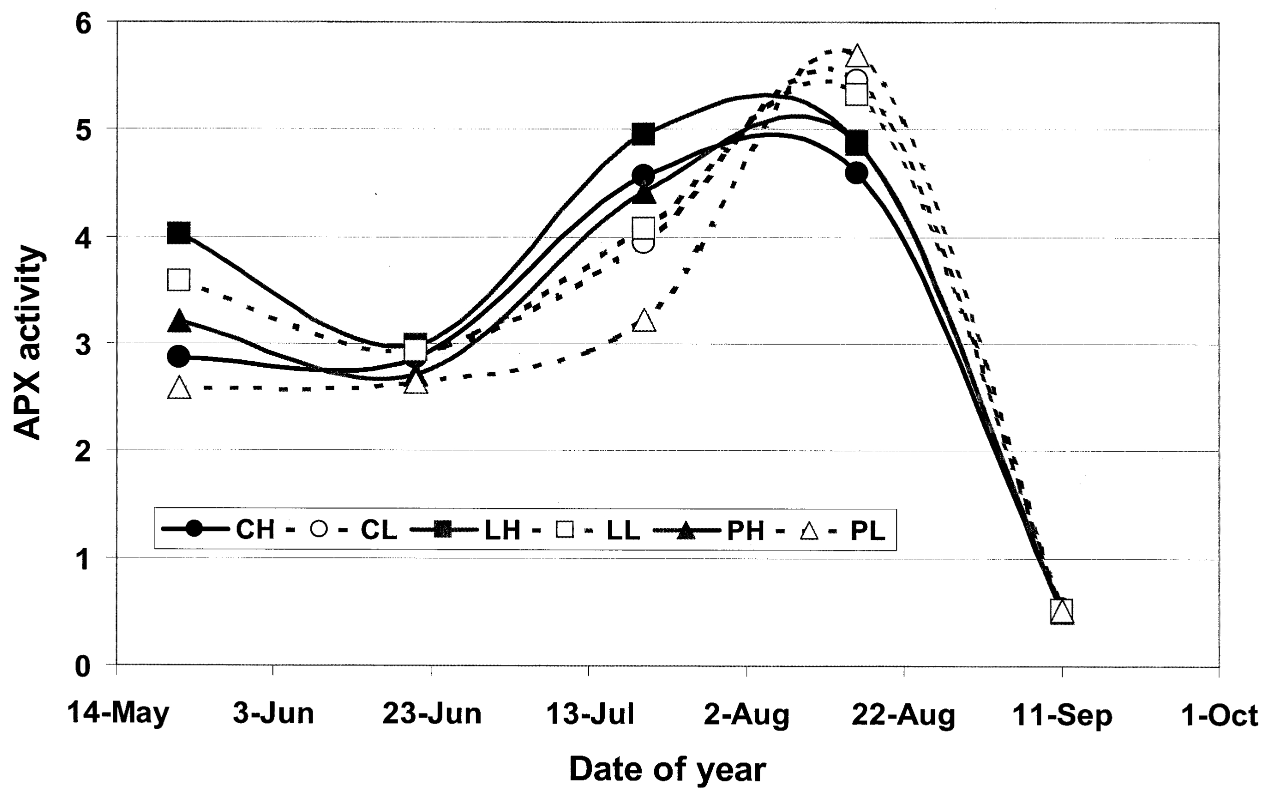

APX activity
6
5
4
3
2
1
0
CH
CL
LH
LL
PH
PL
14-May
3-Jun
23-Jun
13-Jul
2-Aug
22-Aug
11-Sep
1-Oct
Date of year

Fig. 8