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Research Article

Impact of fertilizer combinations on malformation physiology of mango panicles (*Mangifera indica*. L) cv. Dusheri

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Abstract

Mango malformation is destructive malady in mango producing countries and causing significant economic loss. The present/This study was undertaken to evaluate the effect of different combinations of N, P and K on incidence of malformation physiology of mango (*Mangifera Indica*. L) Cv. Dusheri. Each treatment of N (1000 g), P (750 g) and K (750 g) was soil applied during February and August to investigate time of flush emergence, malformation frequency and morphological parameters. Results revealed that the minimum number of malformed panicles and higher number of healthy panicles was observed in NPK treated plant. In addition, NPK treated plant exhibited higher length of healthy panicles. Moreover, NPK treatment showed lowest malformation intensity percentage as compared to other fertilizer treatments. The results regarding regrowth pattern of shoots after pruning showed that overall maximum percentage of such terminals remained pruned (93.59%) while some of its produced vegetative flushes (2.19%). However, alone or combine fertilizer application cannot control this malady. The present study, therefore, suggests proper and regular implementation of pruning practice to control this malady.

Keywords: Malformation; Mango; N, P and K fertilizer; Soil application

Introduction

Mango (*Mangifera indica*. L) is considered as king of fruits and praised due to its unique taste and aroma among the peoples. Its export demand has been significantly increased in international market -. However, mango industry is facing a serious disorder "mango malformation" in the orchards which is decreasing the production, quality of fruit and productive life in different countries.

Several studies have reported about the etiology of mango malformation which may be associated with different biotic and abiotic factors, viruses, fungus, nutritional imbalances and mites (Rymbai and Rajesh, 2011).
Two types of malformation are recorded such as vegetative and floral malformation. Vegetative malformation is less observed, while bearing mango plants shows more floral malformation [1]. Malformed inflorescences are short, fail to produce fruits which ultimately reduced the yield which is great economic loss. Depending upon the severity of disease, crop production may limit by 50-60% and in some sever cases 100% in the orchards [2, 3]. However, malformed parts showed the presence of the fungus (*fusarium moniliforme* var. Subglutinans), and mycelial growth was noted during different bud development stages under electron microscopy [4]. Fungicide were used but remain failed to control this malady [5]. Malformed shoots removal reported to be effective method to control this widespread disease in the commercial orchards [6].
Although, mango is grown throughout the world, while high production is limited in few countries [7]. Mango is successfully cultivated on a large area in Pakistan. After citrus, it is second largest commercial fruit of the country and is cultivated over an area of 156.6 thousand hectares, contributing about 15.77% of the total fruit area (1753.9 thousand hectares) of the country Anon [8]. It is exported in different countries and earn foreign exchange. Climatic conditions are favorable for proper mango cultivation, production and good quality. However, mango malformation is an emerging threat to mango industry which is causing great economic loss to farmers.
Numerous researchers have reported that malformation is endemic and common disease in major mango growing countries throughout the world [9-13]. Malformation is widespread disease and was first time reported 120 years back from Darbhanga district Bihar by Maries [14] and never recovers in infected tree [15]. Yield losses cannot be accurately measured due to no linear relationship with the severity of disease [16]. However, branches with malformed inflorescences remain unproductive, thus reducing the yield [17]. It has been reported that 86% decrease in yield occurred during three years. Malformation affected the 50% trees and caused sever yield losses in northern India mango orchards, as well as significant effects has been reported in Egypt [18]. Moreover, 73% mango farms have reported malformation severity from 1 to 70% in South Africa [19]. Despite of consistent research on this issue, no effective control of this disease has been found [20-22]. Young mango cv. Totapuri showed higher fruit yield and TSS with nitrogen application, while P and K showed non-significant results [23]. Fertilizer application of 400 N, 125 P, 440 K, 40 Mg, and 80 S (g/tree/year) significantly improved yield and quality of mango in Guangdong, China [24]. Higher number of fruits/plant, yield, pulp content and fruit quality improved with the application of N, P, and K in West Bengal, India [25]. Higher fruit weight and yield were recorded with the application of urea at 500 or 1000 g N/tree and potassium sulfate at 400 g K2O/tree [26]. Higher dose of K fertilizer along with other manures were applied in three splits doses, and improved the leaf and fruit characteristics, total acidity, Vit. C, TSS and total sugar content on mango cv. Mabrouka, Egypt [27-28].
There are several factors such temperature, age of tree, time, nutrional status and susceptibility of cultivars that may affect the incidence of malformation. Some studies reported that deficiency of micronutrient and

