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關於馬鈴薯晚疫病的預測和防治的研究*

(摘　要)

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三年的觀察顯示馬鈴薯地裡出現的中心病株是當年該病開始流行的標誌。

在華北北部的條件下，到開花期才可能發現最早的中心病株。田間只有個別的植株成爲中心病株。即便完全播種病薯也是如此。通常在植株特別茂密、開花較早的低窪地點最容易發現中心病株。在田間的一般植株還沒有任何感染的跡象時，中心病株就已經有了衆多的典型病斑，並且其下層葉片開始發黃。

隨後，病害從中心病株順着風向往周圍的植株擴展。但是，傳播的距離是有限的。在觀察的一個典型實例中，中心病株發現後經過10天，田間全部病斑數目的檢查表示90%以上的病斑分佈於中心病株周圍大約800平方米的面積上（圖1）。

在晚疫病可能流行的季節中，每次侵染的潛育期相當恒定，變動的幅度僅在3至4天之間。在潮濕的氣候下，幾乎每天都有大量的孢子出現和侵入。從中心病株的出現開始到田間植株的全面枯死爲止歷時18至42天，因氣候潮濕和植株衰老的程度而異。

但是，如果在病害開始蔓延後不久遇到幾天特別乾旱和高溫的氣候，病斑內的病菌可以死亡而病害幾乎完全停止發展。1955年6月23日在9分地的井字形試驗田內人工接種了中央的四個植株之後，7月20日以前病害已經相當普遍地蔓延到了全試驗田。從7月21日到25日完全沒有降雨，平均氣溫28.9°C，極端最高溫度達到了39.9°C。雖然從7月26日開始連日下雨，溫度顯著降低，病斑數目也不再增加。直到8月8日還只有個別的病斑產生出孢子層。參照表1和圖2的資料可以清楚地看到這種情況。

全部資料使我們得到結論：在預測馬鈴薯晚疫病以指導防治措施的時候，應當把注意力集中在各個農場的中心病株出現的日期以及氣候和物候條件的了解上。病害侵染潛育期的計算在這裡顯然是沒有實踐意義的。

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18	10	105	15	31	12	63	21	2	0
7	87	75	59	178	36	124	30	1	0
5	125	29	76	211	173	144	26	0	0
43	7	96	42	89	279	32	0	4	0
46	22	75	70	306	639	166	24	1	1
57	13	89	65	476	1633	641	15	11	4
36	218	21	28	1054	1480	250	64	217	38
6	34	14	13	181	430	98	66	141	97
3	7	10	7	148	325	167	100	452	58

圖1. 馬鈴薯晚疫病中心病株發現經過10天後的田間病斑數目的分佈（從中心病斑發現起8天內有三天最多風向是西北，5天是東南。圖中每格代表50平方米的面積）

表 1 1955年在沙嶺子試驗地內進行馬鈴薯晚疫病流行觀察期間的氣候情況

日期	降雨日數	降雨總量（毫米）	平均相對濕度(%)	氣溫 °C		最多風向	平均風速（米/秒）
				平均	平均最高		
1/VII— 5/VII	3	17.3	50	23.0	29.3	NNW	2.6
6/VII—10/VII	4	23.8	67	24.3	30.7	ESE	3.2
11/VII—15/VII	3	11.8	72	21.3	26.5	NW	2.0
16/VII—20/VII	1	0.2	67	23.8	31.0	SE	1.6
21/VII—25/VII	0	0	53	28.9	37.7 (39.9)*	SE	2.0
26/VII—31/VII	5	20.9	76	24.7	30.7	ESE	2.5
1/VIII— 5/VIII	2	0.3	68	25.9	30.9	ESE	3.7

* 極端最高溫度

日　期	病　斑　數　目		
6/VII	0	0	0
12/VII	1	14	17
16/VII	28	248	506
22/VII	791	4,317	2,536
30/VII	590	4,922	4,355
8/VIII	52	81	...
6/VII	0	55	0
12/VII	10	531	167
16/VII	452	10,561	2,520
22/VII	3,120	36,075	12,623
30/VII	5,797	27,884	8,769
8/VIII	87	128	51
6/VII	0	0	0
12/VII	7	36	41
16/VII	145	882	437
22/VII	2,516	7,560	9,596
30/VII	4,577	6,082	7,240
8/VIII	166	383	73

