



(RESEARCH ARTICLE)



## Growth and yield response of Swiss chard (*Beta vulgaris* (L.) to media mixture ratios of sand, acacia soil, and goat manure

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### Abstract

Northern Namibian soils are predominantly sandy. A mixture of Acacia soils, sandy and goat manure is frequently used for growing various plants. However, the extent to which variations in proportions of these substrates affect growth and yield is not known. The study was conducted at the University of Namibia, Ogongo campus during the period April to August 2020 to determine optimum mixing ratios for sandy, *Acacia erioloba* soil and goat manure on the growth and yield of Swiss chard. Treatments were Sandy, Acacia soil and goat manure mixed in 5 different ratios of respectively; 1:2:1; 2:3:2; 1:1:1, 2:1:2, 1:1:2 and Acacia soil (control). Samples from each mixture used for pot filling were taken to the soil laboratory for textural analysis. A complete randomized experiment with 8 replications was laid under the University's shade house. Measured parameters were plant height, leaf area, fresh and dry matter weight and chlorophyll content. Results showed that media was significantly different across all the measured parameters at 1 % probability level. The medium mixture 2:3:2 outperformed the rest of the mixtures in almost all the parameters. The results of the study indicated that acacia soil alone is not optimum for pot filling but must be supplemented with substrate that is rich in mineral content like goat manure. However, the mixing ratio is a key consideration for optimal vegetable production. We recommend the use of media mixture 2:3:2 to improve yield of Swiss chard.

**Keywords:** Nursery; chlorophyll content; leaf area; fresh weight; basin; leaf elongation

### 1. Introduction

Swiss chard (*Beta vulgaris* L.) incorrectly referred to as Spinach [1] is a biennial leafy vegetable belonging to Chenopodiaceous family [2, 3, 4] which has been cultivated in Europe for thousands of years, with its extensive cultivation in Switzerland earning it the name "Swiss chard" [5]. The leaves are often used in salads because of its attractive flavor and delicate texture [6]. The stalks are eaten because they are tender and rich in fiber [4,7]. Swiss chard can grow in any soil if it's well-drained, contains organic manure [8], with temperature ranging from 7-24 °C, its half hardy, and can stand light frost conditions. Typically, in hot climate conditions, leaves remain small and are of inferior quantity [2,6].

Swiss chard has been cultivated since 300 B.C. and the wild type is found in the Canary Islands, Mediterranean region, and east to southern Asia [10]. The first records of Swiss chard cultivation suggest the Mediterranean area, perhaps Italy as the center of origin [8,10]. In Africa it is mainly produced in South Africa [12], with small scale cultivation in other countries such as Zimbabwe, Botswana, Zambia, Namibia and so on.

Northern Namibia is the most densely populated area in the country [13], as well as the poorest with high rate of extreme poverty [12,13], majority of the population are resource-poor subsistence farmers, mainly living on natural

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resources, livestock farming, and rain fed agriculture [15]. In fact, it is estimated that 700 000 people or over, representing one third of the total population lives in the northern part of the country [16].

Though Swiss chard has been successfully grown in Namibia, production remains low. The reason for low production not only of Swiss Chard, but vegetables in generally, is partly due to poor soil fertility in the northern part which is predominantly sandy [17], concurrent with high evapotranspiration and lack of resources for poor farmers to buy commercial fertilizers to improve soil fertility.

Despite the low level of vegetables cultivation in Namibia, demand for vegetables has been on the rise, resulting in a variety of major imported horticultural products becoming visible in the shelves of major shops in the country. Consequently, there is need to improve the local production of many vegetables in the country by generating scientific agronomic information which is currently limited for a number of vegetables.

Low soil fertility and high evapotranspiration have caused Swiss chard growers to prefer producing the crop in polyethylene plastic pots which create a number of advantages such a reduction in soil borne diseases, nematodes and weeds. Detrimental effects of poor soil conditions can be drastically reduced by switching to a container garden [18]. In fact, container garden is cheap to start, and guarantees better control over growing conditions, water, nutrients, and sunlight. Furthermore, it is easier to defend plants from unsuitable weather conditions, and insect pests [18, 19]. However growing plants in pots require the use of suitable growing medium. A suitable medium has sufficient plant nutrient, optimum pH and has the ability to maintain optimum moisture. Such media are however costly, not locally available and require expertise for proper utilization. Examples of these media include, palm peat, coconut peat, posting soil and compost. Local producers growing Swiss chard in pots have been using garden soil, acacia soil (soil collected from under the canopy of *Acacia erioloba* trees), animal manure and sometimes mixing them in varying proportions. The crop yield from these growers varies significantly.