macronutrient may or may not be associated with the extent of malformation. Nutrient insufficiency in mango orchards may or may not be regarded as basic reason of this malady [29]. It has been observed that malformed panicles had higher level of nitrogen than healthy panicles [30]. However, NPK application (9:3:3) did not reduce the incidence of malformation and such nutritional imbalance that is not directly related, nevertheless, may enhance the occurrence of this disease [31]. Higher N application reduces the malformation, whereas P and K addition significantly increases malformation [15]. Therefore, proper amount and type of fertilizer at proper time play a vital role in increasing average yield per hectare. However, there is lack of proper information on effect of nutrition in malformation. In this study, different fertilizer combinations were applied during different months to investigate their effect on incidence of malformation. Therefore, the present studies were conducted to investigate the morphological characteristic of healthy and malformed panicles and malformation intensity of mango cv. Dushari.

Materials and methods

The present study regarding the malformation physiology of mango (*Mangifera indica*. L) cv. Dusheri. panicles regulated by N, P and K fertilizers, applied singly and in combination, was carried out during February and August months N, P and K were applied @ 1000g, 750g and 750g, respectively. N was applied in the form of Urea, P through Triple Super Phosphate (TSP) while K was supplied in the form of (SOP) Sulphate of Potash (Table 1). Fertilizers were applied in February and August. Amount of fertilizer for each treatment was calculated according to the said quantity of each element. Experimental material used in fieldwork consisted of 16, twelve- to fifteen-years-old, healthy trees of mango cv. Dusheri. The research work reported in this manuscript was conducted at fruit Experimental Orchard Sq. No. 9, Institute of Horticultural Sciences, University of Agriculture, Faisalabad during 2009-2010. All the treated mango trees received similar cultural practices. Time of flushes were noted when the first flush emerges on the mango tree and till the last one. Malformation frequency was noted regarding the healthy and malformed number of panicles by the method [32]. A frame of size (2m × 1m) was used on the four sides such as East, West, North, South on the middle height of the canopy of a tree. Total number of healthy and malformed panicles were counted and averaged. Morphological dimensions of healthy and malformed panicles (length and width) were measured with measuring tap (Stanley powerlock 25). Malformation intensity was recorded as described by Khan and Khan (1966). Healthy and malformed inflorescence were calculated for the determination of malformation intensity.

I= M ×100/T

M= Malformed inflorescence

T= Total inflorescence in the sampler

I= Intensity, percentage of the diseased inflorescence

The data were collected and subjected to statistical techniques by using Statistix 8 (version 8.1) software for analysis of variance techniques by using Least Significant Difference (LSD) test at a level of 5% significance ($p \leq 0.05$).

Results and discussion

Effect on time of flush emergence

Time of flush emergence during different months was observed. From the observations, it was found non-significant effect of fertilizer application on the early or delayed emergence of flushes (Table 2). In the same way, observations did not confirm the findings of Marloth [33] that adequate supply of nitrogen induced early flush of vegetative growth, which encouraged flowering in litchi.

Effect on time of emergence of malformed panicle and malformation frequency

Time of emergence of malformed panicles were usually started in mid-December and continue till the first week of February in treated and control plant (Table 3). Malformed panicles were observed maximum in T1 plant, while minimum was observed in T8. In addition, T8 treated plant exhibited higher number of healthy panicles, while lower number of healthy panicles was found in T7 (Table 4). It has been reported that foliar application of low biuret urea increased leaf N level, as well as the intensity of malformation **[34]**.

Effect on length of healthy panicle (cm)

The result revealed that average length of healthy panicle was affected by the different combinations of fertilizers. Maximum length of healthy panicle was observed highly significant in T8 treated plant (Table 5). With the interaction of fertilizer T6 was found higher length of healthy panicle as compared to T5 and PK. Among single application of fertilizer, T2 had higher length which was closely followed by the T3, T4 and control.

Effect on width of healthy panicle (cm)

The data showed that application of different fertilizers showed significant results regarding the width of healthy panicles. However, higher width of panicle was found in T8 (Table 5). When fertilizer applied singly, lower width was recorded in T3. When studied the interaction of different fertilizers, T6 showed higher width followed by T5 and T7, respectively. Minimum width of healthy panicle was recorded in the control.

