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Garlic (*Allium sativum*) Propagation Alternatives using Bulblets and Cloves of Different Sizes in a Semi-arid Sub-tropical Environment

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Authors' contributions

This work was carried out in collaboration between all authors. Author MLM designed the study, performed the statistical analysis and wrote the first draft of the manuscript. Authors FCN and MTM managed the literature searches and write up. All authors read and approved the final manuscript

Research Article

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ABSTRACT

Aims: Garlic (*Allium sativum*) is increasing in popularity in Southern Africa. However, there is dearth of information on alternative propagules to use. The trial was carried out to find out the yield of garlic produced from aerial bulblets and two clove sizes.
Study Design: The treatments were laid in a randomized complete block design (RCBD) replicated 3 times.
Place and Duration of Study: This trial was carried out at the Horticulture Research Centre, Marondera, Zimbabwe from April to August of 2007.
Methodology: The small cloves, large cloves and bulblets were sown in seedling trays and transplanted in the field at 30 days after planting in plots of 2m by 2m. The plant spacing was 40 cm between the rows by 10 cm within the row.
Results: There were significant ($p<0.001$) differences for time to shoot emergence and plant height at transplanting. The results showed that at 5 days after planting 89% of the large cloves emerged early followed by aerial bulblets at 47 % and small cloves at 34 %.

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Small cloves and bulblets took a longer time to emerge at 80 % and 76 % respectively at 14 days after planting. Large cloves produced the tallest mean seedlings (29.70 cm) at transplanting while bulblets had the mean shortest seedlings (20 cm). Large cloves produced plants with the highest flowering incidence of 61 % and small cloves had the lowest of 22 % while bulblets had 37 %. The flowering incidence was also significantly ($p<0.001$) different for the three types of propagation materials. There were no significant differences in yield between the large cloves, small cloves and the bulblets. The results indicated that bulblets can be used as garlic seed in the same way as cloves.
Conclusion: The yield from small cloves, large cloves and bulblets was not significantly different. Bulblets can be used to propagate garlic.

Keywords: Aerial bulblets; Allium sativum; cloves; growth parameters; propagation; transplanting, yield.

1. INTRODUCTION

Garlic (*Allium sativum*) is a hardy perennial bulb plant that originated from central Asia with a secondary centre in South Europe where it has been used for more than 2000 years [1]. The plant belongs to the *Liliaceae* family [1,2]. It differs from onion in that onion produces one bulb while garlic produces a group of small bulbs called cloves. Garlic is the second most widely cultivated *Allium* after onion. The cloves are used as a condiment largely for flavouring meat, fish in sauces, soups, stews, salads and to some extend in pickles. Young floral stems and young green plants are used in Spain, China and Indonesia. Garlic has health benefits and medicinal properties and can be used as an antioxidant and an antibiotic [3]. Crushed raw cloves are strongly antibiotic and have a reputation of lowering blood pressure and cholesterol [3]. Leaves and bulbs are considered to have hypotensive, carminative, antiseptic, anthelmintic, diaphoretic and expectorant properties. Clinical tests showed that regular consumption of garlic is correlated to reduced risk of stomach cancer. Garlic has insecticidal properties; it is used for organic garden pest control as a natural pesticide and insect repellent [4]. The use of organically derived pesticide to avoid the negative impacts of synthetic fertilizers on the environment and human health is encouraged [5].

Garlic plants rarely bolt however there are bolting and non bolting cultivars. The bolting cultivars are from the Mediterranean region and are largely grown in Spain, Argentina and Chile [6]. The cultivars have strong thermo – photoperiodic requirements. In cases where the plants bolt, the seed stalk is similar to that of the onion plant. It bears seed and bulblets (bulbils). The seed produced is not true seed and cannot be propagated. Cultivated garlic is sterile and therefore it does not produce true flowers, garlic varieties are completely sterile. They do not produce seeds and are vegetative propagated only. Modern garlic varieties have vegetative topsets (bulblets) which develop into garlic inflorescence [7]. Vegetative propagation of garlic is either by bulbs (cloves) or by bulblets for bolting cultivars. Cloves are more commonly used and are termed ‘seed’ by garlic growers [8]. The cloves of the same garlic bulb have two main sizes composed of large outer cloves and small inner cloves while some cultivars have smallest inner most cloves. Bulbs are separated into cloves which become the seed that is planted into the soil. In China, bulbs when used as seed tend to degenerate and get infected with virus and therefore some growers use bulblets as seed sets [9]. Bulbils offer an alternative approach to growing garlic that is economical and avoids soil borne disease [7]. Growing from bulbils is also said to increase the vitality of strains that do not seem to be living up to their potential.

