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Mitigating mango malformation: A study on physical modifications and chemical treatments

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Mango malformation is a serious disease causing severe economic losses every year. The aim of the present study was to assess the current disease position and devise an integrated strategy to control this malady in commercial orchards. The assessment of malformation was done at forty locations in eight mango growing districts of Pakistan. Malformation showed 100% prevalence in the surveyed orchards. Jhang was the most affected district with 60.13% severity while Khanewal was least affected with 13.80% severity. All the common mango cultivars were found more or less disposed to the disease. Effect of clipping of malformed branches at 15, 30 and 45 cm distance, respectively behind the panicles alone or combined with benomyl 50 WP spray at 2.0 gm L⁻¹ water in the respective treatments was evaluated. The treatment with clipping at 45 cm distance followed by spray of benomyl showed the best results giving 70.37% decrease over previous years count. The results of the present studies will be helpful to minimize the losses inflicted by mango malformation disease globally.

Key words: *Mangifera indica*, malformation, *Fusarium mangiferae*, assessment, clipping.

INTRODUCTION

Mango (*Mangifera indica* L.) is a prominent commercial fruit of Indo-Pakistan. It is susceptible to various biotic and abiotic diseases (Shahbaz et al., 2009). Malformation has become a crux amongst biotic diseases of mango. It causes deformation of vegetative and floral tissues in mango (Chakrabarti, 2011). Yield may be reduced by as much as 90% (Ploetz et al., 2002). Different etiologies were put forward previously in the world literature due to lack of authentic information on the causal agent. Recently two new taxa viz. *Fusarium sterilihyphosum* (Britz) and *Fusarium mangiferae* (Britz) have been found associated with malformed tissues of diverse origins. *F.*

sterilihyphosum has been identified from South Africa only. *F. mangiferae* has now been confirmed to cause mango malformation in different countries of the world (Britz et al., 2002; Iqbal et al., 2008).

Many control measures such as clipping practices, spray of chemicals and growth regulators have been reported to reduce the damage inflicted by malformation. The fungus *F. mangiferae* has a specifically localized distribution within malformed mango trees. It is internally localized and does not spread systematically all over the plant. The isolation of fungus *F. mangiferae* at proximal and distant sites of panicles revealed maximum recovery of 85.71% at panicle-shoot juncture and only 4% at 40 cm distance behind the panicles in malformed branches (Saleem and Iqbal, 2005). This necessitates the need to concentrate the control strategies on clipping of

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Figure 1. Malformed heads hanging on mango tree.

symptomatic tissues.

Early removal of affected vegetative and floral terminals reduces intensity of malformation (Muhammad, 2000; Ploetz et al., 2002). An integration of physical alteration and chemical spray results in slower development of fungal inoculum and reduced levels of incidence and severity (Noriega-Cantu et al., 1999). Mango diseases are best managed by integrated strategies including disease prevention, pruning and use of chemicals (Barbosa-Martinez et al., 2002). But a comprehensive study to assess malformation in maximum no. of orchards from diverse locations and find out its control through different pruning distances combined with chemical spray is still lacking. The objectives of the study were to record the prevalence, incidence and severity percentage of malformation in mango growing areas and devise an integrated strategy to control this notorious problem. The results will be helpful to provide scientific disease estimation and manage the major floral disorder of mango worldwide.

MATERIALS AND METHODS

Disease assessment

Survey of mango malformation was done on complete emergence

of healthy and malformed panicles (Figure 1) during the flowering cycle of the year 2003 under Pakistan conditions (March-April: Temp., 21.1-28.93°C; Rainfall, 14.56-1.56 mm; humidity, 54.6-35.3%). Five locations were chosen in each of the eight surveyed districts and a total of 40 locations were assessed in mango growing areas of the Punjab Province of Pakistan. Six limbs having various small and large branches were selected on each assessed tree at random covering almost 10% of the orchard area (Sao-Jose et al., 2000). Diseased, healthy and total number of inflorescences were counted on each limb. Percent severity was recorded quantifying number of affected panicles. Disease index was calculated by multiplying incidence and severity values. On the basis of calculated Disease Index (DI), a disease rating scale (1-9) was used for grading of different cultivars: Grade 1 = Free from disease (Resistant); Grade 3 = 0.1-1.0% DI (Moderately resistant); Grade 5 = 1.0-10.0% DI (Tolerant); Grade 7 = 10.1-20% DI (Moderately susceptible); Grade 9 = >20% DI (Susceptible) (Kumar and Beniwal, 1992).