Effect on length of malformed panicle (cm)

Length of malformed panicle were also measured after application of different fertilizer combinations. It was found that maximum lengths of malformed panicle were found in T1, whereas T3, T2 and T4 treatments also had closely similar results. However, minimum length was recorded in T8 treated plant (Table 5).

Effect on width of malformed panicle (cm)

The results regarding the width of malformed panicle was found higher T1, while lower width was recorded in T8 (Table 5). However, some trees showed slight differences in width of malformed panicle in some treatments.

Effect on malformation intensity (%)

Mango malformation is serious malady and destructive disease which causing significant economic loss in in mango producing countries **[35]**. It is ubiquitous present and destructive due to its etiology and still farmers are not fully successful to control and understand this disease. Alone, proper fertilizer application cannot control the malformation diseased because it is complex disorder.

There were remarkably significant differences with the application of different fertilizers combination on the control of malformation intensity. The highest malformation intensity was found in the control. Whereas, T8 treatment showed lowest malformation intensity percentage. The results of malformation intensity were found similar to the treatments T7, T4 and T5, respectively (Table 5). These result are in similar with Prasad **[36]** who found that nutrition plays an important role in reducing the incidence of malformation. Application of N, P and K in the ratio of 9:3:3 reduced the incidence of the floral malformation. It has been observed that in mango increased nitrogen level through spray on otherwise reduced the proportion of affected panicles **[37]**.

Fertilizer with different combination N, NK or NP treatments reduces the incidence of malformation of the inflorescence in the cultivar Bombay Alphonso **[38]**. It has been depicted that in cv. Langra, incidence of floral malformation was the lowest (20%) when treat with rogar, multiplex and urea (insecticide, trace elements and N fertilizer respectively) and the highest (55%) in non-treated trees [39]. During fruit development at pea stage, malformed shoots removed and found 60-79% reduction of malady in the next year. It has been noted that control of disease was variable in different varieties [40].

Effect on regrowth pattern of malformed panicle

Regarding regrowth of pruned malformed panicles during next year, overall maximum percentage of such terminals remained pruned (93%) while some of its produced vegetative flushes (2%). Reproductive growth from pruned malformed sites was 3% in which malformed panicles were 1% and healthy panicles were 1%. The significant results were obtained and it was assumed that there was no relationship between the treatments but as minimum number of malformed panicles emerged in the T3, T7 and T6 treatments. Maximum number of malformed panicles emerged in the T5. While more percentage of healthy panicles was found in the T5 followed by T8 and T4 treatments. Minimum number of healthy panicle was found in the T7. More number of vegetative shoots emerged from P followed by T5 and minimum number of vegetative shoots emerged in the T2 and T7. While percentage of ceased branches were almost same i.e. in the T8 and T2 application (Table 6)

Similar findings were recorded by [37] who founds that increase nitrogen level through spray reduced the percentage of malformed panicles in mango. In this experiment level of nitrogen was suitable to control malformation as observed earlier in studies by [38] reported that the incidence of malformation was found to decrease in plants under N, NK or NP treatments, but increased in plants receiving either PK or P alone, which clearly indicated that nitrogen level in leaves is inversely proportional to malformation percentage. These results are not in conformity with the findings of [41] who found significantly higher nitrogen in malformed panicles. Our results are in line with the findings of [42] who reported that foliar spray of N at monthly intervals during winter significantly reduced malformation.

Table 1. Fertilizer treatments for mango Cv. Dusehri

Treatments	Macro Element	Time of application	Amount of fertilizer(s)
T1	Control		
T2	N	February	1000g Urea
		August	1000g Urea
T3	P	February	1500g TSP
T4	K	February	1500g SOP
T5	NP	February	1000g Urea + 750g TSP
		August	1000g Urea + 750g TSP
T6	NK	February	1000g Urea + 750g SOP
		August	1000g Urea + 750g SOP
T7	PK	August	1500g TSP+ 1500g SOP
T8	NPK	February	1000g Urea + 750g TSP + 750g SOP
		August	1000g Urea + 750g TSP + 750g SOP

Table 2. Effect of fertilizer combinations on time of flushes emergence

Treatments	April	May	June	July	August
T1 (control)	3 to 19*	20-28	19-28	18-29	19-30
T2 (N)	21-29	21-29	14-23	16-25	18-27
T3 (P)	1-18	16-27	19-26	13-22	21-30
T4 (K)	3-25	18-26	14-25	14-21	16-27
T5 (NP)	2-19	19-27	18-28	11-20	22-28
T6 (NK)	2-20	21-29	17-26	17-25	16-29
T7 (PK)	3-21	24-30	13-23	16-27	21-29
T8 (NPK)	4-31	13-27	13-29	14-28	13-26

