ORCHARD MANAGEMENT AND SANITARY PRUNING ON THE INCIDENCE OF MANGO MALFORMATION

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ABSTRACT

It was evaluated the effect of different orchard managements and pruning types on the proportion of deformed buds in mango cv. Haden from 1999 to 2001. Three management technologies were established: integrated management (IM), high input management (HM) and traditional technology (TT); the types of pruning applied in each technology were: pruning after harvest and during blooming, pruning of only deformed buds at 30 cm from these, pruning after harvest at 30, 80, and 120 from deformed buds, and a control with no pruning. Integrated management showed a significantly lower proportion of deformed buds and area under the curve of the disease progress, when compared to TT at the end of the period 2000-2001, suggesting a long-term effect. Even though we found significant differences among types of pruning, there was no interaction between management and pruning types. Pruning types were statistically different when compared to the control, suggesting that the proportion of deformed buds decreases by pruning affected branches. Pruning after harvest at 80 and 30 cm from the affected zone maintained the lowest bud deformation values in both periods; this leads us to recommend this type of pruning as a part of IM.

ADDITIONAL KEY WORDS: *Fusarium subglutinans*, *Mangifera indica*, disease, integrated management.

MANEJO DE HUERTO Y PODAS SANITARIAS EN LA INCIDENCIA DE LA ESCOBA DE BRUJA DEL MANGO

RESUMEN

Se evaluó el efecto de diferentes manejos de huertos y tipos de podas en la proporción de yemas deformes en mango cv. Haden durante 1999 a 2001. Se establecieron tres tecnologías de manejo: manejo integrado (IM), manejo de altos insumos (HM) y tecnología tradicional (TT); los tipos de poda aplicados en cada tecnología fueron: poda después de la cosecha y durante la floración, poda sólo de las yemas deformes a 30 cm de ellas, poda después de la cosecha, a 30, 80 y 120 cm de las yemas deformes, más el testigo, sin poda. IM mostró una proporción significativamente más baja de yemas deformes y de área bajo la curva del progreso de la enfermedad, comparado con TT al final del periodo 2000-2001, lo que sugiere efecto a largo plazo. Aunque se encontraron diferencias significativas entre los tipos de poda, no se encontró interacción entre el manejo y dichos tipos de poda. Los tipos de poda fueron estadísticamente diferentes respecto al testigo, lo que sugiere que la proporción de yemas deformes es reducida por la poda de las ramas afectadas. La poda después de la cosecha a 80 y 30 cm de la zona afectada mantuvo los valores más bajos de deformación de yemas en ambos periodos, lo que lleva a recomendar este tipo de poda como parte de IM.

PALABRAS CLAVE ADICIONALES: *Fusarium subglutinans*, *Mangifera indica*, enfermedad, manejo integrado.

INTRODUCTION

Floral and vegetative malformations are very important and worldwide limiting factors for mango production; they interfere with normal development of inflorescences and shoots, respectively. Vegetative malformation is also known as bunchy top. After Tripathi's suggestion (1954) and the experimental work carried out by Kumar and Beniwal (1987), they are considered manifestations of the same syndrome. Several causes of this mango disease have been postulated: viruses, mites, physiological disturbances and pathogenic fungi. However, many researchers

Recibido: 7 de agosto, 2003
Aceptado: 18 de agosto, 2004

consistently refer to *Fusarium subglutinans* (Wollenweb. & Reinking) (Summanwar *et al*., 1966; Ploetz and Gregory, 1993; Freeman *et al.*, 1999) as the causal agent. The mite *Aceria mangiferae* Sayed, also found in close association with mango shoots, is suggested to be a possible disseminator of *F. subglutinans* propagules (Nariani and Seth, 1962; Sternlicht and Goldenberg, 1976).

Assays to control both floral and vegetative malformations have been directed mainly to eliminate the causal agents or the possible disseminators with the application of systemic or contact fungicides, acaricides-insecticides, growth regulators and pruning of diseased buds (Narasimhan, 1959; Mahumdar *et al.,* 1970; Bindra and Bakhetia, 1971; Butani and Srivastava, 1976; Osman, 1979; Darvas, 1987).

