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Effect of Spacing on Severity of *Phytophthora* Leaf Blight and Yield of Colocasia

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Abstract

Leaf blight of taro or Colocasia (*Colocasia esculenta*) caused by *Phytophthora colocasiae* is an important yield restricting factor. As a component of integrated disease management strategy, effects of different spacing levels on disease incidence and leaf area damaged were studied. The closer spacing (40 cm × 20 cm, 30 cm × 30 cm or 40 cm × 30 cm) enhanced the spread of the disease and total leaf area damaged was higher compared to wider spacing. However, the yield loss due to disease was compensated by yield from more number of plants per unit area in closely planted plots. The effects of wider and closer spacing on taro leaf blight disease incidence and total leaf area damaged due to blight are discussed.

Keywords: *Phytophthora colocasiae*, *Colocasia esculenta*, spacing, disease incidence, disease severity

Introduction

Taro or Colocasia (*Colocasia esculenta* (L). Scott) is one of the tropical tuber crops serving as food security as well as vegetable crop in many parts of the world. In South East Asian countries, Pacific and Solomon Islands, it is considered as a staple food crop. It has higher carbohydrate and mineral contents. It has medicinal properties and used in Ayurvedic medicines. Taro is seriously affected by leaf blight caused by *Phytophthora colocasiae*. Many authors have reported the yield loss due to this disease (Butler and Kulkarni, 1913; Gomez, 1925; Jackson and Gollifer, 1975a,b; Misra, 1993, 1997; Parris, 1941; Plucknett, 1970; Trujillo and Aragakai, 1964 and Trujillo, 1967). The symptoms include dark brown round or irregular necrotic spots on the leaf lamina. During favourable weather the sporulation of the fungus can be observed as white powdery coating in rings. Clear exudates of brown colour also observed. Intermittent rain and cloudy weather are ideal for rapid development of the disease (Trujillo, 1965; Misra, 1997). Metalaxyl and Mancozeb based fungicides have proved effective in controlling the disease (Misra, 1997). Colocasia grown as summer crop with short duration varieties and assured irrigation generally escapes the *Phytophthora* leaf blight. However, many farmers grow this crop under rainfed conditions and plant only in the month of June or July after the starting of the monsoon in India. The waxy layer on the leaf surface, intermittent rain during the crop season and cost of fungicides prevent the subsistence level farmers to go for chemical control of the disease. Among the cultural practices, spacing is also tried as one of the component in management of plant diseases. It is generally believed that closer spacing helps in quicker spread of the disease and results in epidemic condition. However, many farmers go for closer spacing with more number of plants per unit area hoping that will help in compensating the yield loss due to disease by yield from more number of plants. The effect of different spacing levels on the *Phytophthora* leaf blight incidence, disease severity and yield of tubers were studied. Eventhough closer spacing increased disease severity, the increase in yield due to more number of plants per unit area compensated the yield loss due to the leaf blight infection. The effect of spacing on disease severity and yield are discussed in this paper

Materials and Methods

To study the effect of spacing on the incidence and severity of the taro leaf blight, field trials were taken up in two seasons (1999 and 2000) in the experimental farm of Regional Centre of Central Tuber Crop Research Institute, Bhubaneswar. The susceptible cultivar 'Telia' was planted in 6 different spacing *viz.*, 60 cm × 40 cm, 60 cm × 30 cm, 60 cm × 20 cm, 40 cm × 20 cm, 40 cm × 30 cm and 30 cm × 30 cm. Planting was done in the month of June that coincides with South West monsoon. The number of plants infected, number of spots per leaf and size of the blighted area were recorded. The percentage of infection and leaf area damaged were calculated from the above-mentioned observations. The leaf area damaged was calculated based on the number of spots per plant, average size of the spots and number of infected plants per plot. The observations were made in 10 day intervals from the first appearance of the disease in the field. Yield per plot with different spacing levels were also recorded.