Garlic propagation in Zimbabwe has not been relatively high due to limited demand, however recently due to proliferation of fast food outlets, surge in the population of the Asian community and increased health consciousness, demand has been increasing exponentially. Production was also limited by lack of planting material [10]. Demand was previously from the Asian community and spice manufacturers. Garlic demand is becoming popular across all communities in Zimbabwe due to its flavour and medicinal properties. There is a general shortage of horticulture seed in Zimbabwe and garlic is no exception. There are no certified seed suppliers of garlic in the country; some of the garlic growers get their seed from neighbouring South Africa. Garlic planting material is sold as single seedlings. Cloves are planted in seedling trays and are charged per seedling making the seedlings to be relatively expensive. The Horticulture Research centre has been receiving several phone calls from new farmers on garlic seed requests. There has been not much research carried out on garlic propagation in Zimbabwe. Garlic is gaining increasing importance as a commercial crop. There is urgent need to carry out research on this profitable crop. The trial was carried out to find the potential of bulblets, inner small cloves and outer larger cloves for garlic propagation as evaluated by growth parameters measured which included days to shoot emergence, plant height, flowering, yield indices and yield.

2. MATERIALS AND METHODS

2.1 Experimental Site, Design and Management

The experiment was carried out at the Horticultural Research Centre with a latitude of 18^{o} 18'S and longitude of 31º 55'E, average elevation of 1692 m. Average day length is 13.2 hours in summer to 11.1 hours in winter. The average rainfall per annum is 873 mm while mean temperatures range from 19.5 ^{o}C (July) to 24.6 ^{o}C (January). The site is characterised by deep sand soils [11]. The pH of the granite derived sandy soils range from 4.0 to 6.2.

Cloves of 'Israeli' garlic bulbs were separated into two different sizes, the outer large cloves and the inner small cloves. The outer larger cloves had average fresh mass of 8.0 g while the inner relatively smaller cloves, had average fresh mass of 4.0 g. The smallest innermost cloves were discarded. Bulblets were collected from the previous crop and planted in 2006 / 2007 growing season. The garlic that was available on the station was planted in April 2006 for seed multiplication. The cloves and the bulblets were planted in seedling trays, which were filled with nursery potting media made from vlei soil and pine bark. Trays with the seed were placed in a glass house under natural photoperiods, 4 000-6 000 lux light intensity and watered regularly to field capacity (FC) when soil water potential reached 20 centibars. Records on shoot emergence were taken at 5 days, 14 days, 21 days and 30 DAP. Seedling height was recorded at transplanting. The seedlings were transplanted at 30 days after planting with the treatments laid in a Randomised Complete Block Design (RCBD) replicated three times. The treatments were bulblet material, inner small cloves and outer large cloves. The row spacing was 40 cm and in row spacing was 10 cm. Data were collected on emergency, plant height, flowering and yield.

2.2 Fertiliser Application

A basal fertiliser application of 800 kg / ha compound fertiliser (8:14:7) [N:P:K] was applied at planting. Top dressing was applied at 100 kg / ha ammonium nitrate (30% N) at six weeks after transplanting.

2.3 Data Analysis

The collected data was analysed using MSTAT C statistical package [12]. The data was subjected to analysis of variance (ANOVA), where significant differences were detected, mean separation was done by (LSD), least significant differences [13].

3. RESULTS AND DISCUSSION

3.1 Emergence

The data on shoot emergence is shown in Table 1. There were significant (P<0.001) differences in emergence at 5 days after planting (DAP), at 21 DAP and at transplanting (i.e. 30 DAP). The seedling height at transplanting was also significantly (P<0.001) different for the three treatments. Large cloves had the earliest and fastest emergence with tallest seedlings; bulblets were least to emerge with shortest seedlings at transplanting while small cloves exhibited intermediate attributes.

Shoot emergence of both cloves and bulblets occurred within 5 DAP. At 5 DAP shoot emergence ranged from, 34 % for small cloves, 47 % for bulblets to 89 % for large cloves. The majority of the large cloves's shoots emerged within 5 days while bulblets and small cloves did not reach 50 % shoot emergence within 5 DAP. Most of the small cloves and bulblets' shoots emerged after 14 days. The cloves had higher shoot emergence values (98 % for small and 99% for large) than bulblets which had 84 %. Almost all the cloves' shoots (small and large) emerged. Plant height at transplanting was highest for large cloves with a height of 29.7 cm, followed by small cloves with a height of 24.5 cm while bulblets were shortest with a height of 20.0 cm (Table 1).

Table 1. Growth parameters of garlic (*Allium sativum*) from bulblets, small cloves and large cloves

Growth parameters	Bulblets	Small cloves	Large cloves	CV %	LSD	*P*
% emergence 5 DAP	47b	34c	89a	8	10.42	0.0003**
% emergence 14 DAP	76a	80a	90a	9	16.34	0.0578 NS
% emergence 21 DAP	81b	90a	96a	4	7.21	0.0111**
% emergence 30 DAP (transplanting)	84b	98a	99a	1	2.07	0.0001**
Height at transplanting cm (up to last leaf tip)	20c	24.5b	29.7a	6	3.19	0.0028**

*Treatments with same letter within a row are not significantly different. DAP: Days after Planting, NS: Not significant, **Significant at P<0.01, CV: coefficient of variation, LSD: least significant difference, P: Probability.*

3.2 Flowering

There were significant (*P*=0.05) differences in plant height and flowering incidence (Table 2) among treatments. Small cloves and bulblets were not significantly different in terms of plant height at flowering; however, large cloves significantly differed from them. The number of bulblets per flower was not significantly different among the propagules. The number of days to flowering was not recorded.

