Effects of Seed Sowing Depth on Emergence and Early Seedling Development of Two African Indigenous Leafy Vegetables

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Abstract: Depth of sowing can affect early crop establishment due to poor seedling emergence. A glasshouse study was conducted to investigate the effects of sowing depths (1.5, 3.5, 7, 10, 15, 20, 25, 30 mm) on emergence and early seedling development of two each of African indigenous (Amaranthus hybridus & Cleome gynandra) and exotic (Spinacia oleracea & Brassica napus) leafy vegetables. A split plot design with four replicates was used. Exotic vegetables had significantly higher ($p<0.05$) seedling emergence (95%) than the indigenous ones (60%). Among the indigenous species, Cleome gynandra had a higher emergence (70%) than Amaranthus hybridus (61%). However, there were no significant differences on emergence amongst the exotic vegetables. Exotic vegetables also had significantly higher ($p<0.05$) mean plant height (8.6 cm) than indigenous vegetables (1.01 cm). In all the vegetable species, both emergence and plant height decreased with deeper sowing due to higher soil strength. The biomass yields of the seedlings were reduced with deeper sowing although the differences were not significant. There were however significant differences ($p<0.05$) among the biomass yields of the vegetable species at different sowing depths. Generally, significantly higher biomass yields (6.4 g/plant) were obtained in exotic species compared with indigenous ones (0.2 g/plant). The results suggest that seeds of African indigenous leafy vegetables were more sensitive than the exotic ones to deeper (>5 mm) sowing and their emergence was more adversely affected by soil strength at this depth. It is concluded that seeds of African indigenous vegetables should be sown at shallower depths (1-5 mm) in order to ensure rapid emergence and early establishment of seedlings if sown directly into the soil.

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Introduction

Indigenous leafy vegetables (ILVs) have the potential to provide a valuable source of nutrition in areas with hot, dry climates (Flyman and Afolayan, 2006). ILVs could fill a valuable niche in the production of food in rural areas especially where the climate is not conducive to the production of exotic vegetables. ILVs can play a significant role in addressing the problems of low income, malnutrition, poor health and loss of biodiversity among resource-poor households in sub-Saharan Africa (Smith and Eyzaguirre, 2007). However, the indigenous leafy vegetables of Africa are being displaced in many areas due to land degradation, leading to a decline in production, use and diversity of vegetables being grown. Most rural farming families in sub-Saharan Africa have traditionally made conscious efforts to preserve indigenous vegetables around their homesteads, in crop fields and communal lands (Smith and Eyzaguirre, 2007). The integration of indigenous vegetables into agricultural production systems of many countries in sub-Saharan Africa has been promoted as a practical and sustainable way to achieve dietary requirements (Aphane *et al.* 2002). This is because such vegetables are efficient sources of important micronutrients, with respect to cost of production per unit area. However, most of the information on the production of indigenous and traditional leafy vegetables tends to be anecdotal (Smith and Eyzaguirre, 2007. Very little is known about the production of African leafy vegetables.

Sowing depth is one of the important factors in crop management of field crops and vegetables (Campbell *et al.*, 1991; Kirby, 1993). The depth of sowing seeds is important as it contributes to achieving a good crop stand establishment and higher yields (Karayel and Ozmerzi, 2008). The use of optimum sowing depth is generally viewed as a desired goal for all crop establishment systems. Too shallow sowing results in poor germination due to inadequate soil moisture at the top soil layer (Desbiolles, 2002). On the other hand, deep sowing can also significantly reduce crop emergence and yield (Aikins *et al.*, 2006; Desbiolles, 2002; Mahdi *et* *al.,* 1998). Seedlings often fail to reach the surface when seeds are placed at uneven depths due to high soil strength that may develop above the seedling (Karayel and Ozmerzi, 2008). Although there is generally more information available of the sowing of exotic leafy vegetables and other field crops, there is limited information about the effect of seed sowing depth on African indigenous vegetables. Yagmur and Kaydan (2009) studied the effects of sowing depths (3, 5, 7, 9 cm) on grain yield and yield components of wheat cultivars in Eastern Turkey and found grain yield and yield components to be positively correlated with coleoptile length. The results showed a marked decline in grain yield and yield components among wheat varieties with shorter coleoptiles and deep sowing. The highest yield and grain yield (2.98 t ha^{-1}) were obtained with the cultivar sown at a depth of 5 cm while sowing at a depth of 9 cm significantly reduced grain yield of all the varieties tested.