Results and Discussion

In the first year (1999), in the closer spacing *i.e.,* 60 cm × 20 cm, 40 cm × 20 cm and 30 cm × 30 cm, the appearance of the disease was early. The weather factors were favourable for the disease appearance and spread in 1999. The disease appeared well in advance and by 45[th] day after planting the disease appeared and by 60[th] day the number of plants with symptoms reached almost 100 per cent in very closely spaced plots (40 cm × 20 cm). During the second observation the infection was more than 90 per cent in all plots (Fig.1). The number of spots per leaf was high initially in the closely spaced plots (10.4 spots per leaf in 40 cm × 20 cm spacing, 10.46 in 30 cm × 30 cm spacing) and by second observation the number of spots in all plots increased and then started declining due to defoliation (Table 1). The disease appeared again in the newly formed leaves and the number of spots per leaf increased again by sixth observation. There were not much significant changes in the number of spots per leaf. However, the leaf area damaged was less in the widely spaced plots. The leaf area damaged per plant reached 235.55 cm^2 in 30 cm × 30 cm spaced plots by 60 days and increased upto 307.23 cm^2 within one week and then started declining due to defoliation. In other closely spaced plots (40 cm × 20 cm, 60 cm × 20 cm) also the leaf area damaged per plant was high. However, the leaf area damaged was less in widely spaced plots (60 cm × 40 cm), the maximum leaf area damaged being 216.73 cm^2 during the peak period of the disease (Fig. 2). The yield per plant was less in the closely planted plots. Eventhough the leaf area damaged varied significantly and it was higher in closely spaced plots, the yield was higher in them due to increase in the number of plants. In widely spaced plots, the leaf area damaged was less and yield per plant was higher than that of closely planted plots. However, the total yield per plot was less due to reduction in total number plants per unit area. The increase in number of plants had taken care of loss of yield due to leaf area damaged by the disease (Table 3) in the plots with close spacing.

In the second trial in 2000 the weather parameters were not conducive for the disease spread and after 90 days of planting, the disease started appearing and the percentage of plants with symptoms were increasing in the closely spaced plots in the initial stage and reached upto 50 per cent (Fig.3) while in widely spaced plots the percentage of plants with infection was less and reached a maximum of 32 per cent by fourth observation.