Effect of clipping and chemical spray

Ten years old trees of a susceptible cultivar Anwar rataul growing under similar conditions were selected at Mango Research Station, Multan, Pakistan during the year 2003. Eight treatments were replicated thrice and distributed randomly in randomized complete block design (RCBD). Uniform sized limbs were selected from all sides of each tree totaling to 9 such limbs per tree (Das et al., 1989). Pre treatment data on randomly selected limbs of each replicated tree were recorded by counting diseased, healthy and total number of panicles on each branch. Severity of malformation

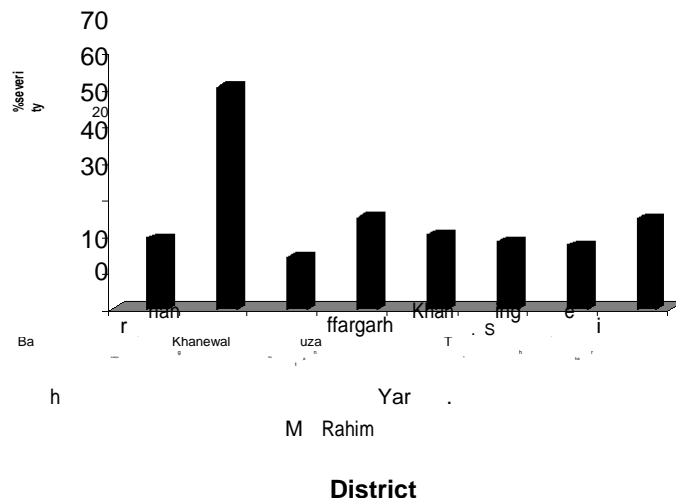


Figure 2. Severity percentage of mango malformation in different mango growing districts of the Punjab Province of Pakistan during the year 2003.

Table 1. Severity and susceptibility expression of nine mango cultivars assessed in eight mango growing districts of the Punjab, Pakistan.

Cultivar	Assessed inflorescences		% severity	Disease index	Rating	Expression
	Diseased	Total				
A. rataul	594	1875	31.68 b	31.68	9	Susceptible (S)
Chaunsa	3110	11665	26.66 c	26.66	9	Susceptible (S)
Dusehri	666	1900	35.05 a	33.10	9	Susceptible (S)
Seedling mango	263	705	37.30 a	37.30	9	Susceptible (S)
Sindhri	476	1300	36.61 a	36.61	9	Susceptible (S)
Fajri	95	474	20.04 d	15.03	7	Moderately susceptible (MS)
Langra	950	4388	21.64 d	19.23	7	Moderately susceptible (MS)
Malda	65	495	13.33 e	13.33	7	Moderately susceptible (MS)
S.S.-I	112	591	18.95 d	15.54	7	Moderately susceptible (MS)

Values sharing the same letters are not significantly different at $P < 0.05$ by LSD test.

on each tree was calculated. Clipping was done at 15, 30 and 45 cm distance, respectively from top (behind the panicles) to downward followed by spray of benomyl in the respective treatments in the month of July after harvest.

A fungicide spray programme was prepared as a routine plant protection practice. Two sprays of benomyl at 2.0 gmL^{-1} water were done in the month of January at 12 days interval before flowering in the treatments where benomyl was to be applied. Third spray was done in September to prevent infection on new vegetative growth. The schedule was followed every year till the termination of the experiment. All the standard cultural practices such as irrigation, fertilization, weed control and routine management were adopted for all the treatments. Final observations were recorded during third year (2005) to avoid erroneous data due to alternate bearing.

RESULTS AND DISCUSSION

Disease assessment

Maximum severity of 60.13% was recorded in Jhang

district followed by Multan with 24.50%. Least severity of 13.80% was noted in the orchards of Khanewal followed by Toba Tek Singh with 16.82% (Figure 2).

All the common mango cultivars were found more or less disposed to the malady. Seedling mango proved to be highly susceptible showing 37.30% severity while Sindhri, Dusehri, Anwar rataul, Chaunsa, Langra, Fajri, S-S-I and Malda exhibited 36.61, 35.05, 31.68, 26.66, 21.64, 20.04, 18.95 and 13.33% disease severity, respectively (Table 1). According to the assessment principle, disease index was taken as a product of disease incidence and severity. Seedling mango and four cultivars viz. Sindhri, Dusehri, Anwar rataul and, Chaunsa proved to be susceptible with 9 disease rating while other four i.e. Langra, Fajri, S.S.-I and Malda were designated as moderately susceptible with 7 rating.

A lot of surveys and assessment studies have been conducted in different countries of the world to record prevalence and severity of malformation. Transmission

Table 2. Effect of clipping at various distances behind the panicles and chemical spray on severity of mango malformation.

Treatment	% severity before treatment (2003)	% severity after treatment (2005)	% decrease over previous years count (2005 over 2003)
Clipping 15 cm	40.55	27.56	29.37 e
Clipping 30 cm	63.33	37.41	40.92 d
Clipping 45 cm	68.42	27.02	60.50 b
Clipping 15 cm + benomyl spray	75.58	50.90	32.65 e
Clipping 30 cm + benomyl spray	54.21	27.33	49.58 c
Clipping 45 cm + benomyl spray	70.85	20.99	70.37 a
benomyl spray	61.37	49.33	19.61 f
Control	87.75	86.84	1.03 g

Values sharing the same letters are not significantly differed at $P < 0.05$ by LSD test.

from plant to plant is slow and is suggested that most of the plants are infected at the nursery stage. The variable response of different cultivars at different locations may have been caused by different isolates or undefined pathotypes of fungus *F. mangiferae* (Ploetz, 1999).