These control measures have shown inconsistent results because a reduction in the incidence of the disease was observed in some orchards and not in others (Chakrabarti, 1996). However, a combination of some of these individual measures resulted in a better control of the disease. This alternative is based on the assumption that multiple technological actions acquire a synergistic effect favoring the crop (GIIM, 1998); under this assumption an integrated management package includes sanitary pruning, incorporation of organic matter to the soil, control of vectors, irrigation management, balanced chemical fertilization, protection of new buds, weed control and promoting anticipated blooming (GIIM, 1998; Noriega *et al.,* 1999).

Pruning is widely suggested as a practice to control vegetative and floral malformation (Toledo y Antones, 1996). However, both appropriate times for pruning and the distance from malformed buds to be mowed vary among the different authors. The reason to use a pruning technique has not been provided by any of them; they do not take into account the systemic distribution of the causal agent, as suggested by Varma *et al*. (1971). In addition, pruning has an important effect on the physiology of the trees and on their growing patterns and yield; therefore equilibrium between sanitary requirements and minimal disturbance of growth has to be found.

This study was carried out in order to evaluate times of pruning, distances from malformed tissues and the combined effect of pruning with three systems of mango orchard management.

MATERIAL AND METHODS

Experimental orchard

The experiment was carried out in Iguala, Guerrero, Mexico (17° 57' latitude North, 99° 26' longitude West), during the periods 1999-2000 and 2000-2001 in a 14 years old commercial orchard of mango cv. Haden, distributed in a design of 10 x 10 m. The trees averaged 5 m height and 0.30 m of trunk diameter. A design of divided plots was used for the application of three different technologies of orchard management and five pruning treatments were applied at different times and distances from malformed buds. Such technologies included integrated management (IM, Table 1), high input management (HM, Table 2), and traditional technology (TT, Table 3). Orchard management technologies corresponded to big plots; as to IM and HM ten trees (replicates) were selected at random, whereas five trees were selected regarding to TT as replicates. The activities for controlling weeds, ants and fruit flies, irrigation, addition of organic matter, as well as harvesting, were the same for the three technologies. Such activities are concentrated in Tables 1 to 3.

In these three management systems all treatments of sanitary pruning were carried out in the following stages: (1) during vegetative growth period and blooming, pruning only symptoms (VB-S); (2) during vegetative growth period and blooming, pruning 30 cm far from the last malformed bud (VB-30S); (3) after harvesting, pruning at a 30 cm distance from the last malformed bud or inflorescence (AH-30S); (4) after harvesting, pruning at a 80 cm distance from the last malformed bud (AH-80S); (5) a branch with visible symptoms of mango malformation, control without pruning (NP). A treatment was added during the 2000-2001 period: pruning after harvesting at a 120 cm distance from the last malformed bud (AH-120S). The pruning treatments corresponded to small plots; the experimental unit was a branch; in consequence, all the treatments were applied once to each tree.

Data analysis of orchard management and types of pruning

The incidence of malformed buds was compared among the technologies of orchard management and types of pruning; cumulative proportions of malformed buds, taken during 13 sampling dates, were analyzed by ANOVA using a design of divided plots with the procedure PROC GLM and the Tukey test for multiple comparisons of means (SAS, 1998). An ANOVA for two sources of variation (technology for orchard management, or large plots, and types of pruning, or small plots, plus the interaction between such sources) was also carried out for the ratio of malformed buds. Data of December 1999, May and December 2000, and June 2001, were selected because the natural recess in growing allowed the buds enough time to express themselves as healthy or malformed (Otero-Colina *et al.,* 2000).

RESULTS

Evaluation of the disease

The progression curves of the proportion of malformed buds showed a lower incidence in IM and HM compared with TT although during the 2000-2001 period, disease incidence increased. Considering both production periods, the incidence of malformed buds recorded was below 50, 55, and 80 % for IM, MP and TT, respectively (Figure 1).

TABLE 1. Cultural activities of integrated management (IM). Mango cv. Haden, Guerrero, México. Periods 1999-2000 and 2000-2001.

