Low-Level Jet Winds, Aphid Vectors, Local Weather, and Barley Yellow Dwarf Virus Outbreaks

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ABSTRACT

Aphids (greenbugs and English grain aphids) that transmit barley yellow dwarf (BYD) virus were studied in Iowa in relation to low-level jet winds from Texas, Kansas, and Oklahoma. Usually, winged aphids appeared in small grain plots after each jet wind, and yellow dwarf symptoms were noted about 3 weeks later. Early planted cereals sustained the least damage from BYD. Key factors in predicting yellow dwarf outbreaks are knowledge of viruliferous vector population levels in the Southern Plains states, the incidence of low-level jet winds blowing from the Southern Plains states, and weather conditions prevailing in the small grain after aphid fall-out. Phytopathology 61:1068-1070.

The past work on aphid flight behavior, migration, and authentic records of long-distance migration has been reviewed elsewhere (13). Live aphids were found in the ice 180 miles west of Spitzbergen, their probable source (12). Nearly 100 years later, again at Spitzbergen (2, 3), living aphids were found 800 miles from their nearest host trees. There was evidence that the peach-potato aphid, *Myzus persicae* Sulz., may have been wind-transported from West Germany to Britain (5).

The greenbug, *Schizaphus graminum* Rond., appeared in the north central USA under circumstances suggesting long-distance migration (4, 14, 16). The 1959 barley yellow dwarf (BYD) epiphytotic in Wisconsin was attributed to winged greenbugs from the south early in May (10).

Wind directions from southern areas coincided with the first appearance of greenbugs and English grain aphids in Wisconsin in 1969 (11). Another outbreak of the greenbug in Wisconsin (9) was associated with a heavy dispersal of airborne aphids from the south. Data from the use of yellow pan traps demonstrated that the dispersal included Missouri and Kansas. Air currents in the USA were illustrated and suggested as aiding aphid and leafhopper migration northward each spring (8). There is some doubt on the so-called "optima" for aphid flight (7). Southerly winds (1) and well-defined, low-level jet-wind systems (6) were suggested as methods of transporting BYDV aphid vectors from the Southern Plains states into the North Central states.

Advisories of low-level jet winds from the Southern Plains and early aphid detection in Iowa were useful in predicting the incidence and severity of barley yellow dwarf virus (BYDV) in 1965 (15). The first aphid incidence was documented by scanning plots of barley, oats, and wheat daily. Barley yellow dwarf symptoms were detected on California Red oats in the plot 24 days after the first aphid fall-out. The average incubation period for BYD is 21 days. The disease increased in extent and severity as the season progressed.

The purposes of the investigation reported herein were (i) to determine the feasibility of predicting BYD extensity and severity by correlating aphid movement with jet winds; and (ii) the relationship of small-grain planting date to BYD severity.

RESULTS.—*Vectors.*—Barley oats and wheat were surveyed in Texas and Oklahoma during late March through 1 April 1966 to determine the potential aphid population ready for northward migration. Greenbugs were abundant in the high and rolling plains areas of Texas. Counts in a few fields were 2,000-5,000/ft of row. Moderate to heavy populations were present in many areas of Oklahoma. Trace numbers were present on wheat. English grain aphids were present on wheat in Oklahoma and Kansas.

Greenbugs and English grain aphids collected in Texas and Oklahoma in 1966-67 were assayed on Clintland oats in our greenhouse and found to be viruliferous. Greenbugs collected from oats and wheat in March and April (1967) from southwestern Iowa and eastern Nebraska also were viruliferous. Presumably then, greenbugs from more southern areas can carry and transmit the virus to small grains in the North Central states.

Relationship of jet winds to initial appearance of BYDV.—Dates as furnished by the U.S. Weather Bureau, etc., on which low-level jet winds occurred over Iowa from 1965-1969 are shown in Table 1. Of particular importance was the occurrence of jet winds on nearly the same dates in different years. There were five instances in which they occurred on about the same dates for 3 or more different years. Five occurred each year during 4 of the 5 years, and 4 occurred in 1969.

The relationship of jet winds to the development of BYD was studied by means of small grain aphid-trap plots planted at Ames. Baart wheat, Black Hulless barley, California Red oats, and Clintland oats which are excellent indicators of BYDV were planted at weekly intervals, weather permitting. Plots were 6 × 12 ft, and were 6 rows 1 ft apart. Plantings were made 7, 14, 21, and 28 April 1966; 31 March and 7 April 1967; 29 March, 8, 26 April, and 9 and 16 May 1969. The results obtained in the 1967 season are typical of those obtained during the entire study, and are considered in detail here.

A very strong low-level wind blew from 29 to 30 March 1967. Six days later, 5 April, the first winged

TABLE 1. Dates when the low-level jet wind transport system for migrant aphid vectors occurred over Iowa (March, April, and May) in 1965-1969

Month	1965	1966	1967	1968	1969
March			29-30		
April	3-4		4-5[a]		5-7
	10-11			11-12	
	14			13	
		16-17	15-16	16[a]	
		18-19	19-20		
	22-23	24[b]	24-25	21-23	24-25
		27-28			29-30
May	4-6[a]	4-5		5-7	4[b]
					15-17

[a] First greenbugs or English grain aphids noted in plot on barley.
[b] No jet wind this date, but aphids first noted in plot on barley.

greenbug appeared in a yellow pan trap in our plots, 19, 11, and 29 days earlier than in 1966, 1968, and 1969, respectively. Only the tips of the emerging oat plants were evident. On the same data, we found winged greenbugs and English grain aphids on oats 1.5 inches high in another planting 5 miles from Ames.