Kumar and Chakrabarti (1997) found the faster spread of the disease in regular bearers than in alternate bearing cultivars. The rate of the disease spread within the plant assumed logarithmic growth after the establishment of secondary source of inoculum as necrotic malformed panicles of the last year. The direction of disease gradient curves co-related with the direction of rain drop drift in June-July (Kumar and Chakrabarti, 1997). The climatic factors and host metabolites affect the population of *F. moniliforme* resulting ultimately in seasonal variation of the disease incidence. Disease manifestation requires proper balance of mangiferin and the *Fusarium* population (Chakrabarti et al., 1997; Chakrabarti and Kumar, 1998).

Most of the Pakistani and Indian cultivars manifest typical symptoms of malformation. In our study, seedling mango and eight mono-embryonic cultivars were assessed and no one was found disease resistant. In India, out of 100 tested mono and polyembryonic varieties, only one variety Bhaduran was found disease free (Kumar and Beniwal, 1992).

Impact of a disease like malformation can not be simply evaluated from disease incidence. Floral malformation is most important because it directly affects the yield of the plants leaving unproductive inflorescences. Just a few numbers of trees in one or two orchards at the same location do not provide correct estimate. The results are confirmed by evaluation of a higher no. of trees and inflorescences in different growing areas. In the present study, a total of 23,393 inflorescences representing 40 distant locations were assessed and amongst these 6,331 were found malformed.

Some previous reports on cultivar resistance may be based on simple visual observations. Akhtar et al. (1999) identified land races and seedling germplasm for resistance / susceptibility to malformation. None of the

cultivars was found resistant. The results were consistent with the findings of Prakash and Raof (1987) who observed the incidence of malformation in 121 cultivars. All of them were rated as susceptible. Quantitative assessments prove beneficial to reach a better understanding of dissemination of the disease and its harmful effects. A good assessment method provides comparable results from one location to another and from one fruiting season to the next.

Effect of clipping and chemical spray

Maximum pretreatment severity of 87.75% was recorded in control followed by 75.58% in the treatment of clipping 15 cm + benomyl in the year 2003 (Table 2). Clipping was done on malformed branches to increase healthy growth flushes during the same year and reduce the disease severity and carry over effect during alternate flowering season.

Post treatment data were recorded during the 2005 flowering season. Maximum disease severity of 86.84% was observed in the control. Least severity (20.99%) was noted in the treatment, clipping 45 cm + benomyl spray. The same treatment without benomyl spray showed 27.02% severity. The results were statistically highly significant when compared for effects of treatments. The treatment where clipping was done at 45 cm distance with spray of benomyl proved to be the best giving 70.37% decrease over previous years count (Table 2). Data of every treatment with pre-treatment observation figure served as control to compare with final observations and calculate percent decrease over previous years count.

Clipping at 45, 30 and 15 cm exhibited 60.50, 40.92 and 29.37% disease decrease, respectively, over previous count. Simple clipping at 45 cm distance was still much effective. Spray of benomyl alone could not prove effective and showed less disease decrease (19.61%) over previous count after control. The present study shows the positive effect of an integrated strategy

to reduce the intensity of malformation.

Percent disease decrease in 45 cm clipping was 60.50% which was much higher than 30 cm clipping (40.92%) and statistically much significant than 15 cm clipping (29.37%). Effect was enhanced when clipping was combined with benomyl spray (69.59%). Association of the fungus with the malformed tissues necessitates their removal. Basipetal colonization of mango below the apical parts does not commonly occur. Removal at 45 cm distance eliminates most of the pathogen (Ploetz, 1994). When benomyl was sprayed alone, it appeared least effective after control (19.61%). This shows the persistency of fungus in malformed shoots. Fungicide kills landing conidia and avoids chances of reinfection in pruned branches.

Muhammad et al. (1999) got good control of malformation with spray of Benlate or Topsin-M (0.2%) in July. Pandey and Chakrabarti (2004) studied the effects of carbendazim (Bavistin) on *F. moniliforme* var. *subglutinans* on disease development. The infection rate in treated plants was decreased. The effect of bavistin was less in the first year but it showed better control in the 2nd year of the treatment. Some earlier workers (Chattopadhyay and Nandi, 1977c; Gafar et al., 1979) claimed good control with spray of copper oxychloride but Das et al. (1989) did not observe any positive control with the use of the same chemical.

Mango malformation attains severe position only if effective control measures are not taken in the beginning. The disease has been reduced to insignificant levels by integrated management (IM) consisting of pruning and fungicide sprays (Manicom, 1989; Noriega-Cantu et al., 1999).

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