* Unit days

Table 3. Effect of fertilizer combinations on time of emergence of malformed panicles

Treatments	2011	2012
T1 (control)	17 Dec to 12 Jan	05 Jan to 21 Jan
T2 (N)	03 Jan to 21 Jan	29 Jan to 10 Fab
T3 (P)	09 Jan to 18 Jan	23 Jan to 06 Fab
T4 (K)	29 Dec to 13 Jan	27 Dec to 15 Jan
T5 (NP)	02 Jan to 11 Jan	19 Dec to 11 Jan
T6 (NK)	19 Jan to 23 Jan	07 Jan to 27Jan
T7 (PK)	30 Dec to 14 Jan	19 Dec to 16 Jan
T8 (NPK)	09 Jan to 19 Jan	21 Dec to 05 Jan

Table 4. Effect of fertilizer combinations on malformation frequency

Treatment	Healthy panicles	Malformed panicles
T1 (control)	24e	15a
T2 (N)	26d	7b
T3 (P)	25d	6c
T4 (K)	29c	5d
T5 (NP)	31b	5d
T6 (NK)	28c	7b
T7 (PK)	30b	8b
T8(NPK)	36a	5d

Table 5. Effect of different combination of N, P and K on Malformation physiology of mango Cv. Dusehri

Treatments	Length of Healthy Panicle (cm)	Width of Healthy Panicle (cm)	Length of Malformed Panicle (cm)	Width of Malformed Panicle (cm)	Malformation Intensity (%)
T1 (control)	13.28e ± 1.74	10.17f ±1.99	14.28a ± 2.33	9.24a ± 1.80	85.35a ± 2.06
T2(N)	17.23cd ± 1.88	13.36cde ± 2.29	13.51a ± 2.09	6.48ab ± 1.90	69.37b ± 1.87
T3(P)	15.37de ± 1.95	12.47ef ± 2.23	13.58a ± 2.22	7.54ab ± 1.90	57.36d ± 2.38
T4(K)	16.38cde ± 1.86	13.47cde ± 1.95	13.10a ± 2.62	7.55ab ± 1.80	61.47c ± 1.70
T5(NP)	19.23bc ± 1.80	16.40bc ± 2.07	11.67ab ±1.95	7.62ab ± 2.09	61.41c ± 2.27
T6(NK)	22.15b ± 1.90	17.38ab ± 1.92	11.42ab ± 3.01	5.69b ± 2.10	55.28d ± 2.01
T7(PK)	18.20cd ± 1.96	14.72bcd ± 1.85	10.63ab ± 2.12	6.85ab ± 1.90	64.27c ± 1.87
T8(NPK)	29.40a ± 1.89	20.55a ± 1.97	8.951b ± 2.360	5.52b ± 2.01	49.30e ± 2.08

Table 6. Regrowth pattern of pruned malformed panicles (%)

Treatments	Reproductive Pattern		Vegetative Pattern	Ceased Growth
	Malformed	Healthy		
T1 (control)	2.75c	1.25c	2.25d	93.75ab
T2(N)	3.25b	0.74e	0.55f	96.75a
T3(P)	0.278g	1.25c	5.44a	93.56b
T4(K)	2.25d	4.67b	1.54e	92.08ab
T5(NP)	3.37a	5.54a	4.33b	86.76ab
T6(NK)	1.22e	1.21d	2.56c	95.5ab
T7(PK)	0.75f	0.56f	2.54c	97.25ab
T8(NPK)	2.25d	4.67b	0.55f	93.08a

Conclusion
Mango malformation is enigmatic disease due to nature of disorder and symptoms, their cause and control is not clearly understood for proper control of this malady. Combine fertilizer application effect on the growth physiology of healthy panicles. According to our observation, fertilizer in combination showed the higher morphological attributed in healthy panicles as well as lower malformation intensity in mango (*mangifera indica*. L) cv. Dusheri than single fertilizer application.

Authors' contributions
Conceived and designed the experiments: M Azam, R Qadri & MI Khan, Performed the experiments: M Azam & R Qadri, Analysed the data: MI Khan, CM Ayub, N Akhter. Contributed materials/analysis/ tools: M Azam, M Khan, R Qadri & NH Khan, Wrote the paper: M Azam, NH Khan, & MI Khan.

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