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Effect of bioslurry effluent on growth, biological yield and nutritional content of Swiss chard (*Beta vulgaris* L.)

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Swiss chard is amongst the widely cultivated green leafy vegetables that play a significant role in alleviation of food insecurity and malnutrition in South Africa. Greenhouse experiments were conducted to evaluate the effect of Bioslurry effluent on growth, biological yield and nutrient content of Swiss chard. Two cultivars of Swiss chard (Fordhook giant and Star 1801) were planted in 10 plots of 4.5 m² using sand incorporated with different rates of Bioslurry (Bio), namely, control (no fertiliser incorporation), 50% Bio, 100% Bio, 200% Bio and the recommended rate of 2:3:4 (30) NPK fertilizer as a growing medium. One seedling was planted per hill at an intra and inter row spacing of 0.25 m x 0.5 m. At 20-day intervals, five randomly selected plants were sampled to measure growth and yield parameters until 60 days after transplanting. The results showed that fertiliser treatment and cultivar significantly (p<0.05) influenced growth and yield parameters of Swiss chard. Fordhook giant showed significantly (p<0.05) higher growth and yields in all sampling intervals in summer compared to Star 1801. Inconsistencies were observed on leaf nutrient elements; however, NPK showed relatively higher nutrient elements for macro-elements.

Key words: Bioslurry, cultivar, Fordhook giant, NPK fertiliser, Star 1801.

INTRODUCTION

Amongst other vegetable crops, green leafy vegetables play a significant role in the provision of adequate amounts of vitamins, minerals and plant proteins required in human diet worldwide (Debebe et al., 2016; Haile et al., 2018). Swiss chard (*Beta vulgaris* L.) is a leafy biennial vegetable, belonging to the *Chenopodiaceae* plant family, along with beetroot. Swiss chard is consumed in many parts of the world including South Africa for its high nutritious properties and low production cost (Gao et al., 2009). According to Musazura (2014) and Gamba et al. (2020), Swiss chard leaves contains the highest fiber, sodium, magnesium, and vitamin C contents, whilst the stems are high in potassium content. Bulgari et al. (2017) described Swiss chard as concentrated with health-promoting phytonutrients such as carotenoids and flavonoids, the powerful antioxidants that are required to reduce malnutrition deficiencies to human. Furthermore, flavonoids in Swiss chard possess

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is widely grown and plays a significant role in supplementing the nutritional needs of rural communities where its leaves and stalks are often cooked and served as side dish with staple foods (Skenjana and Kubheka, 2013). However, Swiss chard can cause digestive and absorptive complications when consumed raw due to high concentration of oxalic acid (Leskovar and Piccinni, 2005). According to Zheng et al. (2019), intake of oxalate in high concentrations constitutes a health risk for infants and cause metabolicay problems to adults. However, cooking the leaves prior to consumption reduces the oxalic acid concentrations (Ndololwana, 2015). Moreover, Baldermann et al. (2016) suggested that women with calcium or vitamin D deficiency (osteoporosis) should not only rely on Swiss chard as a significant source of calcium.

