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Effect of Different Forms of Argel (*Solennostemma argel* Del Hayne) Applications on Flowering, Fruit set and Fruit retention in Vegetatively Malformed 'Tommy Atkins' Mango Cultivar

Tagelsir Ibrahim Mohamed Idris[1]*, Hamdan Salih Elnour[1], Elfatih M. Mahdi[2]

[1]Department of Horticulture, Sudan University of Science and Technology
[2]Department of Horticulture, University of Khartoum
*Corresponding Author: Tagelsir Ibrahim Mohamed Idris, Department of Horticulture, Sudan University of Science and Technology, e-mail: tagelsiribrahim@sustech.edu
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Abstract:
Vegetatively malformed mangos are prone to floral malformation. In this study foliar and soil treatments with argel leaves and stems were tested as part of integrated malformation management to elucidate their impact on flowering, fruit set and fruit retention in malformed 'Tommy Atkins' mango cultivar. Soil application of ground argel stems and the foliar application of argel leaf water extract enhanced the percentage of flowering branches significantly. Soil dressing with ground argel stems improved the characteristics of the inflorescence. All argel treatments improved fruit set compared to the control, but the best fruit retention was gained from the foliar application of the leaves water extract.
Key words: Argel, mango, malformation, flowering, fruit set, fruit retention

Introduction:
The mango (*Mangifera indica* L.), a native of India and South East Asia was introduced to Sudan in the early years of the last century. Currently it leads Sudan horticultural exports. Most of the trees are seedlings raised from the local cultivar 'Kitchener' in spite of the availability of around 35cultivars of the Indian and Philippine groups known in the world market. The situation reflects poor awareness about the importance of growing competent cultivars. Recently new introductions of the Florida group mangoes were made by imports from South Africa. Unfortunately, they exhibited severe symptoms of vegetative malformation even at the nursery stage. Vegetative or floral malformations were rarely recognized in Sudan.

The mango malformation is a malady of pathological and physiological disorders that cause mortality or tardy growth in the vegetative phase, or heavy yield losses in adult trees. The malady is one of the most serious and destructive diseases of mango in nature (Prakash and Srivastava, 1987; Kumar and Beniwal, 1992; Ploetz, 2001) because of economic losses faced every year (Kumar *et al.*, 1993; Srivastava, 1998). Malformation had been reported in several countries (Iqbal *et al*., 2004; Youssef *et al*., 2007). The severity of the disease varies according to variety, environmental conditions and cultural practices (Shawky *et al*., 1980; Kumar and Chakrabarti, 1997). Different races of the fungus *Fusarium* had

been reported as causal agents of mango malformation (Iqbal *et al*., 2003; Freeman *et al*., 2004; Haggag *et al*., 2010). Haggag *et al*., (2010) also reported that *Fusarium* isolates inoculated on seedling mango root systems became systemic, and spread in above-ground plant tissues including apical and lateral buds. Both floral and vegetative malformations were reported to be reproducible by simply spraying spore suspension of *Fusarium spp*. (Chakrabarty and Ghosal, 1989; Ploetz and Gregory, 1993).

Management of mango malformation was tried with varying degrees of success. Early removal of affected vegetative and floral terminals reduces intensity of malformation (Ploetz, 2004). Mango malformation is best managed by integrated strategies including disease prevention, pruning and use of chemicals (Barbosa-Martinez *et al.,* 2002). In line with this, Yadav (1972) reported good control by clipping infected shoots at 45 cm distance followed by spraying with fungicides.

Extracts of some plants had been shown to have anti-fungal properties (Kumar *et al*., 2007; Kumar *et al*., 2009). Botanical pesticides are more safe and cheap than synthetic ones. Sudan is rich in native and domesticated flora, but the potential of most plants as alternatives of pesticides did not receive adequate attention.

Hence, the objective of these experiments was to study the effects of argel (*Solennostemma argel* Del., Haynne) applications on flowering and fruit-set in vegetatively malformed 'Tommy Atkins' mango cultivar as part of integrated management of malformation under the conditions of Shambat, Khartoum State, Sudan.