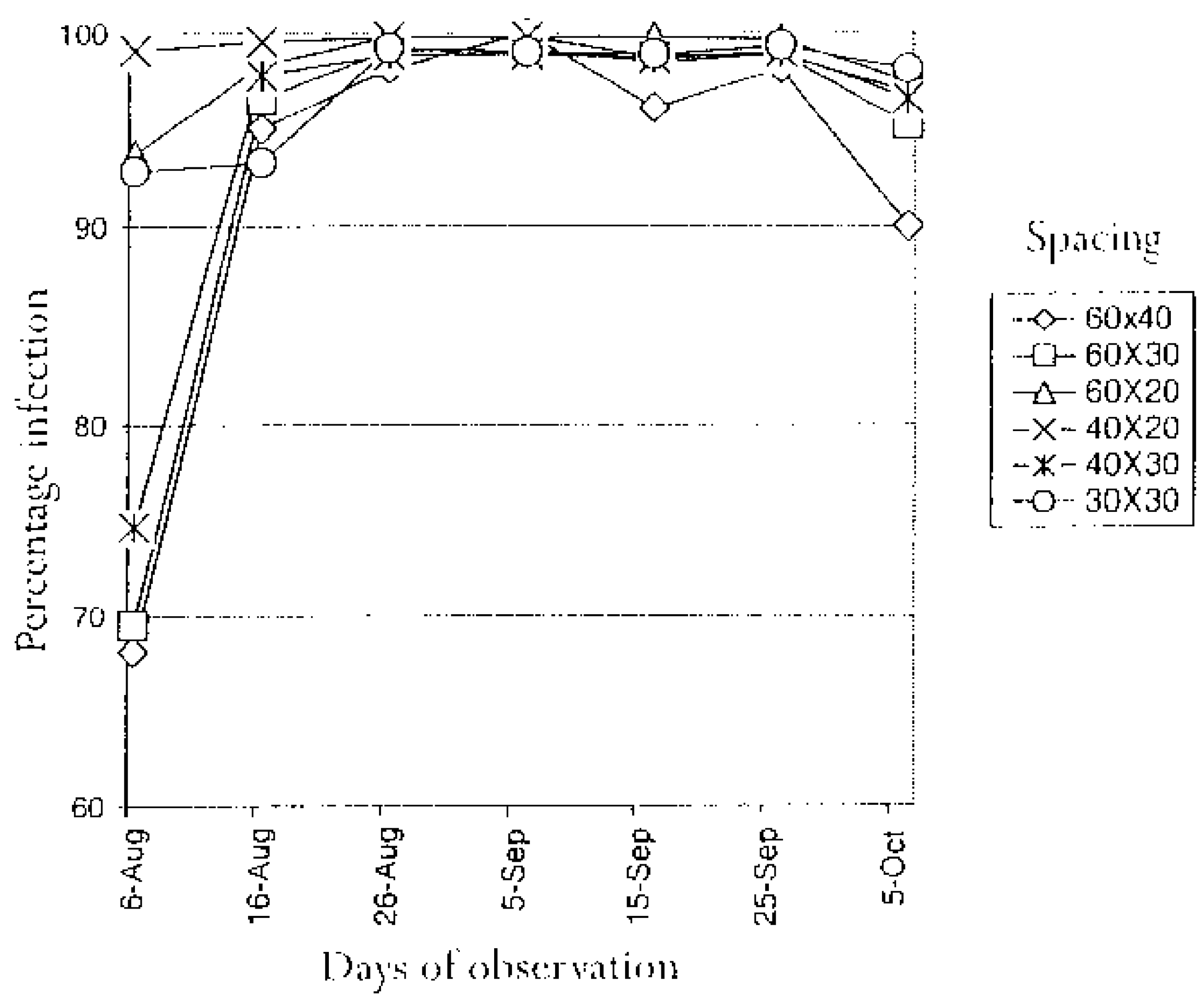


Fig. 1. Effect of spacing on percentage of plants with leaf blight symptoms in 1999

Table 1. Effect of spacing on number of spots per plant due to leaf blight in taro in 1999

Spacing (cm)	Days of observation						
	6 Aug	16 Aug	26 Aug	5 Sep	15 Sep	25 Sep	5-Oct
60X40	4.86	10.3	8.46	8.4	10.6	10.06	6.06
	(2.2)	(3.21)	(2.91)	(2.89)	(3.25)	(3.17)	(2.46)
60X30	4.66	12.4	8.66	7.06	9.6	9.4	6.86
	(2.16)	(3.52)	(2.94)	(2.65)	(3.09)	(3.06)	(2.62)
60X20	6.2	12.33	12.73	8.2	10.13	8.80	7.86
	(2.48)	(3.51)	(3.56)	(2.86)	(3.18)	(2.96)	(2.8)
40X20	10.4	11.66	7.86	9.00	10.73	10.06	7.93
	(3.22)	(3.41)	(2.8)	(3.00)	(3.27)	(3.17)	(2.81)
40X30	5.66	11.53	9.46	7.4	11.33	9.73	8.73
	(2.38)	(3.39)	(3.07)	(2.72)	(3.36)	(3.12)	(2.95)
30X30	10.46	13.53	9.2	8.66	12.5	10.6	7
	(3.23)	(3.67)	(3.03)	(2.94)	(3.54)	(3.25)	(2.64)

Age of the plant on first observation 65 days; Obscrations were made at 10 days intervals; Values in the parentheses are square root transformed values; CD : Spacing : 0.213; Observation : 0.23; Spacing X Observation : 0.564

However, the leaf area damaged per plant was less in the year 2000 compared to 1999 in general. The increase in number of plants had taken care of loss due to the defoliation. Leaf area damaged was higher (Fig.4) in the closely spaced plot (40 cm × 20 cm). The number of spots per plant was very less (Table 2) in the year 2000 due to unfavourable weather conditions for the spread of the disease. In the second year also yield was higher in the closely spaced plots due to higher number of plants per unit area (plot size 15m^2) compared to wider spaced plots.

The difference between the weather conditions between the two years is the reason for the differences on the effect of spacing on the disease and severity between two seasons. The cumulative rainfall and number of rainy days during the two seasons were 925mm (35 days no rain) and 759mm (43 days no rain) respectively. In the first year (1999), four days before the initiation of the disease (2nd August to 4th August), the average maximum and minimum temperatures were 30.22 and 24.68°C and the cumulative rain fall received during these four days was 23.27mm. The average maximum RH was 94.75% and average minimum RH was 88.5%. During this period sunshine duration was also very short. Because of this favourable weather, disease spread fast immediately after the initiation irrespective of the spacing levels.