Mbave et al. (2018) stated that Swiss chard grows well under cool climatic conditions with an optimum growth temperature of 16 to 24°C; however, it adapts to hot and long day conditions (Niederwieser, 2001). Crop production output of small-scale farmers in the Eastern Cape Province is usually low and one of the contributing factors is lack of fertilizer due to low nutrient status of the Eastern Cape soils (Silwana, 2000; Mhlontlo et al., 2009). Mkile (2001) reported that Eastern Cape soils have the problem of nutrient decline (NPK deficiency) and P is the most limiting nutrient, resulting in negative nutrient balance. Mkile (2001) further reported that most of the small-scale farmers in Eastern Cape rarely spend money or cannot afford the high prices of chemical fertilizers to replenish the nutrients lost from the soil through crop removal. However, improved soil fertility and increased food production was achieved through the application of bioslurry on cultivated loamy soils (Zuma, 2015). Mofokeng et al. (2020) also reported that bioslurry could be used as organic amendment to sandy soils, due to its positive effects on health and fertility. Although chemical fertilizers have readily available and large quantities of plant nutrients compared to organic fertilizers, the fact that organic fertilizers have growth-promoting agents makes them important for the enhancement of soil fertility and productivity (Sanwal et al., 2007; Adeleye et al., 2010). Moreover, organic fertilizers offer sufficient nutrients to sustain crop yields and soil fertility when applied at recommended rates (Silwana, 2000; Seadi et al., 2008). According to Islam (2006), bioslurry is a by-product from biogas production and a good quality organic fertilizer. Warnars (2014) reported that, bio-slurry is made through anaerobic fermentation process whereby about 25 to 30% of organic matter is transformed into biogas, while the rest is converted into bioslurry. Bioslurry is an environmentally friendly fertilizer, which promotes the use of livestock waste for sustainable crop production (Zuma, 2015). This residual manure is normally rich in macro and micro nutrients (Islam, 2006). Hence, the use of bioslurry can greatly reduce the utilization of chemical fertilizers to benefit the farmers in lowering the production costs (Muhmood et al., 2014). This study was conducted to evaluate the effect of bioslurry effluent on growth, development and the nutrient content of two local Swiss chard cultivars.

MATERIALS AND METHODS

Study location

A greenhouse experiment was conducted in the summer of 2017 and repeated in the winter of 2018 at Döhne Agricultural Development Institute (DADI), (32°31’34.077” S; 27°27’37.473” E) in Stutterheim, Eastern Cape Province of South Africa.

Plant material (Cultivar selection)

Two cultivars of Swiss chard (*B. vulgaris.* L.) namely: Ford-hook giant and Star 1801 commonly grown in the farming communities of the Eastern Cape were used. The certified seeds of these cultivars were sourced from the commercial seed companies. The two cultivars differ morphologically to each other; the Fordhook giant is characterized by green leaves and a white stalk while Star 1801 has dark green thick succulent leaves and a yellow stalk.

Treatments

The treatments were applied using organic (Bioslurry) and inorganic (NPK) fertilizers. Nasir et al. (2015) defined bioslurry as a by-product after biogas (Methane) extraction from a cow-dung, which comes in a liquid form. Bioslurry was collected from a biogas digester in Nyara Village, Komga (32°44’53’’S; 28°08’47’’E). The bioslurry was a 100% cow-dung product. After collection, it was analysed to evaluate its mineral composition prior to application (Table 1). Its application on the experiment was based on soil chemical results and plant requirements. The different bioslurry treatment application volumes were as follows: Control (C) no fertilizer application, 10 L Bioslurry (50% Bio), 20 L Bioslurry (100% Bio) and 40 L Bioslurry (200% Bio). The inorganic fertilizer was NPK 2:3:4 (30) and its application was based on soil chemical results and plant requirements for optimal plant growth and yields.

Experimental design

The experiment was a split plot laid out in a Randomised Complete Block Design (RCBD) replicated three times with the cultivar allocated to the main plot while subplots were fertilizer treatments.

Experimental procedure

A 300-m^2 greenhouse was cleaned and disinfected with spore-kill (Didecyldimethylamonium chloride). The surface of the greenhouse was then covered with a black landscape fabric in order to avoid contact between the soil surface and the established plots. The river sand obtained from the Barnard Camp River Valley at DADI was sieved through a 2-mm wire-mesh screen to ensure removal of stones and plant residues prior to establishment of plots. Ten plots measuring 4.5 m^2 were established within the greenhouse and were replicated three (3) times. A space of 1 m was allocated between the plots and 2 m between replicates. The river sand was analysed to determine its nutrient composition at DADI Analytical Laboratory

Table 1. Chemical composition of bioslurry for summer and winter season.