圖2，1955年沙嶺子馬鈴薯晚疫病流行試驗田內各小區在不同日期病斑數目檢查記錄（23/VI在田中央接種了四個植株；8/VIII僅計數帶有孢子層的活病斑，其他數字係病斑總數；每小區一分地）

與研究馬鈴薯晚疫病的流行和預測的同時，我們也進行了關於該病的化學防治的試驗。在1953年對於低濃度硫酸銅溶液噴射做了試探而得到美滿的效果之後，1954—1955連續兩年的較大規模的田間試驗證明這一種噴射具有廣泛應用的價值。1954年氣候潮濕，晚疫病發生得早。用0.1%硫酸銅溶液從7月1日開始每隔7天一次噴射4或5次的，結果延緩了晚疫病的發展大約15—20天，提高產量大約30—45%。1955年特別乾旱，晚疫病發生得晚。用0.15%硫酸銅溶液從7月12日開始每隔14天一次噴射4次仍然顯著地延緩了晚疫病的發展並提高了產量，產量的提高在灌溉地裏也幾乎達到20%，而在不灌溉的馬鈴薯地裏大約10%。雖然在晚疫病發生得早而嚴重的情況下低

濃度硫酸銅液噴射的效果不如標準的波爾多液，但是在旱年晚疫病較不嚴重的情況下，硫酸銅溶液的作用等於或超過波爾多液（表2）。應當特別指出的是，低濃度硫酸銅液的藥劑成本遠比波爾多液低，並且配製手續簡便，大大有利於大面積的使用。

表 2 低濃度硫酸銅溶液及其他藥劑的噴射在防治馬鈴薯晚疫病並減少塊莖產量損失上的作用

	藥劑種類	噴射次數	噴射開始日期	每次間隔日數	葉面積枯死達到60%的日期	平均產量（斤/畝）	產量比率
一九五四年	對照	0	0	0	25/VII	2160	100.0
	0.1% 硫酸銅溶液	4	1/VII	7	16/VII	2845	131.7
	0.1% 硫酸銅溶液	5	1/VII	7	20/VII	3136	145.2
	0.2% 硫酸銅溶液	2	1/VII	10	5/VII	2661	123.2
	1% 波爾多液	3	1/VII	10	27/VII	3428	158.7
一九五五年灌溉地	對照	0	0	0	26/VII	3913	100.0
	0.15%硫酸銅溶液	4	12/VII	14	14/IX	4583	117.1
	0.1% 硫酸鋅溶液	4	12/VII	14	9/IX	4338	110.9
	0.15%硫酸銅溶液+0.1%硫酸鋅溶液	4	12/VII	14	14/IX	4490	114.7
	1% 波爾多液	4	12/VII	14	21/IX	5030	128.5
一九五五年不灌溉地	對照	0	0	0	10/IX	4275	100.0
	0.15%硫酸銅溶液	4	12/VII	14	17/IX	4690	109.7
	0.1% 硫酸鋅溶液	4	12/VII	14	14/IX	4678	109.4
	0.15%硫酸銅溶液+0.1%硫酸鋅溶液	4	12/VII	14	17/IX	4568	106.9
	1% 波爾多液	4	12/VII	14	28/IX	4588	107.3

根據上述的試驗結果做全面的考慮，我們認爲至少在華北北部地區，低濃度硫酸銅溶液噴射可以作爲經常的農業技術措施列入馬鈴薯生產計劃的經濟核算中。在每年實施的時候，建議從馬鈴薯的開花期起密切注意本農場裡中心病株的出現，一發現中心病株就開始噴第一次，以後陸續噴射的時間間隔視氣候及物候條件而定。在多雨的氣候和植株接近衰老的情況下，需要每隔一星期噴射一次。在乾旱的條件下，噴射的間隔時間可延長至兩星期或更長。我們估計一般用0.15%硫酸銅溶液一共噴射3—5次就足以避免晚疫病的嚴重爲害，保證馬鈴薯的穩定高額產量。

在我們的1955年的噴射試驗中，我們還試探了各種其他微量元素的作用。結果表示0.1%硫酸鋅溶液也有相當大的防病增產作用。奇怪的是：硫酸銅和硫酸鋅的配合並不加强效果。鋅的原料來源比銅更爲豐富，而且目前已經有相當大量的硫酸鋅態的工業副產品。因此，對於這一問題，有必要做進一步的研究。

STUDIES ON THE FORCASTINC AND CONTROL OF POTATO LATE BLIGHT

(Abstract)

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Appearance of sporadic diseased-plant centers has repeatedly been shown to be a good signal for forcasting the current year's outbreak of potato late blight in an individual farm.