The plant height at flowering was tallest for large cloves with 30.30 cm height and shortest for small cloves with 23.4 cm height. Plants from bulblets were in between with 24.5 cm height. The number of plants that flowered was highest for large cloves with 61.4 % incidence and lowest for small cloves with 22.9 % incidence. Plants from bulblets were in between with 36.6% flowering incidence. The number of bulblets though not significantly different per flower ranged from 3.7 to 4.4.

Table 2. Plant height and flowering incidence of garlic (*Allium sativum*) from bulblets, small cloves and large cloves

Growth parameters	Bulblets	Small cloves	Large cloves	CV %	LSD	*P*
Plant height (cm)	24.5b	23.4b	30.3a	9	5.17	0.0420 *
Percent plants with flowers	36.6b	22.9c	61.4a	13	12.24	0.0024**
No. of bulblets per flower	3.8a	3.7a	4.4a	10	0.91	0.1676 NS

Treatments with same letter within a row are not significantly different.
*NS: Non significant, *Significant at P=0.05, ** Significant at P<0.01, CV: coefficient of variation, LSD: least significant difference, P: Probability.*

3.3 Yield and Yield Indices

The yield of garlic plants from large cloves, small cloves and bulblets is shown in Table 3. The yield in kilograms per hectare was lowest for plants from bulblets with 800 kg / ha and highest for plants from large cloves with 1544 kg / ha. The plants from small cloves yielded 870 kg / ha. The number of cloves per bulb was 10 for plants from small cloves, 12 for plants from for bulblets and 14 for plants from large cloves. There were no significant (*P*=0.05) differences among the planting material for number of cloves produced per bulb and yield per hectare. However the bulb weight was significantly different, where plants from the large cloves produced heavier bulbs than plants from small cloves or plants from bulblets (Table 3). Stahlschmit et al. [14] also found that bulbs from larger cloves were heavier. Bulb weight of plants from small cloves and bulblets were not significantly different at (*P*=0.05). In terms of yield bulblets, small cloves and large cloves produced the same yield. A farmer can plant bulblets, small cloves or large cloves without compromising the expected yield. Progeny from bulblets often outperform the parent bulbs [7]. Bulblets can therefore be used as planting material in much the same way as cloves, thus offering alternative planting material. The main advantage of planting bulbils (bulblets) is that it allows growers to increase their planting stock very quickly and to produce bulblet seed stock which is free of soil borne diseases [15]. The disadvantage is that it can take several years of successive planting to achieve good-sized bulbs from the initial bulblet planting stock.

There are difficulties of inducing flowering in garlic which make breeding programs in garlic improvement a challenge [16]. With successive vegetative propagation, many elite garlic varieties and cultivars have been reported to become susceptible to diseases caused by viruses and fungi and may become susceptible to nematode attack [17]. To counter disease build up and to clean garlic propagating material several protocols for in vitro propagation, describing high proliferation rate have been reported [18,19,20,21,22] and recently field performance of the tissue cultured plants [23].

Table 3. Yield indices of garlic (*Allium sativum*) from bulblets, small cloves and large cloves

Yield indices	Bulblets	Small cloves	Large cloves	CV %	LSD	*P*
Number of cloves per bulb	12.0a	10.0a	14.0a	16.0	4.4	0.2858 NS
Bulb weight (g)	7.2 a	7.3 a	11.0 b	17.0	3.2	0.05 *
Weight (kg/ha)	800 a	870a	1544a			0.0864 NS
	(28.12)	(28.16)	(39.08)	15	11.31	

*Treatments with same letter within a row are not significantly different. Figures in brackets are square root transformed values. NS: Non significant, *Significant at P=0.05, CV: coefficient of variation, LSD: least significant difference, P: Probability.*

The main advantage of planting bulbils (bulblets) is that it allows growers to increase their planting stock very quickly and to produce bulblet seed stock free of soil borne diseases and increased vitality of strains that do not seem to be living up to their potential [7, 15]. The disadvantage is that it can take several years of successive planting to achieve good sized bulbs from the initial bulblet planting material.

4. CONCLUSION AND RECOMMENDATIONS

The results indicated that large cloves emerged earlier while small cloves and bulblets emerged later. Large cloves produced tallest and larger seedlings than small cloves and bulblets. The larger cloves produced plants with the highest flowering incidence, smaller cloves had the lowest flowering incidence and the bulblets were in between. The number of bulblets per flower was similar for bulblets and cloves. Larger cloves produced tallest plants in the field than smaller cloves or bulblets. Plants from large cloves produced higher yield than plants from small cloves or plants from bulblets, but the yield was not significantly different for the three propagation materials.

Planting material for most crops is currently limited in Zimbabwe. Garlic farmers may alternatively collect bulblets from their crop to use as planting material in the same way as they do with cloves. There is need to collect local, regional and international garlic germplasm for selection, breeding and *in vitro* multiplication to obtain, disease free relatively high quality and high yielding varieties suited to the various agro-ecological zones of the country and the region.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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