Property	Season	
	Summer	Winter
Total N (%)	3.8	0.8
Phosphorus (%)	0.35	0.3
Potassium (%)	0.29	0.36
Calcium (%)	5.63	0.88
Magnesium (mg kg^{-1})	0.67	0.24
Sodium (Na) (mg kg^{-1})	331	124
Manganese (Mn) (mg kg^{-1})	294	319
Copper (Cu) (mg kg^{-1})	42	22
Iron (Fe) (mg kg^{-1})	1302	980
Zinc (Zn) (mg kg^{-1})	139	76
pH (KCl)	6.9	5.9
EC (S m^{-1})	4	3.71

Table 2. Chemical composition of selected nutrient elements of river sand prior to treatment application.

Property	Composition
Phosphorus (mg L^{-1})	5
Potassium (mg L^{-1})	3
Calcium (mg L^{-1})	154
Magnesium (mg L^{-1})	1148
pH (KCl)	4.55

Table 3. Chemical composition of river sand incorporated with bioslurry and chemical fertilizer for summer and winter season.

Season	Treatment	Properties				
		pH (KCl)	P	K	Ca	Mg
			(mg L^{-1})		Exchangeable Cations [cmol(+) kg^{-1}]	
Summer	50% Bio	4.51	4	51	1074	148
	100% Bio	5.09	8	74	1283	167
	200% Bio	5.55	178	443	1115	103
	NPK	5.81	9	81	754	147
Winter	50% Bio	4.36	10	46	754	174
	100% Bio	4.49	9	40	672	121
	200% Bio	4.38	12	68	762	115
	NPK	3.39	105	278	521	68

before the application of fertilizer treatment (Table 2). Fertilizer treatments, namely: Control, 50, 100, and 200% of Bioslurry effluent and the recommended rate of inorganic fertilizer NPK 2:3:4 (30) were incorporated into river sand a day prior to transplanting of seedlings and the nutrient composition of soil after treatment incorporation was determined in both summer and winter season (Table 3). At planting, one seedling per hill of the two cultivars was transplanted separately into plots with respective fertilizer treatment, using a planting of 0.25 m between plants and 0.5 m between rows. Each plot measured 4.5 m², which resulted into 28 plants per plot and this is equivalent to 28,000 plants ha^{-1}. Transplants were irrigated as per the Swiss chard requirement until the harvest after 60 days from transplanting. Agronomic practices such as weeding and pesticide application were carried out

Table 4. Effect of the interaction between fertiliser and the cultivar on plant height (PH), number of leaves (NL) and leaf area (LA) of Swiss chard grown in summer and winter season.