Seedling emergence is influenced by the depth of sowing, as small seeded crops like those of *Amaranthus spp.* and Cleome *spp.* are very small and may exert limited axial growth pressure to support seedling emergence (Odeleye and Olufolaji, 2010). This limitation often restricts the depth from which many seedlings of leafy vegetables could emerge (Webb, et al., 1987). Odeleye and Olufolaji (2010) also reported that seedling emergence could be influenced by the type of soil since the development of soil strength has been shown to be influenced by the soil characteristics. Most small-scale farmers in the study area usually broadcast the seeds of the African leafy vegetables on the soil, a practice which exposes the seeds to the adverse conditions on the soil surface and reduces the establishment of the stands. Since *Amaranthus hybridus* and *Cleome gynandra* are the two commonly grown African leafy vegetables in the villages around Mafikeng, the aim of this study was to investigate the effects of seed sowing on the emergence and early seedling development of the two indigenous vegetables when compared with two exotic leafy vegetables which are also common in the area.

Material and Methods

A red sandy loam soil was collected from an uncultivated land at a depth of 0-20 cm using a garden spade from an area of about 0.5 ha. The soil was air dried and passed through 2 mm sieve in order to obtain uniform particles. The treatments consisted of a combination of four vegetable species (*Amaranthus hybridus*, *Cleome gynandra*, *Spinacia oleracia* and *Brassica napus*) and eight depths of sowing (1.5, 3.5, 7, 10, 15, 20, 25 and 30 mm) to give a total of 32 treatments. Each treatment was replicated four times in a split plot design. The main plot treatments were the eight depths of sowing and each main plot was split into four sub plots treatments of the four vegetable species. The seeds of each species were sown in rectangular seedling trays measuring 30 cm × 28 cm with 8 bottom holes. The soil in each tray was filled to 2 cm from the top and seeds were sown in rows spaced at 2.5 cm apart. The seeds were watered regularly to keep the soil at field capacity in a glasshouse and soil strength at each sowing depth in the tray was monitored by measuring the penetration resistance using a hand held penetrometer (Souty and Rode, 1993) once every week.

Seedling emergence in each tray was counted daily until there were no more seeds emerging. A seed was considered to have emerged if its cotyledon had reached 2 cm (Memon *et al*., 2007). Emergence percentage of seedlings for each treatment was calculated using the formula of Memon *et al.* (2007). After three weeks of growth, the height of seedlings in each tray was measured using a ruler. The height of shoots for each seedling was measured with a ruler before they were harvested by cutting the stem at the base. Shoot biomass was determined by weighing the shoots on a balance to obtain fresh mass. The shoots were placed in an envelope and dried in an oven set at 60˚C for 48 hours to obtain dry mass yield (Tamet *et al*., 1996). All the data was exposed to ANOVA using the General Linear Model (GLM) procedure of the Statistical Analysis System (SAS Institute., 2000). Tukey's test was used to compare treatment means (Harris, 1996).

Results

The ANOVA showed significant influences of both depth of sowing and vegetable species on all the parameters that were measured. There were also significant depth and species interactions on plant height of all vegetable species. The depth of sowing significantly ($p<0.0001$) influenced plant height in that the shallower sowing depths had the higher plant height (Table 1). Shoot biomass was also significantly affected ($p<0.0001$) with shallower sowing depths produced the highest biomass. The highest biomass was obtained in 3.5 mm and 10 mm sowing depths, followed by 1.5 mm and 7 mm respectively. The emergence percentage was affected by sowing depth significantly ($P<0.0001$). Sowing depth, 10 mm gave the highest (98) % emergence; followed by 3.5 mm sowing depth with 96%. The lowest (85%) value was obtained at 30 mm. The emergence percentage declined as the depth of sowing increased. The vegetable species also had significant (p<0.000) influence on plant height. The tallest (6.08 cm) plants were obtained from *B. napus* while the shortest (1.34 cm) plants were obtained from *C. gynandra* (Table 2). The shoot-biomass was equally significantly (p<0.0001) affected by vegetable species. The highest (3.9 g/plat) performance was recorded in *B. napus* followed by *S. oleracea* (4.46g/plant), *A. hybridus* (0.33g/plant) and the lowest performance was in *A. hybridus* (0.21g/plant). There was a significant influence (p<0.0001) of vegetable species on seedling emergence where S. *oleracea* gave the highest (99%) emergence while *A. hybridus* recorded the lowest (78%) emergence. *B. napus* and *C. gynandra* were 98% and 83% respectively.

