THE EFFECT OF CULTIVAR AND ORGANIC ENRICHED FERTILISERS ON PLUM (*Prunus salicina*) GROWTH AND DEVELOPMENT UNDER HIGH DENSITY MANAGEMENT SYSTEM

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Abstract

High density orchard management systems and ideal nutrition positively influence productivity in deciduous fruits. The main objective was to evaluate the effect of cultivar and organic fertilisers on plum *(Prunus salicina*) growth and development under high density management system of 2222 plants per hectare. The experiment was set as a 4*4 factorial in a Randomised Complete Block Design with 4 replications. Cultivars, Rosearli, Sapphire, Santarosa and Souvenir were evaluated in combination with three organic enriched fertilisers; Comp J organic, Comp C organic tobacco fertiliser, 100 % organic soil builder from Nico orgo Pvt Ltd and inorganic Compound J. Data was collected yearly on tree girth (mm), flowering dates at 50% and 100%, number fruits/cluster, mean fruit weight (mm), fruit length (cm) and fruit diameter (mm). Flowering was generally influenced by cultivar. Sapphire came into flower earlier and lastly Rosearli. Girth extension, fruit width and fruit weight differed significantly ($P<0.001$) with variety. Organic enriched fertilisers can be used in plum production.

Key words: *Prunus salicina*, organic fertiliser, pruning, flower, fruit,

1.0 INTRODUCTION

The horticultural world market is going organic in most horticultural produce and farmers who resist change will eventually find themselves out of business. The Horticultural Research Institute aspires to remain relevant to the Industry and has started to build experiences in organic fruit production, so that they could advise farmers accordingly.

Plums are principally grown in the Eastern highlands and the northern regions of Zimbabwe in commercial orchards and around home gardens. Plums are stone fruits belong in the same family with nectarines, apricots, peaches and almonds. In the region, Zimbabwean plums have an advantage of coming into season earlier between September and November as compared to South Africa which are ready in December. Locally, the fruits are marketed for fresh consumption as a well as processed.

Research has found a number of factors limiting plum production globally. In a Asia (Milošević, Milošević, and Glišić 2013) pointed out that the main limiting factor for intensive plum production is acidic soils with deficiency of organic matter and inadequate major nutrients availability. Nutrient deficiencies result in limited vegetative growth, low productivity and poor fruit quality of plum trees (Milošević and Milošević 2011). Pollination, adequate irrigation and drainage were also cited (Ingels 2000) (Meland 2005) to have an influence on growth and development of deciduous fruits. (Smith 2003) reported that supplying the right and adequate nutrients to the fruits is critical to achieve consistent production and high quality fruits.

Organic fertilisers are an important consideration for both health and environmental benefits.

Plums need substantial cold to end their dormancy. Mild winter delays spring growth and delayed flowering. Studies by (Arroyo et al. 2013) relates the point that the different phenological stages of fruit trees and their seasonal timing vary with local climatic conditions which fluctuate from year to year.

A number of plum varieties were evaluated at HRI since 1986, and most of the varieties were performed well under high density management under Marondera and Nyanga conditions. It is from this background that HRI proposed to conduct further evaluations under low input and organic fruit production management.

1.1.Objectives

The main objective was to evaluate the effect of cultivar and organic enriched compound fertilisers on plum *(Prunus salicina*) growth and development under high density management system in Marondera starting in 2012

2.0 METHODS

2.1. Study site

The trial was carried out at Horticulture Research Centre (HRC) (18°11'S and 31°28'E), which is in agro-ecological region IIa and has an altitude of 1630m above sea level. The experiment was established during the 2012-2013 season. Plum planting material was raised from mother stock plants at HRC. Soil mineral analyses was carried out in winter of 2012. Soil pH was 5.3 on the calcium chloride scale (medium acid soils). The soil type was medium grained sandy loam (MgSL).

2.2. Experimental design

The trial was set as a 4*4 factorial in a Randomised Complete Block Design. The fertilisers and plum cultivars formed 16 treatment combinations which were replicated four times in the form of blocks. The gross plot was made up of 64 trees. Cultivars were planted out as the main plot at four levels and fertilisers were the sub plot at four levels. The trees were spaced at 3*1.5m (2222 plants/hectare) at a planting depth of 60*60*60 cm.

Table 1: Four different plum cultivars and four different compound fertiliser types

Factor 1 Cultivar	**Factor 2 Fertiliser type**
Rosearli (1)	1. Compound J (15:5:20)
Sapphire (2)	2. Compound J organic enriched (15:5:20) *from Nico orgo Pvt*
Santarosa (3)	3. Compound C organic enriched tobacco fert (5:15:12) *from Nico orgo Pvt*
Souvenir (4)	4.100% organic soil builder(2:2:2) *from Nico orgo Pvt*

2.3. Treatment combinations for four plum cultivars and four compound fertilisers

1a Rosearli * 1000g Compound J (15:5:20) -1kg/ tree
1b Rosearli * Compound J organic enriched (1kg/tree)
1c Rosearli * Compound C organic enriched tobacco fert (5:15:12) - 3kg/tree