Season	Effect		1st Sampling			2nd Sampling			3rd Sampling		
	Cultivar	Treatment	PH (cm)	NL	LA (cm^2)	PH (cm)	NL	LA (cm^2)	PH (cm)	NL	LA (cm^2)
Summer	Fordhook giant	Control	11.59^{a}	5.23^{b}	14.03	21.38	9.63	34.00^{a}	40.34^{de}	13.8^{c}	369.73^{d}
	Fordhook giant	50% Bio	12.02^{a}	5.53^{a}	17.34	23.97	11.06	35.63^{a}	38.5^{e}	15.36^{c}	379.00^{d}
	Fordhook giant	100% Bio	11.83^{a}	6.03^{a}	19.54	25.52	11.33	35.83^{a}	41.02^{de}	19.33^{b}	427.56^{cd}
	Fordhook giant	200% Bio	11.54^{a}	5.86^{c}	21.78	27.65	12.06	31.16^{abc}	51.97^{a}	20.7^{b}	584.53^{ab}
	Fordhook giant	NPK	9.18^{c}	4.03^{e}	21.67	26.71	11.83	23.73^{de}	48.83^{ab}	27.66^{a}	593.30^{a}
	Star 1801	Control	8.90^{c}	$4.73b^{cd}$	12.54	20.29	7.16	19.63^{e}	42.96^{cde}	13.1^{c}	489.7^{c}
	Star 1801	50% Bio	10.47^{b}	$5.00b^{c}$	16.25	22.98	8.66	28.23^{bcd}	47.6^{abc}	14.23^{c}	568.83^{ab}
	Star 1801	100% Bio	10.59^{b}	4.65^{cd}	18.13	24.62	9.43	26.56^{cd}	43.88^{bcd}	14.86^{c}	489.46^{bc}
	Star 1801	200 Bio	10.39^{b}	4.80^{bcd}	17.83	24.03	10.16	25.43^{cde}	41.29^{de}	15.46^{c}	440.36^{cd}
	Star 1801	NPK	10.44^{b}	4.46^{de}	20.26	25.34	9.63	35.00^{ab}	40.73^{de}	19.73^{b}	403.68^{cd}
	Mean		10.69	5.03	17.93	24.24	10.09	29.52	43.71	17.42	474.61
	Cv		9.00	12.00	16.00	19.00	14.00	18.00	9.00	24.00	17.00
	P Value		*0.00*	*0.00*	*0.83*	*0.57*	*0.99*	*0.00*	*0.00*	*0.05*	*0.00*
Winter	Fordhook giant	Control	4.33^{b}	5.23	6.98^{c}	5.48^{c}	6.40^{bc}	10.86^{cd}	11.84^{f}	10.63^{c}	51.16^{e}
	Fordhook giant	50% Bio	5.17^{a}	5.33	8.36^{ab}	6.54^{b}	6.73^{ab}	15.11^{b}	15.77^{d}	12.53^{ab}	100.45^{d}
	Fordhook giant	100% Bio	4.64^{b}	5.66	6.94^{c}	6.31^{b}	6.66^{b}	12.87^{bc}	17.62^{c}	13.13^{ab}	126.39^{c}
	Fordhook giant	200% Bio	4.79^{a}	5.53	7.56^{bc}	7.65^{a}	7.23^{a}	18.3^{a}	20.83a	13.46^{a}	131.65^{b}
	Fordhook giant	NPK	3.8^{c}	5.90	4.93^{d}	4.76^{d}	5.96^{d}	7.73^{e}	15.64^{d}	11.53^{bc}	95.01^{d}
	Star 1801	Control	4.17^{b}	5.13	6.99^{c}	4.9^{cd}	5.50^{c}	10.04^{de}	13.69^{e}	10.53^{c}	100.88^{d}
	Star 1801	50% Bio	3.62^{c}	4.53	4.6^{d}	4.71^{d}	5.43^{c}	7.9^{e}	13.01^{ef}	8.53^{d}	82.43^{d}
	Star 1801	100% Bio	4.47^{b}	4.60	6.75^{c}	5.37^{c}	5.63^{c}	1.99^{cd}	17.19^{cd}	11.36^{bc}	148.81^{bc}
	Star 1801	200% Bio	4.68^{ab}	5.03	7.61^{bc}	6.02^{b}	5.76^{c}	13.03^{bc}	18.45^{bc}	12.23^{abc}	161.96^{b}
	Star 1801	NPK	5.04^{a}	5.23	9.84^{a}	6.59^{b}	6.3^{bc}	17.73^{a}	19^{ab}	12.03^{abc}	189.06^{a}
	Mean		4.47	5.21	7.02	6.16	5.83	12.55	16.39	11.59	121.78
	Cv		11.00	18.00	19.00	15.00	9.00	28.00	17.00	12.00	33.00
	P Value		*0.00*	*0.12*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.01*	*0.00*

Values in a column followed by the different letter are significantly different at $P \leq 0.05$. P value: probability value, Cv (%): Coefficient of variance.

following the standard practices.

Data collection

Five (5) plants per replicate were selected randomly and tagged for data collection. Sampling started at 20 days after transplanting and continued at 20-day intervals until the crop was ready for harvest at sixty (60) days after planting (DAP). The vegetative growth parameters (plant height, number of leaves and leaf area) were measured at each sampling period. At harvest, the fresh and dry shoot mass was measured. Samples were then oven-dried at 65°C for 48 h and weighed to obtain dry leaf mass. Nutrient content of the leaves was determined at DADI Analytic Laboratory.