Phenological Stage and Application Date	Activity	Common Name	Commercial Name	Dose and Application
Vegetative growth, June	Chemical fertilization	Nitrogen	Urea	120 N
		Phosphorous	Triple calcium superphosphate	30 P
		Potassium	Potassium sulfato	90 K
July, August, September	Application of cooper, wettable sulfur, and foliar fertilizer	Tribasic copper sulfide	Trimet ®, Dermet	1,852 g·ha^{-1} of a.i.
		Agricultural sulfur (elemental sulfur)	Velsul 725®, Velsimex	1,450 g·ha^{-1} of a.i.
		Foliar nutrients (S, MgO, Fe, Zn, Mn, Cu, B, Mo).	Fertiquel combi ®, Basf	2 kg·ha^{-1} three sprays spaced 15 to 20 days
August	Organic fertilization	Poultry waste	Chicken manure	3 kg·tree·year^{-1}
September	Weed control			Mechanic
Matority of buds October	Hydric stress			No irrigation
November	Hydric stress			No irrigation
November	Application of potassium	Potassium nitrate	Multi-K ®	4 % in a single application
Blooming	Irrigation			Every 25 day
December ,	Application of fungicide and foliar nutrients	Mancozeb	Manzate 200 ® Dupont	1,600 g·ha^{-1} of a.i.
January		Benomyl	Benlate ®, Dupont	250 g·ha^{-1} of a.i.
February (fruit set)	Foliar nutrients	Humic acids + microelements +Secondary elements + phytohormones +Vitamins + NPK 10-5-5	Humifer ®, Cosmocel	1 liter·ha^{-1}
		Foliar nutrient: N, P, K, Br, Cu, Fe, Mo, Zn,	Bayfolan forte ®, Bayer	1 liter·ha^{-1} three sprays spaced 15 to 20 days
Fructification March, April May (harvest)	Irrigation and application of insecticide	Malathion	Malathion 1000E **®,** Tridente	1000 g·ha^{-1} of a.i. every 20 days

TABLE 2. Cultural activities of high input management (HM). Mango cv. Haden, Guerrero, México. Periods 1999-2000 and 2000-2001.

Phenological Stage and Application Date	Activity	Common Name	Commercial Name	Dose and Application
Vegetative growthJune	Chemical fertilization	Nitrogen	Urea	90 N
		Phosphorous	Triple calcium superphosphate	30 P
		Potassium	Potassium sulfate	90 K
July, August	Application of copper, wettable sulfur and foliar fertilizer	Tribasic copper sulfide	Trimet ®, Dermet	1,852 g·ha^{-1} of a.i.
		Agricultural sulfur	Velsul 725 ®, Velsimex	2 liter·ha^{-1}
		Foliar nutrient	Bayfolan forte **®,** Bayer	1 liter·ha^{-1} two sprays spaced 15 to 20 days
Before blooming till setting November, December, January,	Application of potassium nitrate	Potassium nitrate	Multi-K	4 % a single application
February	Application of fungicides and foliar fertilizer	Mancozeb	Manzate 200 **®,** Dupont	1,600 g·ha^{-1} of a.i.
		Benomyl	Benlate **®,** Dupont	250 g·ha^{-1} of a.i.
		Chlorotalonyl	Daconil 2787 **®,** Zeneca	1,500 g·ha^{-1} of a.i.
		Foliar nutrient N, P, K, Br, Cu, Fe, Mo, Zn.	Bayfolan Forte**®,** Bayer	1 liter·ha^{-1} four applica tions every spaced 15 to 20 days

TABLE 3. Cultural activities of traditional technology (TT). Mango cv. Haden, Guerrero State, Mexico. Periods 1999-2000 and 2000-2001.

Phenological Stage and Application Date	Activity	Common name	Commercial Name	Dose and Application
Vegetative growth	Chemical fertilization	Nitrogen	Urea	90 N
June		Phosphorous	Triple calcium superphosphate	30 P
		Potassium	Potassium sulfate	90 K
Before blooming till setting November,	Application of fungicides and	Mancozeb	Manzate **®,** Dupont	1,600 g·ha^{-1}
December, January, February	foliar nutrients	Chlorotalonyl	Daconil **®,** Dupont	1,500 g·ha^{-1} of a.i.
		Foliar nutrient N, P, K, Br, Cu, Fe, Mo, ZN	Bayfolan forte ®, Bayer	1 liter·ha^{-1} two applications spaced 15 days

The first malformed buds appeared 11 weeks after harvesting in the vegetative growth period. This was defined as the initial disease (Y_i). An increasing ratio of malformed buds was observed in coincidence with the blooming period. This took place during the 21st week in 1999 and the 24th week in 2000, and was defined as intermediate disease (Y_m). The trend of increasing the ratio of malformed buds continued until the period of harvest, defined as final disease (Y_f).