1d Rosearli * 100% organic soil builder (2:2:2)- 7.5kg/tree

2a Sapphire * 1000g Compound J (15:5:20) - 1kg/tree
2b Sapphire * Compound J organic enriched (1kg/tree)
2c Sapphire * Compound C organic enriched tobacco fert (5:15:12) - 3kg/tree
2d Sapphire * 100% organic soil builder (2:2:2) - 7.5kg/tree

3a Santarosa * 1000g Compound J (15:5:20) - 1kg/ tree
3b Santarosa * Compound J organic enriched (1kg/tree)
3c Santarosa * Compound C organic enriched tobacco fert (5:15:12) - 3kg/tree
3d Santarosa * 100% organic soil builder (2:2:2) - 7.5kg/tree

4a Souvenir * 1000g Compound J (15:5:20)- 1kg/tree
4b Souvenir * Compound J organic enriched (1kg/tree)
4c Souvenir * Compound C organic enriched tobacco fert (5:15:12) - 3kg/tree
4d Souvenir * 100% organic soil builder (2:2:2) - 7.5kg/tree

2.3. Management and data collection

Pruning was done to remove dead and diseased wood and as part of training. The trees were pruned uniformly during the first winter after planting for the formation of framework and scaffold branch selection. The training system was made into an open centre. General management including irrigation, weeding, spraying was done as and when needed. Fertilisation with the four compound fertilisers was done yearly as a split application in spring and at post-harvest. The fertiliser was placed beyond the canopy edge of the tree and worked in with hoes. Weeds in the line of trees was removed 0.5m on each side of the trees. Sprinkler irrigation was used during the whole planting season. In some years we experienced scale infestations which was controlled with Orchex and Dimethoate. No hand thinning or chemical thinning was conducted in the experiment. The plum varieties were evaluated on basis of plant development, yield levels and fruit quality.

2.4 Data collection and analysis

Data were measured on the extension growth (mm) by measuring girth (girth is the distance around the trunk which is perpendicular to the axis of the trunk) after every year using veneer callipers. The same area at initial measure was used which is about 1.3m above the ground. Observations on flowering dates at 50% and 100% were made. The number of fruits per cluster, mean fruit weight of ten fruits, mean fruit diameter (mm) and mean fruit length (mm) were also recorded. Data was analysed using Genstat 14th edition (VSN International 2012).

3.0 RESULTS

Noticeable differences were noted in increase in girth and flowering pattern within the cultivars and fertiliser treatments. All the cultivars showed vigorous growth in canopy development. It was observed that the pattern of flowering was almost the same with cultivar Sapphire flowering first, second Santarosa, third Souvenir and forth Rosearli. The current results showed that flowering in 2015/2016 was earlier than during 2014/2016 season.

The plums flowered heavily during the 2015/2016 season (Figure 1) but experienced fruit

abortion due to very high summer temperatures and insufficient watering (Figure 2).

Cultivar showed some significant differences ($P<0.05$) on the girth extension over the six years on record (Table 2 and Table 3) with Sapphire having the least girth of 20.53 mm. An incremental girth extension trend was noticeable over the years. There were no significant differences ($P>0.05$) on girth as affected by fertilizer type.

The type of cultivar significantly influenced ($P<0.001$) the number of fruits per cluster with Sapphire having the least (two fruits/cluster). During the 2015/2016 the plants were affected by bacterial canker causing them to exude water/gum on some parts on the stem resulting in gradual wilting of the plants until they die. The cultivar Santarosa was very susceptible resulting in the highest number of trees affected. During the third and fourth year the plums succumbed to Zinc deficiency resulting in small pointed leaves, leaf chlorosis and rosette leaves on tip ends (Figure 2). Boron deficiency symptoms were also noticed during the same period. The interaction effect between type compound fertilizer and cultivar was non- significant for all the measured parameters. The compound fertilizers did not influence the known fruit characteristics such as fruit size and colour. Relatively low fruit counts were recorded for all the cultivars. Cultivar differed significantly for mean fruit weight (g), fruit length (cm) and diameter (cm) as shown in (Table 4). Sapphire had the highest mean fruit weight (64.0 g) and Rosearli the least (37.7 g)

Table 2: The effect of type of compound fertiliser on girth extension (mm), number of fruits per cluster and time of flowering for plums *(Prunus salinica*)

Fertiliser type	**Girth @ 1 year (mm)**	**Girth @ 6 years (mm)**	**Fruits/ cluster**	**50% flowering 2014/15**	**100% flowering 2014/15**	**50% flowering 2015/16**	**100% flowering 2015/16**
Compound J (15:5:20)	12.81	76.3	4.42	05/09/15	09/09/16	25/08/16	29/08/16
Compound J organic enriched (15:5:20)	12.5	78.9	4.00	05/09/15	09/09/15	25/08/16	31/08/16
Compound C organic enriched tobacco fert (5:15:12)	13.13	85.1	3.73	08/09/15	11/09/15	25/08/16	29/08/16
100% organic soil builder (2:2:2)	11.77	73.6	3.57	05/09/15	09/09/15	25/08/16	31/08/16
p- value	**0.519**	**0.115**	**0.589**	**-**	**-**	**-**	**-**
Interaction	**0.94**	**0.573**	**0.905**	**-**	**-**	**-**	**-**
LSD	**1.918**	**9.64**	**2.315**	**-**	**-**	**-**	**-**