The variation in yield and growth rate of Swiss chard in these media calls for more research to be done to determine the optimum media mix ratio of garden soil, animal manure and acacia soil to obtain maximum yield. Critical to note is the fact that these media are readily available in the country at no cost at all. What is required is to establish the optimum mixing ratios for higher yield. Research have shown that there are two major factors that determine the successful production of container-grown plants in commercial nurseries namely: the choice of the media, particularly their physical properties, and the supply of plant nutrients [21].

The current study was therefore conducted to compare the growth and yield response of Swiss chard under different media mixture ratios of sand, acacia soil and goat manure. Swiss chard was chosen as the test crop due to its nutritional and economic importance in most part of the World and equally so, to Namibia. It is the most popular vegetable crop grown in home gardens [22]. Specifically the study seeks to (1) characterise the experimental growing media by texture (2) compare growth rate of Swiss chard, (3) compare number and size of leaves, (4) assess chlorophyll content of leaves, and (5) compare fresh and dry weight of Swiss chard under different media mixture ratios.

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## 2. Methodology

### 2.1. Study area

The study was conducted in the nursery at the University of Namibia, Ogongo Campus (latitude 17°43'S, longitude 15°15'E), Northern part of Namibia, Omusati region between 10 April and July 2020. The area is characterized by sandy loam soil, approximately 20°C temperature and an average rainfall of about 300mm to 400mm annually.

### 2.2. Soil/ media collection

The representative soil samples were collected before planting. Acacia soil was collected under acacia tree (*Acacia erioloba*), goat manure from the goat kraal as well as sand soil (garden soil) was collected from the garden. Both samples were collected from the University of Namibia, Ogongo Campus farm and was used in pot filling.

### 2.3. Media preparation and pot filling

Black cylindrical polyethylene plant bags with a volume of 6401.53cm<sup>2</sup> were used, filled with different media mixture ratios of sand, *Acacia erioloba* soil, and goat manure. A small container was used to measure soil from collected samples for mixing. Different soil samples were poured in a basin and thoroughly mixed using hands to ensure homogeneity. A total of 48 plastic pots were used, 8 filled with 1:3:0 (1 container of sand, 3 containers of acacia soil and 0 of goat manure), 1:2:1 x 8 (1 container of sand, 2 containers of acacia soil, 1 container of goat manure), 1:1:1 x 8 (1 container of

sand,1 container acacia soil,1 container of goat manure ), 1:1:2 x 8 (1container of sand,1 container of acacia soil ,2 containers of goat manure), 2:1:2 x 8 (2 containers of sand, 1 container of acacia soil, 2 containers of goat manure), 2:3:2 x 8 (2 containers of sand, 3 containers of acacia soil, 2 containers of goat manure). After mixing of ratios, pots were filled, transported to the nursery and watered.

#### **2.4. Planting**

Seed of Swiss chard variety Fordhook giant was bought from Oshakati Pharmacy and sown directly into the pots on the 10<sup>th</sup> April 2020 a day after pot filling at a depth of 1 inch deep (2.54cm) and no starter nutrients or artificial fertilizer was added. Pots were watered immediately after planting using watering pipe, this is usually done every after 1-2 days. All the seed germinated on the 13<sup>th</sup> of April 2020 and seedling thinning was carried out so that each pot only accommodated one seedling to prevent competition for nutrients and sunlight. The first harvest was carried out on 10<sup>th</sup> June and plant leaves were allowed to grow back in the same media for another 14 days without additional nutrients.

#### **2.5. Soil sampling and analyses**

The descriptive soil samples were collected before planting, using a shovels. The representative composite samples were taken and analyzed for the soil texture properties. The samples were taken to the Department of Crop Science in the Soil Science Laboratory of the University of Namibia, Ogongo Campus for analysis of soil texture. Hydrometer method was used to determine the soil texture.

#### **2.6. Experimental design**

The experiment was arranged in a randomized complete block design with six treatments, comprising different sand: acacia soil: goat manure ratios respectively mixed as follows:

0:1:0 (control)

1:2:1,

1:1:1,

1:1:2,

2:1:2,

2:3:2.

Each treatment was replicated eight times with pots dispersed over approximately 2 m of the nursery ground area with 20 cm spacing between pots.