Orchard management

According to the ANOVA of the cumulative ratio of malformed buds in 1999-2000, IM showed a significantly

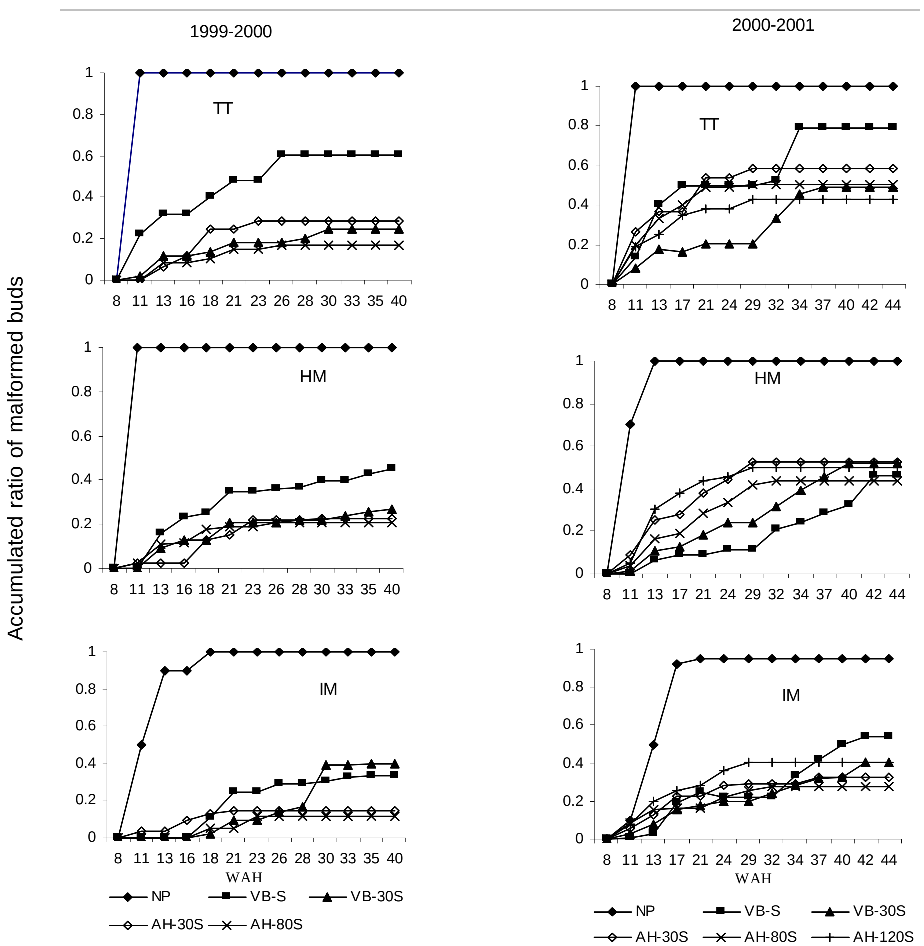

FIGURE 1. Curves of progression of the disease in different management and pruning types of mango cv. Haden during the periods 1999-2000 and 2000-2001. Orchard management technologies; TT: traditional technology; HM: high input management; IM: integrated management. Types of pruning; NP: symptomatic branches without pruning; VB-S: pruning vegetative and floral buds only symptoms; VB-30S: pruning vegetative and floral buds 30 cm far from the last malformed bud; AH-30S: pruning after harvesting 30 cm from the last malformed bud; AH-80S: pruning after harvesting 80 cm far from the last malformed bud; AH-120S: pruning after harvesting 120 cm far from the last malformed bud, WAH: weeks after harvesting.

lower incidence ($P\leq 0.05$) of initial malformed buds, compared with TT. In this same period, IM showed the lowest values of Y_m, Y_f, and area under the curve of disease progression (AUCDP); however, the differences were not significant (Table 4). In contrast, in the period 2000-2001, all Y_i, Y_m, Y_f and AUCDP were significantly lower in IM when compared with TT.

The ratio of malformed buds after pruning increased gradually; (Figure 2) it means that, after vegetative shooting, buds seem healthy, and then malformations will gradually appear. Reductions in the ratio of malformed buds can be due both to pruning and to the appearance of new shoots, apparently healthy, at least at the beginning. During blooming, similar reductions in the ratio of malformed buds were found; they were due to pruning, carried out in the 23rd and 29th weeks of the first and second periods, respectively.

The values of an ANOVA with two sources of variation (orchard management or big plot, and pruning type or small plot, plus the interaction between both sources) in four selected dates, showed that the results of the big plot had significant differences in June 2001 (Table 5), implying that only in this period the incidence of malformed buds was associated with IM. The Tukey's test (Table 6) corresponding to this period points out the difference between IM and TT.