Materials and Methods:

This study was conducted at the mango orchard of the College of Agricultural Studies, Shambat, Khartoum North, Sudan, during November 2010 - March 2011. Five years old malformed trees of 'Tommy-Atkins' mango cultivar were used in this study.

The trees were recent imports from South Africa, exhibiting signs of vegetative malformation expressed as tip necrosis, twig-die back; rosette leaves and overall weak growth of canopy.

Prior to applications, all trees received the following treatments:

1. Pruning of branches and twigs with signs of malformation 5 cm or more below tips to ensure white clean tissue, free of fungal infections.
2. Immediately after pruning, the trees were sprayed with Stroby (acaricide-fungicide) to run-off, to prevent new incidents of fungal infections. Stroby was applied in concentration of 50 mg/l.
3. Each tree received a fertilizer dose composed of 100 g urea (46% nitrogen) and 100 g calcium super phosphate.

In this study, the randomized complete block design was used. The application of argel leaves and stems either in spray forms to the run-off or direct addition to the soil was accomplished on Nov., 7, 2010 in the following arrangement:

1- control
2- Direct application of 50g dry argel leaves to the soil, 50 cm away from tree trunk base (Ar LS).
3- Direct application of 50g ground argel stems to the soil, 50 cm away from tree trunk base (Ar SS).
4- Spray with cold water extract of argel leaves: 16g of dry uncrushed argel leaves were soaked in a liter of tap water for one hour and then filtered with sash cloth for immediate application. A 10 liter manual

sprayer was used for the purpose (Ar LF).

5- Spray with cold water extract of argel stems: 16g of ground argel stems were soaked in a liter of tap water for one hour and then filtered with sach cloth for immediate application. A 10 liter manual sprayer was used for the purpose (Ar SF).

Seven blocks were employed, and in each block one tree was considered a replicate of each treatment. Data were collected on Dec., 17, 2010, for number of flowering branches/tree; number of non-flowering branches/tree; number of secondary spikes within inflorescence; number of tertiary spikes within inflorescence; length of inflorescence (cm); length of secondary spikes within inflorescence (cm); distance between successive secondary spikes (cm); number of flowers/ tertiary spikes. On January 7, 2011, data were collected for number of fruits set per inflorescence. Data for number of fruits retained per inflorescence were recorded twice on February, 21 (first reading) and March, 7, 2011 (second reading).

Data were subjected to analysis of variance for the randomized complete block design, and means were separated by Duncan's multiple range test at 95% confidence limit using MStatC computer program.

Results

The soil application of ground argel stems and the foliar application of argel leaf extract shared top rank and increased the percentage of flowering branches significantly over the control. Applications of argel leaves to the soil and the foliar spray of ground argel stems extract ranked intermediate causing slight insignificant increment in flowering branches compared to the other treatments (Table 1).

Table 1: Effect of argel applications on percentage of flowering branches in 'Tommy Atkins' mango cultivar 40 days after application

Treatment	% of flowering branches
Control	55.86b
Ar SS	71.71a
Ar LS	64.71ab
Ar SF	64.75ab
Ar LF	66.86a
CV%	11.86a

Means followed by the same letter(s) within the same column are not significantly different at P=0.05.

As shown in Table 2, the length of the main spike was not affected by argel applications. Soil applications of argel either as leave or ground stems ranked top for the number of secondary spikes, with significant increase over the foliar application of both forms. The control was in between (Table 2).

The number of tertiary spikes was significantly increased over the control, by the treatment of ground stems application to the soil. The other argel applications induced insignificant increase compared to the control (Table 2).

Table 2 also illustrates the influence of argel application on the length of secondary spikes. Application of ground stems to the

soil resulted in significant increase over all other treatments that shared the second position. The space between secondary spikes was not affected by any treatment (Table 2). The number of flowers in tertiary spikes was affected by the treatments. Figure 1 illustrates the effect and shows the significant increment in number of flowers per tertiary spike upon soil application of either argel ground stems or leaves.