† Means followed by the same letter are not significantly different according to the Least Significance Difference value; - General observations made on 50% and 100% flowering dates

Table 3: The effect of cultivar on girth extension (mm), number of fruits per cluster and time of flowering for plums *(Prunus salinica*)

Cultivar	Girth @ 1 year (mm)	Girth @ 6 years (mm)	Fruits/ cluster	50% flowering 2014/15	100% flowering 2014/15	50% flowering 2015/16	100% flowering 2015/16
Rosearli	13.36	76.5[a]	4.9[a]	05/09/15	09/09/15	01/09/16	07/09/16
Sapphire	13.36	82.2[a]	2.0[b]	05/09/15	09/09/15	17/08/16	22/08/16
Santa Rosa	11.06	68.6[b]	4.7[a]	05/09/15	10/09/15	27/08/16	02/09/16
Souvenir	12.35	85.9[a]	4.0[a]	07/09/15	10/09/15	22/08/16	26/08/16
p- value	**0.062**	**0.05**	**<0.001**	**-**	**-**	**-**	**-**
Interaction	**0.94**	**0.573**	**0.905**	-	-	-	-
LSD	**1.92**	**9.65**	**1.38**	-	-	-	-

† Means followed by the same letter are not significantly different according to the Least Significance Difference value; - General observations made on 50% and 100% flowering dates.

Figure 1: Plum cultivar Santarosa in full bloom during the month of September 2016

Figure 2: Plum cultivar Souvenir with yellowing fruits in the process of abortion

Figure 3: Plum tree showing Zinc deficiency symptoms (leaves are small and pointed occurring in rosettes)

Table 4: The mean fruit weight (g), diameter (mm) and length (cm) of plums as influenced by cultivars

Cultivar	Fruit weight (g)	Fruit diameter (mm)	Fruit length (mm)
Rosearli	45.3[c]	4.26[b]	5.83[c]
Sapphire	64.0[a]	5.26[a]	6.17[a]
Santa Rosa	37.7[d]	5.34[a]	6.27[a]
Souvenir	58.9[b]	5.09[a]	6.15[b]
p-value	<0.001	<0.001	0.005
lsd	1.827	0.2565	0.1796
sed	0.747	0.1048	0.734
% cv	1.8	2.6	1.5

† Means followed by the same letter are not significantly different according to the Least Significance Difference value

4.0 DISCUSSION

There were no apparent significant differences on effects of the organic enriched fertilisers and the control compound fertiliser on the vegetative growth of the different plum cultivars. However, the observed differences in flowering dates of the different varieties could be directly linked to their breeding and genetic background. The varieties maintained their earliness to flowering despite variations in agronomy, management and weather variations. The differences in the earliness to flower can be explained by the variation of the prevailing temperatures (Appendix 1). Vigorous growth and fast canopy development of the cultivars is commendable because it allows for maximum light interception.

The hot summers experienced during some seasons e.g. 2015/16 had a bearing on flower abortion and fruit development because then the country had power shortages resulting in massive load shedding. Due to farm fragmentation and limited farming activities around the farming area our plum trial was highly susceptible to monkey and bird damages affecting total yields not reported here and fruit quality. This rendered most of the fruits unmarketable.

Although the main idea of the experiment was to produce quality plums with as little fertiliser as possible some micronutrient components could not be ignored completely as symptoms showed with time. Boron supplement was recommended as it is an essential trace element required for abundant yield and high quality fruits (Li-Yuehua 2003). Related reports show that Zinc deficiency triggers leaf defoliation resulting in poor bud formation and reduced yields (Dar 2014). Bacterial canker was managed through a number of methods; severely affected trees were removed, dying branches were pruned and removed from orchard, irrigation frequency was increased and weed management improved.

The significant differences observed for fruit characteristics weight, diameter and length influences the potential fruit yield of the different cultivars. Appropriate and well timed fertilisers are key for the expression of yield characteristics in plums as argued by (Dar 2014).

The results of the present study shows that compound fertilisers whether inorganic or organic enriched works best with other micronutrient supplements supporting work by (Thakur and Thakur 2014) who argued the importance of integrated nutrient management on growth and yield of plum cultivar Santa Rosa.

5.0 CONCLUSIONS

Organic enriched compound fertilisers can be used successfully in plum production but with other fertiliser supplements for essential microelements such as zinc and boron to improve on fruit growth, development, flowering and fruiting. Soil and foliar analysis is recommended to apply appropriate management techniques.

ACKNOWLEDGEMENT

We are thankful for the support that we got from all the staff at Horticulture Research Institute who added value to this work. Sincere appreciation to the deciduous fruit trees section team.

DECLARATION

No part of this work has been published elsewhere.

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APPENDICES

Appendix 1: Mean monthly minimum and maximum temperatures (°C) recorded at Marondera Meteorological Station from 2015 to 2018.