Statistical analysis

Data was subjected to analysis using statistical software Statistica (Version 13.2) (Stat-Soft Inc. Tulsa, OK, USA). A two-way Analysis of Variance (ANOVA) was performed for each parameter in different seasons and for each treatment and cultivar. The Least Significant Difference ($LSD_{(0.05)}$) values were at the $p = 0.05$ confidence level. The interactive effects of cultivar and treatments were analysed as a two-way factorial using the same statistical version.

RESULTS AND DISCUSSION

Plant height (PH)

The summer results (Table 4) showed that the interaction between fertilisation and cultivar significantly ($p \leq 0.05$) influenced the plant height in all the three sampling periods although inconsistencies were observed between application rates. During the 1st sampling period, fertilisation of Fordhook giant with 50% Bio produced taller plants (12.02 cm), while the Star 1801 in the control plots produced the shortest plants. These findings concur with the findings of Haile et al. (2018) who reported that fertilisation with bioslurry had significantly affected the plant height of kale crop. Warnars (2014) reported that nutrient supply plays a major role in plant growth.

Table 5. Effect of the interaction between cultivar and fertiliser on fresh leaf mass (FLM) and dry leaf mass (DLM) of Swiss chard in summer and winter growing season.

Season	Cultivar	Treatment	FLM (g)	DLM (g)
Summer	Fordhook giant	Control	189.00^{efg}	14.36^{efgh}
	Fordhook giant	50% Bio	209.86^{ef}	18.06^{efg}
	Fordhook giant	100% Bio	273.39^{de}	21.78^{cde}
	Fordhook giant	200% Bio	388.70^{bc}	29.04^{bc}
	Fordhook giant	NPK	626.44^{a}	47.86^{a}
	Star 1801	Control	282.20^{de}	8.10^{efg}
	Star 1801	50% Bio	412.58^{b}	30.11^{b}
	Star 1801	100% Bio	376.50^{bcd}	26.11^{bcd}
	Star 1801	200% Bio	293.12^{cde}	20.78^{def}
	Star 1801	NPK	281.72^{de}	29.38^{bc}
Mean			**333.36**	**24.56**
Cv (%)			**36.00**	**42.00**
P Value			***0.00***	***0.00***
Winter	Fordhook giant	Control	47.50^{d}	4.51^{e}
	Fordhook giant	50% Bio	107.91^{abcd}	10.15^{cde}
	Fordhook giant	100% Bio	146.17^{abcd}	13.07^{bcde}
	Fordhook giant	200% Bio	151.86^{abcd}	12.61^{bcde}
	Fordhook giant	NPK	113.82^{abcd}	10.70^{cde}
	Star 1801	Control	98.4^{bcd}	8.77^{cde}
	Star 1801	50% Bio	66.97^{cd}	6.14^{de}
	Star 1801	100% Bio	134.83^{abcd}	11.86^{bcd}
	Star 1801	200% Bio	135.96^{abcd}	12.37^{cd}
	Star 1801	NPK	163.00^{abc}	15.14^{abcd}
Mean			116.60	10.50
Cv (%)			30.00	29.00
P Value			*0.00*	*0.00*

Values in a column followed by the different letter are significantly different at P≤ 0.05. P value: probability value, Cv (%): Coefficient of variance.

However, the tallest plants were obtained in Fordhook giant at 200% Bio (27.65 cm) during the 2nd and (51.97 cm) 3rd sampling periods (Table 4). Similar results were reported by Suthar (2009) and Shahabz (2011), who reported an increase in plant height due to increased rate of bioslurry application compared to the control treatment and inorganic fertilizer. According to Rahman et al. (2010), plant height is affected by many factors, such as the genetic makeup of cultivar and soil fertility. However, Shahabz et al. (2014) also found an increased growth when 200% Bio was applied on okra.