Table 2: Effect of argel applications on characteristic of inflorescence in 'Tommy Atkins' mango cultivar 40 days after application

Treatment	Length of main spkie (cm)	No of scondary spikes	No of tertiary Spikes	Length of secondary Spike (cm)	Distance Between secondary spikes (cm)
Control	22.24a	30.60abc	12.60b	8.10b	3.48a
Ar SS	24.96a	33.80ab	16.60a	12.38a	3.88a
Ar LS	22.68a	35.40a	14.00ab	9.40b	3.60a
Ar SF	21.42a	27.80c	14.20ab	7.36b	3.90a
Ar LF	22.30a	29.20bc	13.60ab	8.80b	3.18a
CV%	11.22	12.43	17.92	17.23	16.10

Means followed by the same letter(s) within the same column are not significantly different at P=0.05.

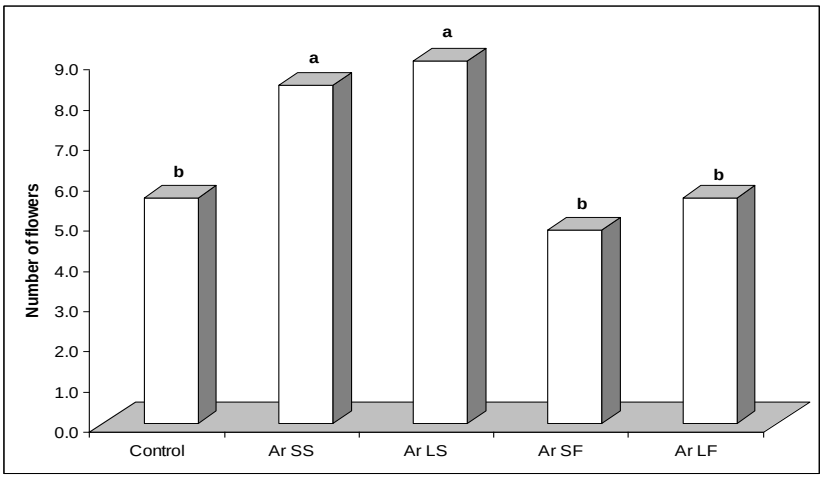

Figure 1: Effect of argel on the number of flowers per tertiary spike in 'Tommy Atkins' mango cultivar 40 days after application

All argel applications increased fruit set significantly over the control as shown in Table 3. As for fruit retention per panicle, all argel treatments significantly sustained higher numbers of fruits in the first reading compared to the control (Figure 2). Reduction in fruit numbers due to natural fruit drop was evident in all treatments. The best retention resulted from the foliar treatment of water leaf extract of argel. However, this treatment did not differ significantly from the foliar application of stem extract or leaf soil application treatments.

Table 3: Effect of argel applications on fruit set in 'Tommy Atkins' mango cultivar 60 days after application

Treatment	Fruit set
Control	34.86b
Ar SS	60.14a
Ar LS	67.29a
Ar SF	66.43a
Ar LF	66.00a

Means followed by the same letter(s) within the same column are not significantly different at P=0.05.

Fruit drop continued as shown in second reading, and maximum fruit retention resulted also from the foliar treatment of argel leaf extract (Figure 2).