#### **2.7. Data collection and statistical analyses**

Data were collected 2 weeks after planting. Data were collected from all 8 plant pots of all the treatments before harvest for 6 weeks. Leaf elongation from the leaf apex to the end of the leaf petiole was measured once every week. Number of green leaves per plant was recorded before first harvest. Plant height was measured from the leaf apex of the longest green leaf to the bottom of the plant at the soil level .The length and width of the leaf lamina of all the biggest leaves were recorded for each medium treatment. The product of the length and width of the leaf lamina was used to estimate average leaf surface area per plant. Chlorophyll content was measured using a SPAD-502 meter. Fresh and dry weight was measured every after harvesting and fresh leaves were taken to the oven for drying at 80° for 72 hours to determine the dry mass.

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### **3. Results and discussion**

#### **3.1. Physical characterization of the substrates**

Prior to planting of the trial, composite soil core samples were collected to a depth of 0.15 m for determination of basic soil physical properties (Table 1). Soils have varied nutrients retentive properties depending on their texture, organic matter content, and cation exchange capacity (CEC). The substrate with high proportion of Acacia soil had the greatest yield compared with other substrate treatments.

**Table 1** Particle size analyses of the soils using hydrometer method.

Substrate type	Texture %			Texture
	Sand	Silt	Clay	
Sand	98.000 (0.010)	2.005 (0.009)	0.005 (0.001)	Sand
Acacia organic matter plus sand	98.004 (0.003)	2.000 (0.001)	0.005 (0.002)	Sand
Goat manure plus sand	98.002 (0.001)	2.000 (0.001)	0.003 (0.001)	Sand

Values in brackets are standard deviations.

### 3.2. Effect of media mixture on growth parameters

#### 3.2.1. Plant height

Media mixtures gave statistically significant results on plant height ( $p < 0.01$ ). Mixture 2:3:2 gave the highest plant height  $23.18 \pm 0.53$  belonging to a unique homogeneous group (Table 3), relative to other media mixtures at the terminal point of the experiment (Fig 1). Mixture 2:1:2 was second with terminal average plant height of  $22.25 \pm 0.53$  (Table 3). Media mixture 1:1:1 gave the least plant height. The growth dynamics as depicted by plant height are reflected by the trend graph (Fig 1). Control medium (Acacia soil) gave the highest plant height up to the middle of week 4 and week 5. Medium mixture 1:1:2 almost maintaining the least plant height on average during the entire experimental period.

### 3.3. Effect of media mixture on yield parameters of Swiss chard

#### 3.3.1. Leaf area

Medium mixture 2:3:2 significantly influenced leaf area of Swiss chard plants. Its influence is significantly higher  $186.65 \pm 82.71$  than that of the rest of media mixtures (Table 3). The least leaf area was observed in the medium mixture 1:1:1 which gave on average  $98.79 \pm 82.71$ , leaf area of which was not significantly different from that recorded from the control treatment.

#### 3.3.2. Number of leaves

Medium mixture 2:3:2 gave the highest number of leaves  $8.34 \pm 0.70$  followed by the 2:1:2 that gave  $6.63 \pm 0.70$  on average. The least number of leaves were recorded for the 1:1:1 medium that yielded  $5.92 \pm 0.70$ .

#### 3.3.3. Chlorophyll content

The chlorophyll content as influenced by media mixture 2:3:2 is significantly higher ( $32.22 \pm 0.77$ ) than that of other treatments, apart from that of 2:1:2 ( $31.45 \pm 0.77$ ) (Table 3)

#### 3.3.4. Fresh and dry weight

Significant different results were recorded on dry and fresh weight at 1 % probability level. 2:3:2 gave highest results on fresh weight  $55.97 \pm 3.30$ , followed by the control  $44.87 \pm 3.30$ , although belonging to the same homogeneous group. The least yield was recorded for the mixture 1:2:1 with a fresh weight of  $21.81 \pm 3.30$  and the least dry weight of  $2.29 \pm 0.28$ .

**Table 2** Effect of media mixing ratios on growth and yield components of Swiss chard.

Treatment structure	DF	Leaf area (cm <sup>2</sup> )	Number of leaves	Plant Height (cm)	Chlorophyll content (μmol/cm <sup>2</sup> )	Fresh weight (g)	Dry weight (g)
Model	11	10605.22***	154.49***	1736.42***	3029.73***	3435.44***	18.24***
Media	5	5463.14***	4.54***	19.11***	17.33***	3545.02***	18.18***
Week	5	85873.29***	18.05***	615.06***	137.44***	2997.14***	18.46***
Error	25	712.76	2.51	0.63	1.14	115.88	0.86