The interactive effects of sowing depth and vegetable species on plant height showed superior performance by *B. napus* while *C. gynandra* was least (Fig. 1). The heights of *S. oleracea* and *A. hybridus* were intermediate across all sowing depths. The results suggest that the best sowing depth for the leafy vegetables were: *B. napus* and *S. oleracea* (3.5 mm), *A. hybridus* (1.5 mm) and *C.gynadra* (7mm). The performance of all the vegetables declined as the sowing depth increased. There were also significant interactive (p<0.01) effects of sowing depth and vegetable species on shoot biomass of seedlings. All vegetable species performed best when sown at 3.5 mm except for *C.gynandra* which showed superior performance when sown at 10mm. The interactive influence of sowing depth and vegetable species was highly significant (p<0.0001) on emergence of seedlings of all vegetable species. In all sowing depths, the highest percentage was obtained in *S. oleracea* while the lowest percentage was associated with *A. hyridus*. The emergence percentage of *B. napus* and *C. gynandra* were intermediate although *B. napus* outperformed *C. gynandra*.

Discussion and Conclusion

The short plants were obtained from sowing at deeper depths from 15mm-30mm. This may be attributed to extended time needed by the seedlings to push their shoots above the soil surface. The reason being that the deeper the seed is sown the more strength it needs to push its shoots above the soil surface (Nabi *et al.*, 2001). A number of previous studies (Tamet *et al.,* 1996; Nabi *et al.,* 2001; Shanmuganathan and Benjamin, 1992) showed that there is more soil resistance at deeper sowing levels. The findings of this study suggest that the best sowing depth for the studied vegetable species was 3.5mm except in *A. hybridus* at 1.5 mm. However, farmers in very hot regions can still use deeper sowing to avoid moisture loss as satisfactory percent emergence can still be obtained. The lowest mean value (0.090g/plant) of biomass yield was obtained from indigenous vegetable. Very small seeds take time to establish if sown at deeper sowing depths and this reduces biomass yield (Harris, 1996). Poor crop establishment is recognized as a constraint to crop production (Harris, 1996). The effect of sowing small seeds at deeper depths was explained by Odeleye and Olufolaji (2010) who suggested that for emergence to take place, the radical and hypocotyls have to develop a pressure to pierce through the soil. As the distance the hypocotyls has to traverse in the soil to the surface increases, the pressure that must be developed and utilized to pierce the soil also increases, while the inherent seed energy decreases.

The negative effects of deep sowing depth was also reported by Nabi *et al.* (2001) who found that seedling emergence of cotton seed was decreased with increased sowing depths. Seeds of cotton were sown at 23, 46 and 92 mm depth in each plot in a split plot design. Emergence in control plots decreased with increased sowing depth and there was no emergence from 92 mm. These results are also similar to those of Aikins and Afuakwa (2008) who showed that sowing depth affected mean seedling emergence, plant height, stem girth and dry matter yield of cowpea. Aikins and Afuakwa, (2008) found that sowing cowpea at a depth of 50 mm resulted in optimum growth and yield while 20, 30, 70 and 90 mm did not give good yield. This study showed significant interactions between sowing depth and vegetable species with most of the species performing well at 3.5 mm and lowest mean values were recorded at 30mm. This is similar to the findings of Odeleye and Olufolaji (2010) who found that *Amaranthus cruentus* and *Celosia argentea* performed best at 1.0 cm and emergence was poor at 3 cm. These results demonstrate that sowing depth affected seedling emergence, plant height and biomass yield of the crop.

Our results show that indigenous vegetables (*Amaranthus hybridus* and *Cleome gynandra*) performed well when sown at shallow depths in terms of seedling emergence, biomass and plant height but not be exposed on soil surface. This might have been caused by their smaller seed sizes. Different seed sizes of a cultivar having different levels of starch and other food storage may be one factor which influences the expression of physiological-dependent character of the seed (Shanmuganathan and Benjamin, 1992). Sowing at 3.5mm may be preferable for these indigenous species. It is suggested that with smaller seeds, shallow sowing depths are best. Sigh *et al.* (1972) reported that large seeds of soybean had greater supply of stored energy to support early seedling growth and subsequently affected plant growth and development. However, not all studies demonstrated positive effects of large seed-size on seed emergence in crops such as spring wheat (Lafond and Baker, 1986) and soybean (Edwards and Hartwing, 1971). Burrie *et al.* (1973) have argued that even though the largest seed sizes have the largest cotyledon area, the higher photosynthetic rate from smaller seed size could compensate and support seedling growth.