Types of pruning

In the period 1999-2000, VB-S, VB-30S, AH-30S and AH-80S resulted in a lower incidence of malformed buds at the stages Y_i, Y_m and Y_f; they were significantly different from NP (Table 7). The ratio of malformed buds exhibited a significant difference between AH-80S and VB-S at the stage of Y_i. This trend continued up to Y_f, where AH-80S and AH-30S were significantly different from VB-S and NP. The values of AUCDP showed significant differences ($P\leq 0.05$) between AH-80S and VB-S and NP (Table 7).

In the period 2000-2002, at all the stages (Y_i, Y_m and Y_f), all pruning treatments showed a significantly lower incidence of malformed buds, when compared to the control. At Y_i, VB-30S had the lowest incidence of malformed buds and this treatment kept the same trend up to Y_f. However, at Y_m and Y_f VB-30S was not significantly different from VB-S, AH-30S, AH-80S or AH-120S. The comparison of AUCDP showed two groups, the NP and all types of pruning. In this last one, VB-30S exhibited a significantly lower incidence of malformed buds, compared to AH-120S (Table 7).

In the ANOVA of the ratio of malformed buds, with data from four selected dates (Table 5), a significant interaction between the sources of variation was never found. The types of pruning are considered to act independently of the orchard management technologies. Based on this

TABLE 4. Effect of orchard management on the cumulative ratio of malformed buds. Mango cv. Haden. Periods 1999-2000 and 2000-2001, Guerrero, México.

Orchard management	Y_i (± S)	Y_m(± S)	Y_f (± S)	AUCDP
		Period 1999-2000		
TTHMIMr²	0.32744 a[z]	0.41208 a	0.46212 a	12.362 a
	(±0.4138)	(±0.3820)	(±0.3738)	
	0.29880 ab	0.3794 a	0.42952 a	11.13 a
	(±0.4059)	(±0.4060)	(±0.3986)	
	0.19832 b	0.3071 a	0.39908 a	9.341 a
	(±0.3864)	(±0.3944)	(±0.4005)	
	0.8411	0.7727	0.6878	0.8088
		Period 2000-2001		
TTHMIMr²	0.5133 a	0.541 a	0.6338 a	18.255 a
	(±0.2886)	(±0.2792)	(±0.2454)	
	0.3936 ab	0.4667 ab	0.5644 ab	14.885 ab
	(±0.3418)	(±0.3080)	(±0.2517)	
	0.3422 b	0.3922 b	0.4825 b	12.287 b
	(±0.3338)	(±0.3226)	(±0.3438)	
	0.804291	0.8144	0.6528	0.8184

[z]Values followed by the same letter are not significantly different according to the Tukey's test with a $P\leq 0.05$.
TT: traditional technology; HM: high input management; IM: integrated management; AUCDP: area under the curve of disease progression (weekly ratio of malformed buds); Y_i , Y_m and Y_f: disease incidence; initial, intermediate and final, respectively; ±S: ± standard deviation.

TABLE 5. ANOVA two sources of variation, effect of orchard management and types of sanitary pruning on the ratio of malformed buds, mango cv. Haden, Iguala, Guerrero, México.

Date	Source of variation	Degrees of Freedom	Mean squares	*F*
December 1999	Management (BP)	2	0.09488282	1.13[NS]
	BP x Replicates	13	0.09006928	1.07[NS]
	Pruning types (SP)	4	2.80902592	33.35*
	BP x SP[z]	8	0.08465612	1.01[NS]
	Error	88	0.08423301	
May 2000	Management (BP)	2	0.01440735	0.20[NS]
	BP x Replicates	13	0.07354313	1.02[NS]
	Pruning types (SP)	4	2.72476512	37.64*
	BP x SP[z]	8	0.12252660	1.69[NS]
	Error	88	0.07238429	
December 2000	Management (BP)	2	0.05366154	0.87[NS]
	BP x Replicates	13	0.11405622	1.85[NS]
	Pruning types (SP)	5	1.21090728	19.62*
	BP x SP[z]	10	0.07523813	1.22[NS]
	ERROR	110	0.06172806	
June 2001	Management (BP)	2	0.41383255	7.13*
	BP x Replicates	13	0.07229093	1.25[NS]
	Pruning types (SP)	5	1.02811547	17.72*
	BP x SP[z]	10	0.07348095	1.27[NS]
	Error	110	0.05800757	

[z]Interaction between orchard management (large plot or BP) and type of pruning (small plot or SP).
[NS]; *; not significant and significant witn a $P\leq 0.05$.