Table 5 shows that the interaction between cultivar and fertilizer significantly (p≤0.05) affected PH in winter, with Fordhook giant exhibiting a superior performance in all the three sampling periods. The 1st sampling showed that the tallest plants (5.17 cm) were obtained in Fordhook giant plants fertilized at 50% Bio and the Fordhook giant fertilized with NPK produced the shortest plants (3.8 cm). During the second sampling period, Fordhook giant fertilized with 200% Bio produced significantly taller plants (7.65 cm) while the lowest (4.9 cm) response was obtained from Star 1801 grown in the control plots. At 3rd sampling, results showed that, the Fordhook giant fertilized with 200% Bio (20.83 cm) was superior compared to other interactions and the lowest responses in terms of PH (11.84 cm) were obtained from Fordhook giant grown in the control plots. Jeptoo et al. (2013) reported similar results that plants treated with the highest level of bioslurry exhibited high plant growth when compared to other treatments. The nutrient composition analysis (Table 1) of the river sand (growing medium) incorporated with 200% Bio exhibited the higher amounts of macro-elements. This could explain the higher PH responses found in the plants treated with 200% Bio.

Number of leaves (NL)

In terms of NL, the summer results (Table 4) showed that the interaction between cultivar and fertiliser treatment significantly influenced the number of leaves during the 1st and 3rd sampling periods. During the 1st sampling period, Fordhook giant fertilised with 100% Bio produced significantly higher NL (6.03) compared to other treatments, while the lowest NL (4.03) was obtained from Fordhook giant fertilised with NPK. These findings are in agreement with Haile et al. (2018) who reported that application of 100% Bio produced the highest number of kale leaves compared to other treatments. However, during the 3rd sampling the highest NL (27.66) was obtained from Fordhook giant fertilized at NPK whilst the lowest NL (13.1) was attained in Star 1801 plants grown in the control plots. Masarirambi et al. (2010), concur with the findings of this study reporting that inorganic fertilizers rapidly release and supply plants with large amounts of nutrients, which improves the quality and the number of leaves in leafy vegetables. Maboko and Du Plooy (2013) reported that Fordhook giant cultivar produced the high number of leaves while Star 1801 performed poor.

Table 5 shows the interaction between cultivar and fertiliser treatment in winter. The results showed that this interaction significantly influenced the number of leaves during the 2nd and the 3rd sampling periods. In the 2nd sampling, the Fordhook giant fertilised with 200% Bio produced the highest NL (7.23) compared to other treatments and the lowest NL (5.43) was obtained from Star 1801 fertilised with 50% Bio. A similar trend was observed during the 3rd sampling, whereby the Fordhook giant fertilized at 200% Bio produced the highest NL (13.46) compared to other treatment combinations and the lowest NL (8.53) was obtained from Star 1801 fertilized with 50% Bio. Maboko and Du Plooy (2013) concur with the findings of this study reporting that Fordhook giant produced high number of leaves while cultivar Star 1801 performed lower in all studied parameters.

Leaf area (LA)

In summer, the interaction between cultivar and fertiliser treatment showed a significant effect on leaf area except for the 2nd sampling period (Table 4). During the 1st sampling, the highest LA (35.83 m^2) was obtained from Fordhook giant fertilised with 100% Bio and the Star 1801 in the control produced the lowest LA (19.63 m^2). Islam et al. (2016) observed an increase in leaf area of spinach when 10 t ha^{-1} of bioslurry was applied. At the 3rd sampling, the highest LA (593.3 cm^2) was obtained in Fordhook giant plants fertilised with 200% Bio, while the lowest LA (369.73 cm^2) was obtained from Star 1801 grown in control plots. According to Mog (2007) and Apahidean et al. (2012), fertilisation with bioslurry increased the cell division as well as cell elongation, which resulted in the increase in leaf expansion.