Seedlings from deep sown seeds produced low shoot biomass, very low plant height and low percent emergence and this effect was highly detectable in plants with smaller seeds. This might have been expected as deep sowing has been shown to have a number of consequences on seedling growth. These include, an increase in the time between seed germination and seedling emergence, an increased hypocotyls or epicotyls length, which reduces the probability of the seedlings being capable of overcoming soil-strength (Shanmuganathan and Benjamin, 1991). Exotic plants are also affected by increased sowing depths but establishment can be improved if additional moisture is available at deeper levels of the soil. It is concluded that the African indigenous leafy performed poorly compared with exotic ones with deeper sowing. It is thus recommended that the seeds of the former type should be sown as close as possible to the surface in order to encourage emergence and good early stand establishment.

Table 1. The effect of sowing depth on plant height, shoot-biomass and seedling emergence of various vegetable species

Sowing Depth (mm)	Plant Height (cm)	Shoot-Biomass (g)	Seedling Emergence (%)
1.5	5.09^{a}	2.62^{a}	93^{a}
3.5	5.11^{a}	2.75^{b}	96^{b}
7	4.95^{b}	2.52^{c}	93^{c}
10	4.97^{b}	2.75^{bd}	98^{d}
15	2.49^{c}	0.69^{e}	92^{e}
20	2.52^{c}	0.64^{e}	91^{f}
25	2.35^{d}	0.59^{e}	87^{g}
30	2.32^{db}	0.60^{e}	85^{h}
Mean	3.73	1.09	91.9
SEMD:	0.09	0.08	0.12

Means within a column with similar letter are not significantly different (p<0.01) by the Tukey's test ; SEMD = Standard Error of Mean Difference

Table 2. The effect of vegetable species on plant height, shoot-biomass and seedling emergence sown at different depths

Vegetable Species	Plant Height (cm)	Shoot-Biomass (g)	Seedling Emergence (%)
A. hybridus	3.03^{a}	0.33^{a}	78^{a}
C. gynandra	1.34^{b}	0.21^{b}	83^{b}
S. oleraceae	4.46^{c}	2.13^{c}	99^{c}
B. napus	6.08^{d}	3.90^{d}	98^{d}
Mean	3.73	1.64	89.5
SEMD:	0.06	0.07	0.1

Means within a column with similar letter are not significantly different (p<0.01) by the Tukey's test ; SEMD = Standard Error of Mean Difference

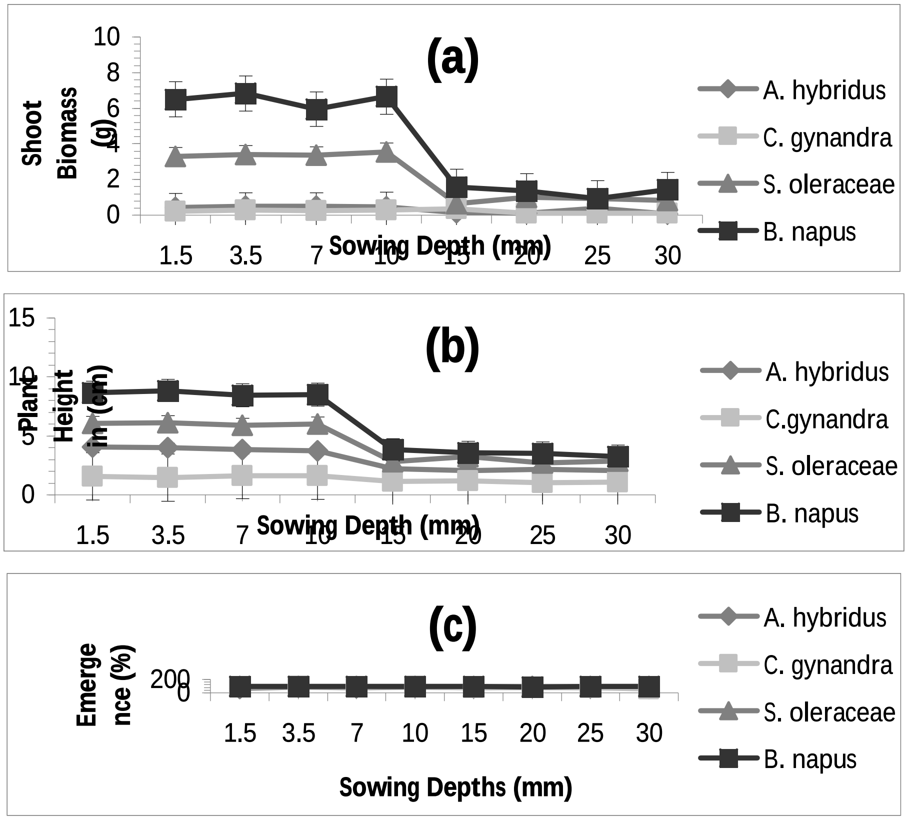

Figure 1.The interactive effect of sowing depth and species on plant height (a), shoot biomass (b) and percent emergence of various vegetables. Horizontal bars represent standard error of means.