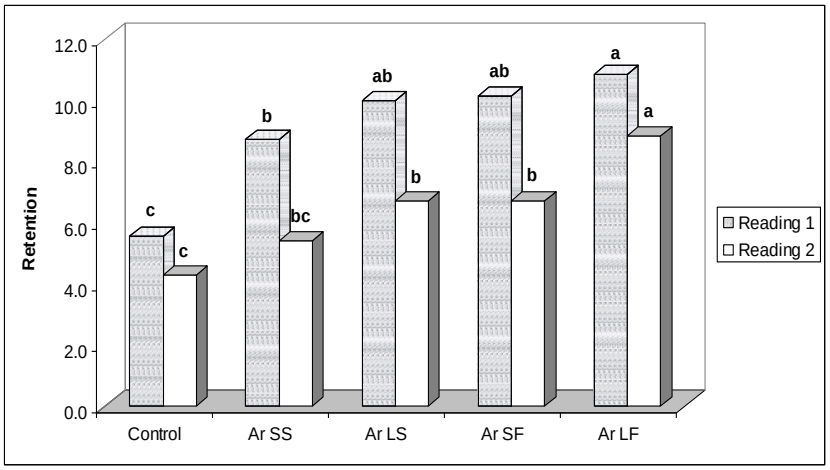

Figure 2: Effect of argel applications on fruit retention in 'Tommy Atkins' mango cultivar 14 and 16 months after application

Discussion

In this study, after treatments, the trees did not show symptoms of vegetative or floral malformation. This may be attributed to the effectiveness of the comprehensive treatment composed of pruning, soil fertilization and foliar application of Stroby (fungicide/Acaricide). However, in 'Tommy Atkins' mango cultivar where the different forms and parts of argel plant were tested, beneficial responses were obtained. The increase in the number of flowering branches was achieved with soil application with ground argel stems or the foliar treatment of the canopy with the water extract of leaves. The latter retained higher number of fruits per panicle. The yield per tree is a function of both the number of flowering branches and the number of retained fruits per panicle. Therefore, the foliar application of the leaf water extract was the most enhancive treatment for the overall productivity of the tree. The result is in line with that of Idris *et al.*, (2011) who reported enhanced flowering and yield in date palms upon soil dressing with dry argel leaves and owed that effect to a pesticide or

growth regulator-like effect from the chemical constituents of argel. Likewise, argel applications were reported effective in the control of the green scale insect on date palm, and the scale mortality was also coupled with yield increment (Eldoash *et al.*, 2011; Taha *et al.,* 2012). In this report, the influence on yield was attributed to both the pesticide and hormonal effects of argel. Nevertheless, this is the first report on the agricultural use of argel stems as the preceding studies were concentrated on argel leaves. In conclusion, the potential of agricultural use of argel leaves and stems for enhanced mango flowering and fruiting had been elucidated in this study and can be tested for other fruit trees. In addition, as the stems are discarded after leaves harvest for herbal medicine use, this study highlights a potential use of stems in agronomy. In as much as, further studies are needed to elucidate the biochemical constituents responsible for argel interactions with plant growth and development.

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أثر المعاملات بالصور المختلفة لنبات الحرجل على ازهار وعقد ومنع تساقط ثمار صنف المانجو " تومى أتكنز" المصاب بالتشوه الخضرى

تاج السر ابراهيم محمد ادريس[1]، حمدان صالح النور[1]، الفاتح محمد مهدى[2]

1. قسم البساتين، جامعة السودان للعلوم والتكنولوجيا
2. قسم البساتين، جامعة الخرطوم

المستخلص:

أشجار المانجو المصابة بتشوة وقصور النمو الخضرى تكون عرضة للتشوه والقصور الزهرى. فى هذه الدراسة أختبرت معاملات رش واضافة للتربة من أوراق وسيقان نبات الحرجل كجزء من معالجة متكاملة لتوضيح تأثيراتها على الازهار وعقد الثمار ومنع تساقطها فى أشجار صنف المانجو "تومى أتكنز" المصابة بتشوه وقصور النمو الخضرى. الاضافة الأرضية لمسحوق السيقان ومعاملة الرش بالمستخلص المائى للأوراق أحدثتا زيادة معنوية فى عدد الفروع المزهرة. المعاملة الأرضية بمسحوق سيقان الحرجل أدت لتحسين خواص الشمراخ الزهرى. كل معاملات الحرجل أدت لتحسين عقد الثمار مقارنة بمعاملة الشاهد، نتج أفضل حفظ للثمار (منع تساقط) من معاملة الرش بالمستخلص المائى لأوراق الحرجل.