In winter, the interaction between cultivar and fertilizer treatment (Table 4) significantly ($p \leq 0.05$) influenced the leaf area in all the three sampling periods. During the 1st sampling period, the highest LA (9.48 cm^2) was obtained from Star 1801 fertilized with NPK while the lowest (4.6 cm^2) was obtained in Star 1801 in the plots fertilised with 50% Bio. Khanafi et al. (2018) stated that inorganic fertiliser increased plant growth due to the rapid release of nutrients directly to plants. However, during the 2nd sampling, Fordhook giant fertilized at 200% Bio produced the highest LA (18.3 cm^2) while the lowest (7.9 cm^2) was attained in Star 1801 plants fertilised with 50% Bio. This is an indication that the two cultivars differ in their nutrient demand with Star 1801, demonstrating a less demand for nutrients, while the Fordhook giant cultivar proved to be a heavy feeding cultivar. It is presumed that the differences in performance of these two cultivars could be due to a natural vigorous growth habit of Fordhook giant compared to Star 1801. These findings agree with the finding by Maboko and Du Plooy (2013) who reported that Fordhook giant produced larger leaves while cultivar Star 1801 performed lower in all studied parameters. Similarly, Haile et al. (2018) reported that fertilisation with bioslurry significantly affected the leaf area of kale crop. In the 3rd sampling period, while the highest LA (189.06 cm^2) was obtained from Star 1801 fertilized with NPK, the lowest LA (51.16 cm^2) was obtained from the Fordhook giant grown in the control. Jeptoo et al. (2013) reported similar results, that plants treated with the highest levels of bioslurry exhibited high growth and yields when compared to other treatments.

Effect of interactions between fertilisation and cultivar on biological yield of Swiss chard

Table 5 shows the effect of the interaction between fertilisation and cultivar on fresh leaf mass and dry leaf mass. The results showed that higher fresh leaf mass was obtained from Fordhook giant plants fertilised with NPK (626.44 g) during summer and a similar trend was observed for DLM. This could be due to the better availability of soil nutrients provided by an inorganic fertiliser and favourable environmental conditions afforded by warm temperatures of the summer season. The ability of Fordhook giant to produce higher biological yield could be attributed to the genetic makeup of Fordhook giant cultivar resulting in plants with large vegetative growth. Maboko and Du Plooy (2013) reported that Fordhook giant outperformed Star 1801 cultivar for fresh and dry leaf mass across all the harvesting frequencies. These results suggest that planting Fordhook giant in summer could be beneficial compared to Star 1801 when fertilised with the inorganic fertiliser.

Repeating the study in winter showed that the interaction between fertiliser treatments and cultivar significantly influenced fresh and dry leaf mass. Contrary to the summer results, the highest fresh leaf mass was obtained from Star 1801 plants fertilised with NPK (163 g)

Table 6. Effect of fertilisation treatment on nutrient content of Swiss chard grown during summer season.

Treatment	N	P	K	Ca	Mg	Fe	Zn
	(%)					(mg kg^{-1})	
Control	28.52^{bc}	17.22^{a}	15.67^{ab}	28.41^{a}	15.79	4624.80^{bc}	2408.33
50% Bio	30.12^{b}	15.23^{ab}	14.36^{ab}	25.33^{ab}	15.76	7222.00^{a}	2387.33
100% Bio	27.18^{bc}	17.44^{a}	12.79^{bc}	24.88^{b}	36.52	5161.16^{b}	2080.33
200% Bio	17.50^{c}	13.35^{b}	8.61^{c}	16.25^{c}	15.02	3874.66^{c}	2116.33
NPK	55.42^{a}	13.35^{b}	17.73^{a}	6.82^{d}	6.82	4148.00^{c}	4327.16
Mean	31.74	15.31	13.81	20.25	17.98	5006.20	2663.90
Cv	39.00	12.00	22.00	39.00	55.00	24.00	32.00
P Value	*0.00*	*0.03*	*0.00*	*0.00*	*0.32*	*0.00*	*0.64*

Values in a column followed by the different letter are significantly different at P≤ 0.05. P value: probability value, Cv (%): Coefficient of variance.

and a similar trend was observed for DLM; however, this did not differ significantly with other treatment combinations with the exception of the control treatment in Fordhook giant. The practical application of these results mean that any of the two cultivars could be planted in winter and use of inorganic fertilisers could offer a relative advantage over bioslurry. Motseki (2008) reported that the application of inorganic fertilizers with nitrogen significantly influenced the leaf fresh and dry mass.