\*\*\* Significant based on probability of 0.001

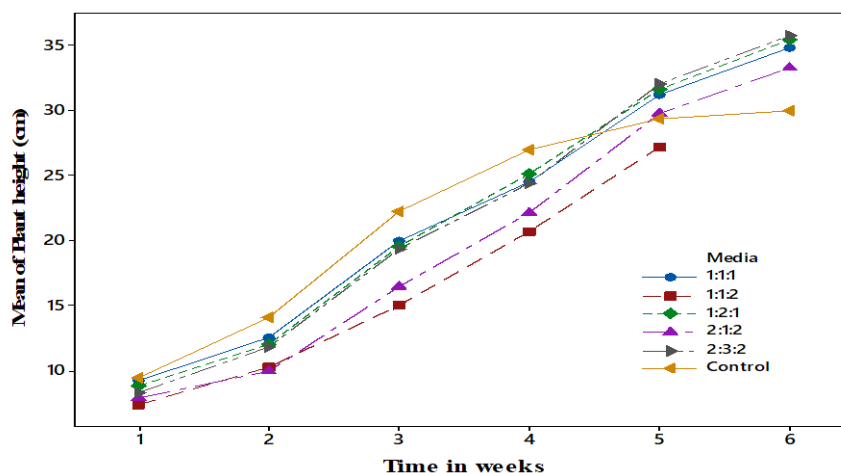
Generally, media mixture 2:3:2 outperformed the rest in almost all the parameters across all the weeks. Its parameters are statistically significantly different from the other mixtures for almost all of the parameters.

**Table 3** Comparison of growth and yield components of Swiss chard across different growth media mixing ratios.

Media (S:A:G)	Leaf area (cm <sup>2</sup> )	Number of leaves	Chlorophyll content (μmol/cm-2)	Plant Height (cm)	Fresh weight (g)	Dry weight (g)
1:2:1	147.32 ± 82.71b	6.48 ± 0.70ab	30.56 ± 0.77bc	21.83 ± 0.53bc	21.81 ± 3.30b	2.29 ± 0.28b
2:3:2	186.65 ± 82.71a	8.34 ± 0.70a	32.22 ± 0.77a	23.18 ± 0.53a	55.97 ± 3.30a	4.49 ± 0.28a
1:1:1	98.79 ± 82.71c	5.92 ± 0.70b	27.80 ± 0.77d	18.30 ± 0.53e	44.87 ± 3.30a	4.82 ± 0.28a
2:1:2	154.47 ± 82.71b	6.63 ± 0.70ab	31.45 ± 0.77ab	22.25 ± 0.53ab	27.62 ± 1.90b	2.92 ± 0.16b
Control	120.18 ± 82.71bc	6.12 ± 0.70b	28.48 ± 0.77d	19.73 ± 0.53d	46.45 ± 3.30a	4.36 ± 0.28a
1:1:2	135.13 ± 87.28b	6.36 ± 0.78ab	29.92 ± 0.86c	20.93 ± 0.59c	27.62 ± 1.90b	2.92 ± 0.16b

Means with the same letter in a column are not statistical significantly different at 5% probability level.

Post hoc analysis is based on Duncan's method [23]. Data are 6 week averages ± SE.



**Figure 1** Swiss chard growth under the influence of different media mixing ratios across the experimental period

#### 4. Discussion

The study found that the substrate with high proportion of Acacia soil had the greatest yield compared with other substrate treatments. This finding is supported by some researchers who revealed that acacia soil has a strong effect on soil nutrient concentration [24]. Higher soil fertility under tree canopies has been reported for a broad range of savannas [25–27]. Acacia leaves are known to have high nitrogen content which promotes chlorophyll formation and vegetative growth, especially in leafy vegetables like Swiss chard. Besides its nutritional property, Acacia soil is also rich in organic materials, which improve soil conditions by increasing water infiltration, aeration and water holding capacity of the soil. Therefore, a combination of nutritional properties and structural improvement capability of the Acacia soil should have contributed to improved performance of Swiss chard compared with the other substrates.

Several lines of evidence suggest that growth and yield parameters of Swiss chard increase with increase in nitrogen application [28]. Other researchers also reported an increase in chlorophyll content in maize associated with the increase in nitrogen levels [29].

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## 5. Conclusion

We conclude that under the conditions of the current experiment, media mixtures with high proportion of nitrogen source substrates, has positive effects on chlorophyll content, leaf area, leaf fresh and dry weight and plant height of Swiss chard.

The results showed that substrates mixed in different proportions affect growth and yield of Swiss chard. This indicates that growth and development of Swiss chard were affected by nutrient levels in the media which obviously vary depending on the mixing proportion. Higher nitrogen in media induced positive results. Thus in order to increase yield of Swiss chard, media mixture of 2:3:2 should be used.

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## Compliance with ethical standards

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### *Disclosure of conflict of interest*

The authors declare no conflict of interest.

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