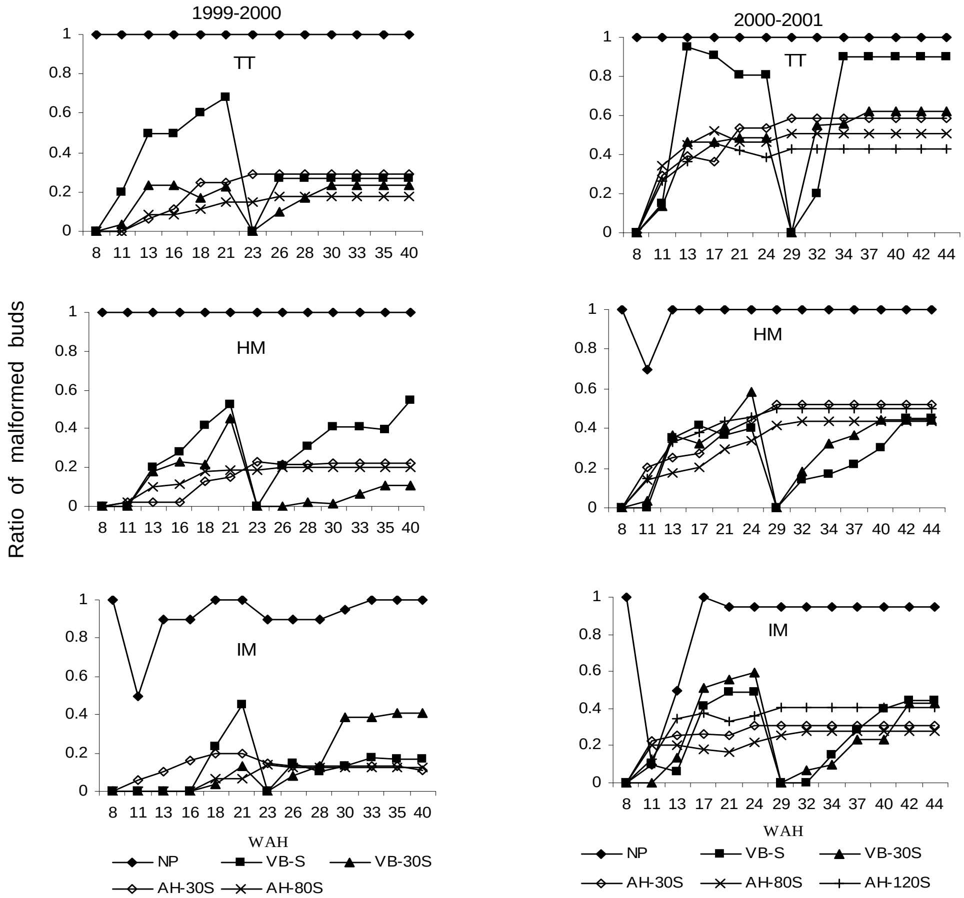

FIGURE 2. Ratio of malformed buds in different management packets and types of pruning of mango cv. Haden during the periods 1999-2000 and 2000-2001. Orchard management technologies; TT: traditional technology; HM: high input management; IM: integrated management. Types of pruning; NP: symptomatic branches without pruning; VB-S: pruning vegetative and floral buds only symptoms; VB-30S: pruning vegetative and floral buds 30 cm far from the last malformed bud; AH-30S: pruning after harvesting 30 cm from the last malformed bud; AH-80S: pruning after harvesting 80 cm far from the last malformed bud; AH-120S: pruning after harvesting 120 cm far from the last malformed bud; WAH: weeks after harvesting.

TABLE 6. Comparing mean ratios of malformed buds of mango cv. Haden. May and June 2001.

Orchard Management	May 2000 (± SD)	June 2001 (± SD)
TT	0.3925 a[z] (±0.3988)	0.6744 a (±0.2563)
HM	0.3952 a (±0.4198)	0.5590 ab (±0.2716)
IM	0.3614 a (±0.4212)	0.4681 b (±0.3775)

[z]Values followed by the same letter are not significantly different according to the Tukey's test with a $P \leq 0.05$.
S: standard deviation.

assumption, the types of pruning were compared in a single pool, regardless to their position in the big plots. In addition, it should be pointed out that a significant effect of pruning was present in all four dates.