During the weeks ending 7 and 14 April 1967, scattered, moderate-to-heavy greenbug populations persisted in Oklahoma, and trace-to-moderate numbers were present in some northeastern Kansas wheat fields. During these periods, English grain aphids were present in many fields in Oklahoma and Kansas.

On 15-16 April 1967, a strong, low-level jet wind blew from the Southern Plains across Iowa. On 17 April 1967, winged greenbugs and English grain aphids appeared in our plots on oats and barley 2 to 3 inches high. Greenbug feeding injury was obvious on the leaves in plants of the first and second dates of planting.

A greater number of winged greenbugs appeared in the second oat and barley planting. Presumably, the aphids increased and migrated from the first planting, and more arrived on 16 April 1967.

On 7 May 1967, 21 days after the first greenbugs were noted on oats, typical BYD red-leaf symptoms appeared on California Red and Clintland oats in the first planting. Few aphids could be found on this data, but more greenbugs than English grain aphids were present, as usual.

Temperatures during the period from 7 April to 18 May 1967 were below normal, and few lady bird beetles were present. Aphids increased steadily, but not rapidly.

During the season, the trap plots indicated that BYD would be more severe in the later plantings. Presumably, some of the aphids migrated from the earlier plantings coincident with aphid fall-out.

Barley yellow dwarf disease counts were made 7 July 1966, 1 July 1967, 11 July 1968, and 9 July 1969. Four counts of 100 plants each were made in each grain plot, and the number of diseased tillers in the 400 plants were counted and tabulated in Table 2.

Barley yellow dwarf was most severe in 1966 and 1969. The disease was the least severe in 1968, and this was the first year when greenbugs failed to arrive first in Iowa. They did not reproduce much upon arrival, and were difficult to find in our plots throughout the 1968 season.

DISCUSSION.—Meteorological data taken in the BYD plots during the 5-year period, 1965-1969, indicated that amount and frequency of rainfall were not critical factors in the severity of BYDV. Although BYD severity counts were not made in 1965, the weather conditions after aphid arrival are pertinent to this analysis, and thus, will be included.

Possibly, heavy rainfall immediately after aphid fall-out might kill the newly arrived vectors, thereby reducing the chances of virus transmission. For example, rainfall of 1.05 inches 4 days after aphid arrival was greater in 1968, the lightest BYD year, than during any year of the 1965-1969 period. In contrast, rainfall during the first 4 days after aphid fall-out in 1969, a moderate-to-severe year, was only 0.49 inches. Rainfall during the first 2 weeks after aphid fall-out was least in 1965, 1966, and 1969, the severe BYD years.

Temperatures after aphid fall-out are probably critical in BYD infection. Temperature maxima immediately after aphid arrival in 1965, 1966, and 1969, the most severe years, differed from those of 1967 and

TABLE 2. Percentages of tillers exhibiting barley yellow dwarf symptoms at different planting dates, Ames, Iowa

	Percentage[a]							
	1966					1967		
Crop	4/7	4/14	4/21	4/28		3/31	4/7	
California Red oats	28	65	85	85		48	91	
Clintland oats	35	20	75	70		40	32	
Baart wheat	50	60	60	65		26	34	
Black Hulless barley	60	75	85	98		37	48	
	1968				1969			
	3/29	4/8	4/26	5/6	4/22	4/30	5/9	5/16
California Red oats	7	3	7	2	37	90	97	98
Clintland oats	5	1	9	2	24	51	56	53
Baart wheat	1	1	11		32	37	68	66
Black Hulless barley	3	1	13	10	50	64	66	75

[a] Based on counts of 400 tillers.

1968. In 1965, temperature maxima were not below 21 C after vectors arrived. In 1966, temperatures the first 4 days after vector incidence were 19 C and above; in 1967, only 2 days were above 19 C; in 1968, 1 day of 19 C; and in 1969 there were 4 days of 19 degrees and above.

Temperature minima the first 4 days after aphid fall-out were higher in 1965, 1966, and 1969 than in 1967 and 1968. In 1965, temperature minima the first 4 days were 14-17 C; in 1966, 11-19 C; in 1967, the first 3 days, 0-8 C; 5-9 C in 1968; and 11-16 C on 3 days in 1969.

Our results indicated that BYDV caused the greatest damage to small grains in Iowa when they were planted late and the aphid migrants arrived late. Small grains planted the last of March or the first week of April sustained the least damage. The successful development and spread of BYDV seemed to depend upon the temperatures prevailing immediately after new migrants arrived.

Aphid vector populations in the Southern Plains states, low-level jet-wind warnings, early aphid detection in the target area, and prevailing weather conditions after aphid fall-out are key factors for forecasting the incidence and the possible severity of BYDV in Iowa and the surrounding states.

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