During the second year, there was less rain and during the main growth period there was scanty rain that the favourable weather conditions were not prevalent for a

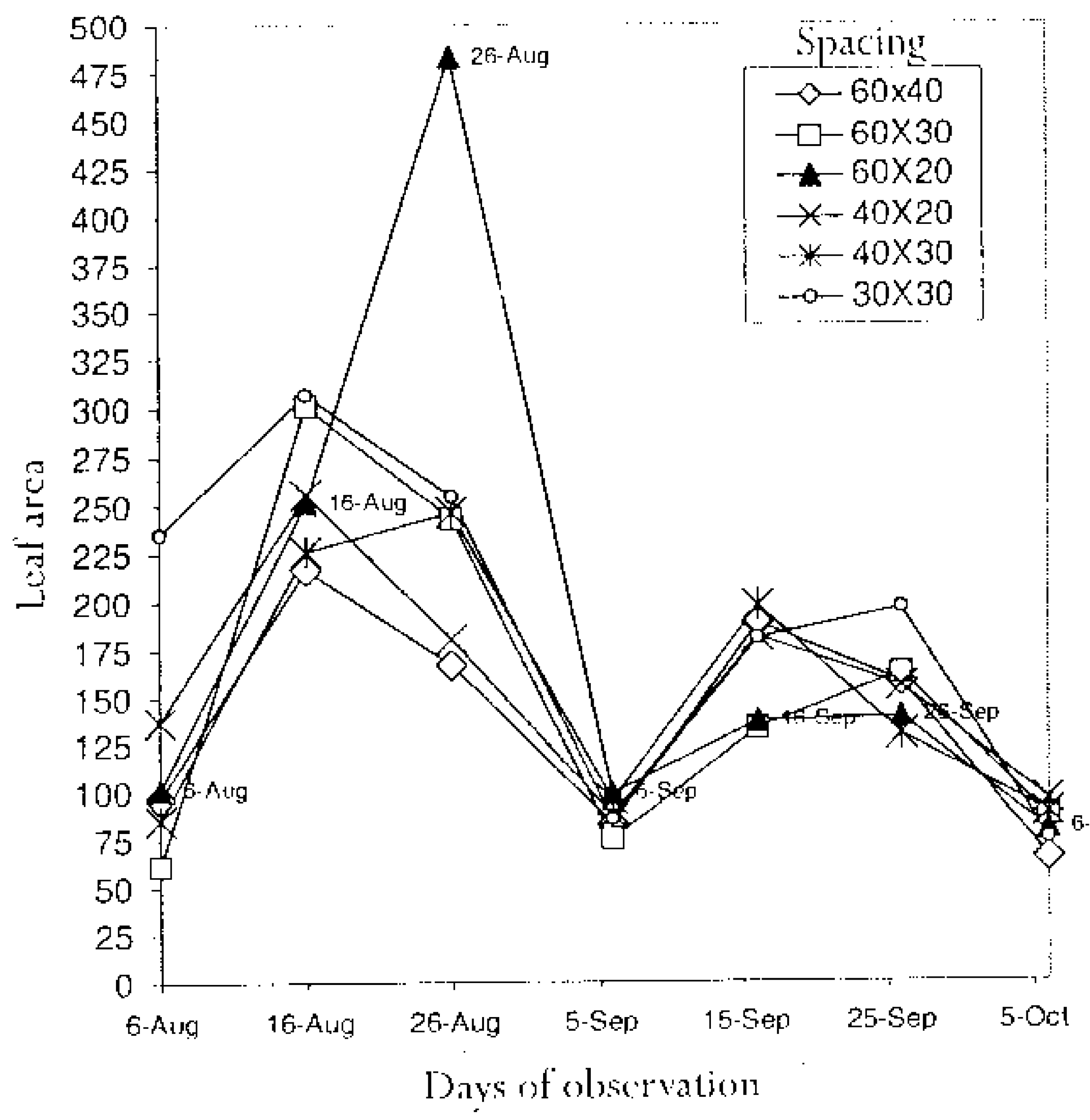


Fig. 2. Effect of spacing on leaf area damaged in 1999

Table 2. Effect of spacing on number of spots per plant due to leaf blight in taro in 2000