Under North China conditions, diseased-plant centers have never been found before the blooming period. Only a very few plants within a large area of potato plantation act as disease-spreaders, even if all plants are grown from infected seed-tubers. They are usually located at places with poor drainage and dense stand. Before all other plants show any trace of infection, many characteristic lesions can be seen on diseased-plant centers where the lower leaves of plants already begin to turn yellow.

Then, the disease gradually spread to surrounding plants corresponding to wind direction. Effective distance of spore dispersal is apparently guite limited. In a typial case, 10 days after the discovery of a single diseased-plant center in an area of over 5,000 sq. m., actual count of the number of lesions in the entire plantation showed that over 90% of them are distributed in an area of not more than 800 sq.m.

In the period during which epiphytotic of late blight occurs, the length of the

incubation period of each secondary infection is rather constant, varying only between 3 and 4 days. Under humid conditions, abundant sporulation and penetration of the fungus may be expected almost every day. The time interval between the appearance of initial diseased-plant centers to final total blight in a potato plantation varies from 18 to 42 days, in accordance with the amount of rainfall and the age and the rate of decline of the plants themselves.

If, however, a few days of continuous drought and high temperature occur soon after the disease already has begun to spread, the fungus in the plant lesions may die out and the disease almost entirely ceases to make further development. In 1955, in the center of a #-shaped experimental plot with an area of 540 sq. m., 4 plants were inoculated on June 23, and the disease spread over the entire plot by July 20. During July 21 to 25, rain and dew were entirely lacking and the air temperature averaged 28.9°C with an extreme maximum as high as 39.9°C. Although it rained continually during the following 5 days and the air temperature suddenly dropped down, there were no increase in the number of lesions for a long time. Until August 8, the fungous sporulation was seen only on a few lesions.

All these observations lead us to conclude that in forcasting late blight of potatoes, attention must be directed to the date of the appearance of diseased-plant centers in each plantation as well as to the knowledge of climatic and phenological conditions. Here, determination of the incubation period of each infection is unnecessary and of no practical value.

While studying the epiphytology of potato late blight, experimentation on its chemical control has simultaneously been undertaken.

In a preliminary experiment carried out in 1953, some promising results have been obtained with dilute copper sulphate spray. Again in 1954—1955 large scale field experiments proved this spray to be highly profitable. In 1954, a serere blight year, 4—5 sprays with 0.1% $CuSO_4$ solution applied at 7-days interval beginning from the first of July retarded the development of late blight by 15—20 days, and resulted in an increase of yield by 30—45% over the control. It was dry in 1955 and blight occurred very late in the season. Four sprays with 0.15% $CuSO_4$ solution applied at 14-days interval beginning from

July 12 again gave farorable results, increase of yield being almost 20% in irragated land and about 10% in non-irragated land. Although dilute copper sulphate solution is less effective thsn standard bordeaux mixture under severe blight conditions, it equals or even exceeds the latter in case the late blight is less severe. It is important to note that dilute copper sulphate solution is much cheaper than bordeaux mixture and much easier to prepare, so as to permit its general application over a large area.

As dilute copper sulphate spray will always give good profit under various conditions, we are of the opinion that, at least in northern North-China, it can be put into regular cultural practice. It is recommended to look carefully each year, beginning from the blooming of potato plant, for the appearance of the diseased-plant centers in every plantation in order to adjust the time for the first application of spray. When precipitations are heavy and the plants are quickly declining in vigor, it needs to repeat the spray every week. Otherwise, intervals between successive sprays may be lengthened to two weeks or longer. It is estimated that 3-5 sprays with dilute copper sulphate solution will be sufficient to protect the potato plants from severe blight and to insure high yield of tubers.

In our spray experiments in 1955, various other micro-elements were also investigated. 0.1% zinc sulphate spray also resulted in good control of late blight and significant increase in yield, although no synergetic effect was observed in a combination of copper and zinc spray. Since zinc is more readily obtainable than copper, further studies on this problem will be justified.