Effect of fertilisation on nutrient content of Swiss chard

This study showed that there was no significant interaction between fertiliser treatments and cultivar in both seasons. However, the treatment as a main factor significantly influenced the nutrient element composition of Swiss chard in summer. For this reason, only summer fertiliser results are discussed. This effect showed that plants fertilised with NPK showed relatively higher total nitrogen (TN) (55.2%) and the lowest TN was obtained in plants treated with 200% Bio (17.5%) as shown in Table 6. Nutritionally, N content of plants is of great importance since it reflects directly the protein content in the plant (Ahmad et al., 2014). These results are in agreement with the findings of Herencia et al. (2011) who reported higher N contents in Swiss chard when fertilised with inorganic fertilizer. This superior performance of NPK fertilizer regarding N supply to plant tissue over other fertiliser treatments suggest that inorganic fertilizers contain N which is readily available and easily absorbed by crops in the soil (Masarirambi et al., 2010). In terms of plant phosphorus (P), the highest P content was recorded in plants fertilised with 100% Bio. Bioslurry like all organic fertilisers improves soil physical structure and water holding capacity, resulting in a more extensive root development and enhanced soil microbial activity affecting availability of micronutrient levels in soil to plants. The results conform to the findings of Warnars (2014) who reported the improved P concentration on leaves of Swiss chard when fertilised with bioslurry. This study showed that plants fertilised with NPK produced the highest potassium (K) content whilst the lowest content of K was found in plants fertilised at 200% Bio. The poor performance on 200% Bio suggest that 200% had a temporal effect on the uptake of nutrient elements. This treatment showed aggression in plant growth parameters, but this is not evident in the leaf nutrient elements. This response could also be attributed to the gradual release of nutrients from their slow rate of mineralization associated with organic fertilisers. These results are in agreement with the findings of Muhmood et al. (2014) who reported the maximum macronutrient contents in leaves of both spinach and chilli in treatment with recommended dose of chemical fertilizer.

With regards to calcium (Ca) content, plants grown in the control plots produced the highest Ca content compared to other treatments. Similar findings were reported by Ndololwana (2015) who reported a significant higher concentration of Ca on leaves of Swiss chard planted in control treatment. The results for Iron (Fe) analysis showed that plants fertilized with 50% Bio produced the highest Fe content, while the lowest Fe content was found in plants fertilized with NPK. These results are incompatible with those of Muhmood et al. (2014) who reported that maximum micronutrient concentration on Swiss chard leaves were obtained when inorganic fertilisers were applied. It can be concluded that the higher concentration of macronutrients presented by NPK treatment is due to quick release of nutrients to the soil. However, fertilisation with bioslurry at 100 and 50% also showed better results in nutrients elements of plant leaves in a relatively consistent manner. This is presumed to be due to its mineralization, which might have occurred on later stages to provide sufficient nutrients to the plants (Sarwar et al., 2007). Therefore, appropriate mixture of bioslurry and NPK fertilizer could provide the most desirable nutrient composition in the leaves of Swiss chard.

Conclusions

This study showed that Fordhook giant fertilised with bioslurry was superior for most of the tested growth parameters in summer compared to this interactive effect of fertiliser on Star 1801. However, there was a lack of consistency between treatments in terms of these interactions for the studied growth parameters. In terms of fresh and dry leaf mass, application of NPK showed a relative advantage but this did not differ significantly with some of the bioslurry treatments. Application of inorganic fertiliser (NPK) showed a superior performance for total N but this could not be translated to other tested leaf nutrient elements in summer. Repeating the experiment in winter showed inconsistencies in terms of the interactive effect of cultivar and fertiliser treatments. However, Star 1801 showed a relatively superior performance compared to Fordhook giant in winter. This study suggests that, under conditions where inorganic fertilizers are not available, the application of bioslurry could be used as an alternative for plant growth. An integration of bioslurry and NPK could improve leaf nutrient content compared to pure bioslurry and further studies on this are recommended.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

Ethical statement

There was no involvement of animals in this study.

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