Spacing (cm)	Days of observation				
	12 Sep	22 Sep	2 Oct	12 Oct	22 Oct
60X40	0.93	1.53	2.13	2.43	1.43
	(0.96)	(1.23)	(1.46)	(1.56)	(1.19)
60X30	1.06	2.13	1.93	2.73	1.48
	(1.03)	(1.46)	(1.39)	(1.65)	(1.21)
60X20	1.13	2.13	1.86	3.26	1.4
	(1.06)	(1.46)	(1.36)	(1.80)	(1.18)
40X20	1.06	2.46	1.86	3.66	2.00
	(1.03)	(1.57)	(1.36)	(1.91)	(1.41)
40X30	1.2	1.86	1.86	2.93	1.53
	(1.09)	(1.36)	(1.36)	(1.71)	(1.23)
30X30	1.13	2.4	1.6	2.26	1.4
	(1.06)	(1.55)	(1.26)	(1.50)	(1.18)

Age of the plant on first observation 65 days; Obserations were made at 10 days intervals; Values in the parentheses are square root transformed values; CD : Spacing : 0.150; Observation : 0.137; Spacing X Observation : 0.336

required period for the rapid spread of disease. Most of the rain occurred in the initial days of the crop and before the initiation of the disease.

More rainfall during the first season masked the effect of spacing on the incidence of *Phytophthora* blight and resulted in overall increase in the disease incidence irrespective of spacing levels. For *Phytophthora* diseases, rainfall is important for the dispersal of sporangia. Frequent rainfall increases splash dispersal of inoculum and could mask the effect of wider spacing. Frequent rainfall prolongs the wetness duration that is required for the faster sporulation and dispersal of zoospores.