All treatments showed a significant lower ratio compared to the control and there were not consistent differences among them (Table 8). However, AH-80S had the most stable and low values of incidence of malformed buds, compared to the control.

Relation between the cost of capital and the economic profit

Table 9 shows the estimated costs of each type of orchard management, and Table 10 presents the yields of such orchard managements. As expected because more products were applied, IM was, 31.7 % more expensive than TT. HM showed an intermediate position, about 19 % more than TT.

The difference in yield between IM and TT ranged from 35.8 to 49.0 %, or about 3000 and 1,500 kg per hectare, for 2,000 and 2,001, respectively. Such differences were not significantly different from TT but a consistent trend was found. As the differential costs between IM and TT amounted about 2,300 Mexican pesos, the differential costs of IM are largely compensated by the increased yield. A conservative estimate of 2 Mexican pesos per mango kilogram is sufficient to recover the investment.

TABLE 7. Effect of types of pruning on the cumulative ratio of malformed buds. Mango cv. Haden. Periods 1999-2000 and 2000–2001. Guerrero, México.

Types of Pruning	Y_i (± SD)	Y_m (± SD)	Y_f (± SD)	AUCDP
		Period 1999-2000		
NP	0.96 a^z (±0.2)	1 a (±0)	1 a (±0)	29.8 a
VB-S	0.1552 b (±0.3082)	0.3326 b (±0.3445)	0.4352 b (±0.3526)	9.35 b
VB-30	0.739 b (±0.1527)	0.1578 bc (±0.1772)	0.3169 bc (±0.3048)	5.546 bc
SAH-30	0.699 b (±0.1287)	0.1698 bc (±0.2579)	0.2058 c (±0.2556)	4.814 bc
SAH-80S	0.624 b (±0.1314)	0.1248 c (±0.1665)	0.1613 c (±0.1810)	3.8 c
r^2	0.8411	0.7727	0.6878	0.8088
		Period 2000-2001		
NP	0.97 a (±0.1)	0.98 a (±0.1)	0.99 a (±0.1)	32.08 a
VB-S	0.2237 bc (±0.2187)	0.2337 c (±0.2137)	0.5581 b (±0.2930)	9.77 bc
VB-30S	0.1878 c (±0.1635)	0.2228 c (±0.1751)	0.4507 bc (±0.2748)	8.84 c
AH-30S	0.3553 b (±0.2310)	0.4505 b (±0.1930)	0.4505 bc (±0.1930)	12.823 bc
AH-80S	0.2715 bc (±0.2326)	0.37 b (±0.2026)	0.3847 c (±0.2089)	10.591 bc
AH-120S	0.3638 b (±0.2092)	0.4493 b (±0.1879)	0.4493 bc (±0.1879)	13.07 b
r^2	0.8043	0.8144	0.6528	0.8184

^{z}Values in the same column, followed by the same letter, are not significantly different according to the Tukey's with a $P \leq 0.05$.
NP: non pruned symptomatic branch; VB-S: pruning of vegetative and floral shoots only malformed tissues; VB-30S: pruning of vegetative and floral shoots 30 cm far from the last MB; AH-30S, AH-80S and AH-120S: after harvesting pruning 30, 80 and 120 cm far from symptomatic tissues, respectively. AUCDP: area under the curve of disease progression (weekly ratio of MB); Y_i, Y_m and Y_f are the disease incidences, initial, intermediate and final in each cycle, respectively; S: standard deviation.

TABLE 8. Mean ratio of malformed buds after different kinds of pruning. Mango cv. Haden, Guerrero, Mexico.

Types of Pruning	December 99 mr (± SE)	May 2000 mr (± SE)	December 2000 mr (± SE)	June 2001 mr (± SE)
NP	1.0 a^z (±0)	1.0 a (±0)	0.98000 a (±0.1)	0.98000 a (±0.1)
VB-S	0.48794 b (±0.4377)	0.29677 b (±0.3870)	0.51700 bc (±0.4191)	0.53510 b (±0.3759)
VB-30S	0.27958 bc (±0.3168)	0.25190 b (±0.3556)	0.56756 b (±0.3660)	0.47471 b (±0.3632)
AH-30S	0.18895 c (±0.2995)	0.19029 b (±0.2517)	0.40814 bc (±0.2126)	0.45048 b (±0.1930)
AH-80S	0.13149c (±0.1844)	0.16670 b (±0.1822)	0.31413 c (±0.2205)	0.38468 b (±0.2089)
AH-120S			0.40364 bc (±0.1975)	0.44926 b (±0.1879)