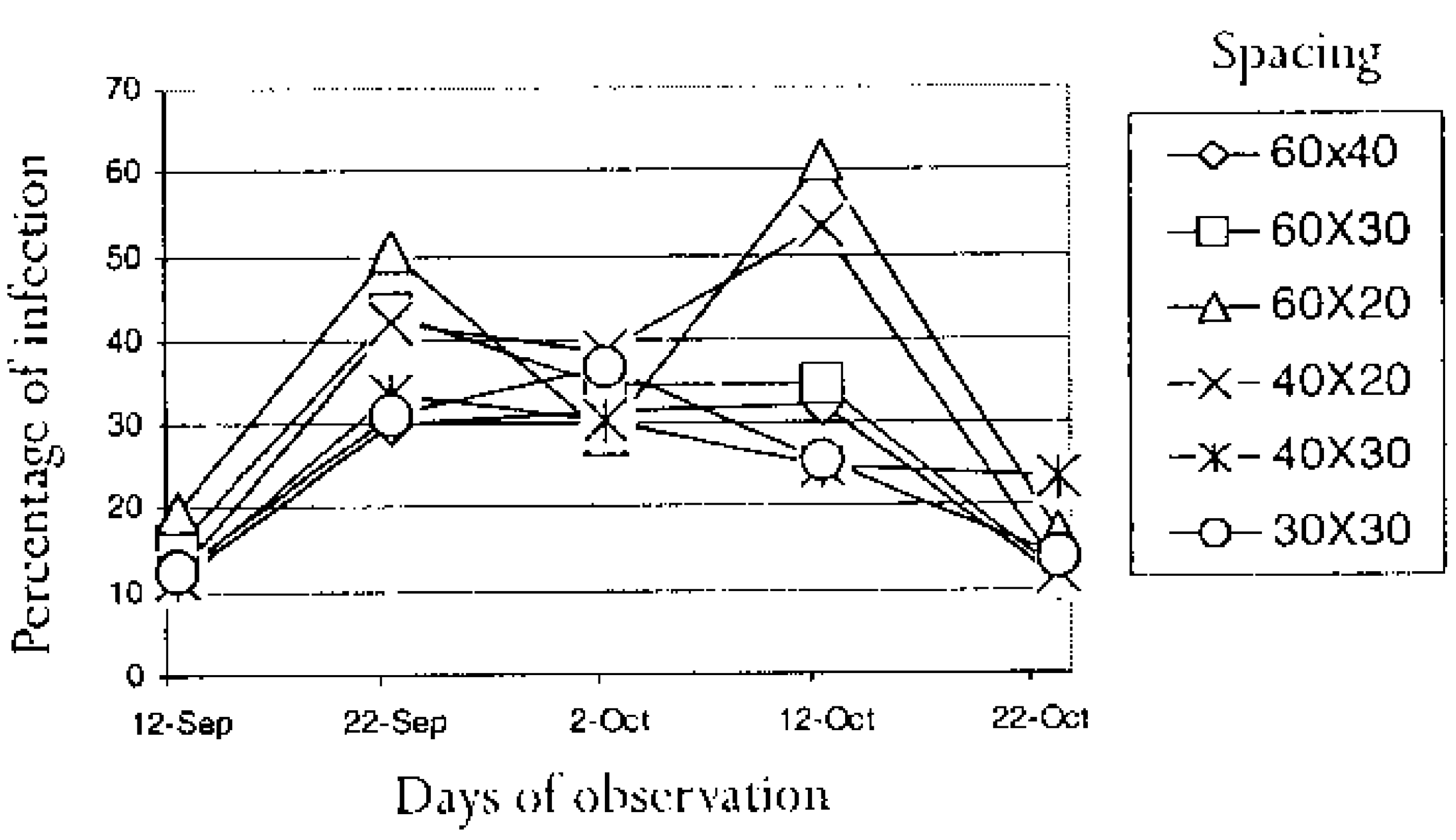


Fig. 3. Effect of spacing on percentage of plants with blight symptoms in 2000

The crop canopy and structure of the plant also matters while considering the sporangial dispersal. The susceptible variety 'Telia' taken in this study is a short one with large leaf area and drooping leaves. The disease tolerant variety Muktakeshi is a comparatively taller one with narrow leaf lamina and leaves are borne horizontally from the petiole end. Effect of host density include (i) Changes in the number of target hosts available to intercept inoculum, (ii) the spatial relationship between the hosts and (iii) spore dispersal gradients. Since sporangia of *P. colocasiae* are dispersed through rain splash, closer spacing will help in easy dispersal of the sporangia to the target host tissues than in wider spacing. However, rainfall or precipitation could increase the splash dispersal of inoculum, possibly overwhelming the advantageous effect of wider spacing. Closer spacing reduced air movement within the canopy favouring the disease development.