^{z}Values in the same column, followed by the same letter, are not significantly different acording to the Tukey's test with a $P \leq 0.05$.
NP: non pruned symptomatic branch; VB-S: pruning of vegetative and floral shoots only malformed tissues; VB-30S: pruning of vegetative and floral shoots 30 cm far from the last MB; AH-30S, AH-80S and AH-120S: after harvesting pruning 30, 80 and 120 cm far from symptomatic tissues, respectively; Mr: mean ratio; SE: standard error.

TABLE 9. Concentrate of costs from three types of orchard managements. Estimates per hectare in Mexican pesos for 1999-2001.

	IM	HM	TT
Pruning	1005	804	804
Disease control	2387	1606	658
Fertilization	2457.68	2690.18	2241.8
Pest control	675	495	495
Irrigation	1605	1605	1605
Weed control	125	125	125
Harvest	1400	1400	1400
Total	9654.68	8725.18	7328.8
Differential costs over TT (%)	31.7	19	

IM: integrated management; HM: high input management; TT: traditional technology.

TABLE 10. Mango yields from three types of orchard management.

Period		IM	HM	TT
1999-2000	Yield/ha	8,254.78 a^z	6,720.99 a	5,505.24 a
	Increased yield over TT (%)	49.9	22.1	
2000-2001	Yield/ha	5,594.8 a	2,818.65 b	4,119 ab
	Increased yield over TT (%)	35.8	-31.6	

IM: integrated management. HM: high input management. TT: traditional technology.
^{z}Values in the same line, followed by the same letter, are not significantly different (Tukey, $P \leq 0.05$).

By contrast, HM exhibited an irregular trend. A higher yield but not significantly difference was observed at the period 1999-2000; surprisingly, at the period 2000-2001, this type of orchard management yielded 31.6 % less than TT. We cannot explain why HM showed such a variable yield, therefore more observations are needed.

DISCUSSION

The IM showed the lowest cumulative ratio of malformed buds, at the stages Y_i, Y_m, Y_f, as well as the lowest AUCDP in both production periods, compared to TT. However, significant differences appeared in the second period (2000-2001) (Table 4). These results coincide with the second ANOVA (Table 5) comparing the ratio of malformed buds in four selected dates; in this case IM ratio of malformed bud was not significantly lower than TT until June 2001. This fact suggests that a constant application of IM could result in a reduction of the ratio of malformed buds. In addition to the effect of IM on the incidence of malformed buds, this technology contributes to overcome the biological and technological limitations of mango production, resulting in increasing yields (Table 10 and Noriega *et al*., 1999).

NP showed a ratio of malformed buds always near 1, an expected fact because in this treatment all the selected branches were malformed. The slight decreases in the ratio of malformed buds have to be interpreted as the development of new shoots, which did not show malformations in their initial stages. However, it is remarkable that the treatment NP is a real situation, meaning total absence of pruning, because once a given branch is it will never recovers spontaneously.

VB-S and VB-30S, pruned twice a year, showed a ratio of malformed buds significantly lower than NP; however, their results were the poorest. After pruning important increases of malformed buds were recorded, leading in several cases to ratios higher than those of treatments with a single yearly pruning. When only malformed tissues are mowed (VB-S), it is supposed that a systemic propagation of the etiologic agent cannot be eliminated, leading to recurrences and consequently to a less efficacy. The higher costs of pruning twice a year and the risk of recurrence of malformations when only symptomatic tissues are removed, lead us not to advice the use of both types of pruning.

Even though all types of pruning showed favorable results, AH-30S and AH-80S had the lowest ratio of malformed buds and they were the most consistent ones; in addition, a single pruning means reduced costs. So, the types of pruning AH-30S and AH-80S: pruning once a year after harvesting, branches 30 or 80 cm far from the last malformed bud, are advised as cultural practices for controlling malformation of buds.

CONCLUSIONS

IM reduced the ratio of malformed buds in mango cv. Haden in the period 2000-2001.

Pruning malformed branches reduces the incidence of that disease.

Pruning after harvesting 80 or 30 cm far from the last malformed bud reduces the ratio of malformed buds and allows the emission of healthy buds.

As IM increased yield in 35.8 to 49.9 %, it is the advisable type of orchard management to be practiced.

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