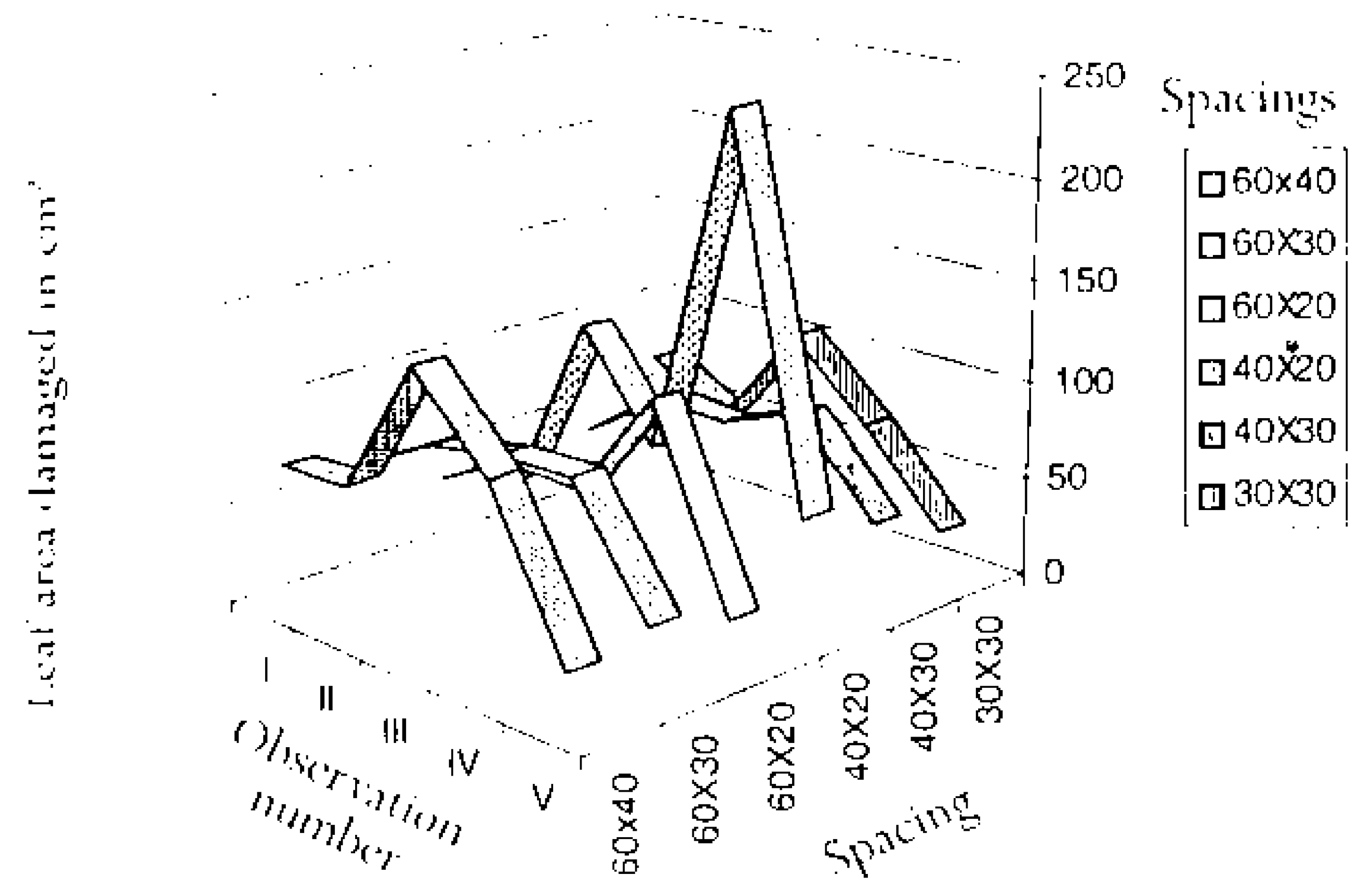
It is widely believed that growing plants in dense stands promotes epidemics (Burdon and Chilbers, 1992).

Table 3. Effect of spacing on yield (in kg per plot*) of tubers in 'Telia' during 1999 & 2000

Spacing (cm)	Number of plants per plot	Area for each plant (cm^2)	1999		2000	
			Yield per plot (kg)	Yield per plant (kg)	Yield per plot (kg)	Yield per plant (kg)
60 x 40	25	2400	5.782	0.2313	5.500	0.2200
60 x 30	33	1800	6.733	0.2020	4.633	0.1390
60 x 20	50	1200	8.099	0.1620	6.433	0.1287
40 x 20	75	800	7.866	0.1049	7.466	0.0995
40 x30	50	1200	8.832	0.1766	5.899	0.1180
30 x 30	67	900	8.033	0.1205	5.199	0.0780
Cd (p=0.05)			0.56		0.48	

*plot size 300 cm X 200 cm

Spread of blight disease in celery caused by *Cercospora apii* was faster in closer spacing than in wider spacing (Berger, 1975). But no spacing effects were observed by Standlberg and White (1978) in celery when grown with commercially viable plant densities. Higher plant densities increased incidence of white mold of common beans (Saindon et al., 1995; Tu, 1989). Wider spacing between the plants within a row reduced the incidence of *Botrytis* fruit rot of straw berries (Legard et al., 2000). Eventhough, narrower spacing had higher incidence of *Botrytis* than wider spacing, marketable yields were higher at narrower spacing. Legard et al. (2000) observed that there were significant differences in susceptibility among the cultivars of strawberry due to spacing.



Days of observation

I 12th Sep; II 22nd Sep; III. 2nd Oct; IV. 12th Oct and V. 22nd Oct

Fig. 4. Effect of spacing on leaf area damaged due to leaf blight in 2000

From the farmers' point of view, optimizing the yield and increasing the profit by increasing the total number of plants will be more important than reducing the disease incidence by wider spacing.

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