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References

1. Aikins, S.H.M., Afuakwa, J.J. and Baidoo, D.: 2006. Effect of planting depth on maize stand establishment. Ghana Institute of Engineers 4(2):20-25.
2. Aikins, S.H.M. and Afuakwa, J.J.: 2008. Growth and dry matter yield responses of cowpea to different sowing depths. Agriculture and Biological Science 3:5-6.
3. Aphane, J., Chadha, M.L. and Oluoch, M.O.: 2002. Increasing the Consumption of Micronutrient-rich Foods through Production and Promotion of Indigenous Foods. AVRDC, Taiwan, pp 9.
4. Burris, J.S., Edje, O.T. and Wahab, A.H.: 1973. Effects of seed size on seedling performance in soybeans. 11. Seedling growth and photosynthesis and field performance. Crop Science 13:207-210.
5. Campbell, C.A., Selles, F., Zentner, R.P., Mcleod, J.G. and Dyck, FB.: 1991. Effect of seeding date, rate and depth on winter wheat grown on conventional fallow in S.W. Saskatchewan. Plant Science 71:51 - 61.
6. Desbiolles, J.:2002. Optimising Seedling Depth in the Paddock. Internet: http://www.unisa.edu.au/amrdc/Areas/Proj/SeedTrials/Seedingdeptharticle Kerribee.pdf Accessed on 15 August 2010.
7. Edwards, C.J. and Hartwig, E.F.: 1971. Effect of seed size upon rate of germination in soybeans. Agronomy Journal 63:429-430.
8. Flyman, M.V. and Afolayan, A.J.: 2006. The suitability of wild vegetables for alleviating human dietary deficiencies. Botany 72: 492-497
9. Harris, D.: 1996. The effects of manure, genotype, seed priming, depth and date of sowing on the emergence and early growth

of Sorghum bicolour (L.) Moench in semi-arid Botswana. Soil Tillage Research 40:73-88

10. Kirby, E.J.M.: 1993. Effect of sowing depth on seedling emergence, growth and development in barley and wheat. Field Crops Research 30: 101-111.
11. Lafond, G.P. and Baker, R.J.: 1986. Effect of genotype and seed size on speed of emergence and seedling vigour in nine spring wheat cultivars. Crop Science 26:341-346.
12. Madhi, L., Bel, C.J. and Ryan, J.: 1998. Establishment and yield of wheat (*Triticum turgidum* L.) after early sowing at various depths in a semi-arid Mediterranean environment. Field Crops Research 58: 187-196.
13. Memon, S.Q., Mirza, B.B. and Mari, G.R.: 2007. Tillage practices and effect of sowing methods on growth and yield of maize crop. Pakistan Agricultural Sciences 40 (3):89-100.
14. Nab,i G., Mullins, C.E., Montemayor, M.B. and Akhtar, M.S.: 2001. Germination and emergence of irrigated cotton in Pakistan in relation to sowing depth and physical properties of the seedbed. Soil Tillage Research 59:33-44.
15. Odeleye, F.O. and Olufolaji, A.O.: 2010. The performance of *Amaranthus cruenthus* and *Celosia argentea* as affected by varying sowing depths. Agriculture and Biology 1(6):1162-1168. Placement Accuracy and Emergence for a Precision Planter. Applied Agric. Engineering 24: 271-271.
16. SAS Institute Inc.: 2000. The Statistical Analysis Software (SAS). SAS Institute Inc., North Carolina.
17. Shanmuganathan, V. and Benjamin, L.R.: 1992. The influence of sowing depth and seed size on seedling emergence time and relative growth rate in spring cabbage (*Brassica oleracea* var, capitata L.). Annals of Botany 69:273-276.
18. Singh, J.N., Tripathi, S.K. and Negi, P.S.: 1972. Note on the effect of seed size on germination, growth and yield of soybean (Glycine max (L) Merr.). Indian Journal 42:83-86.
19. Smith, I.F. and Eyzaguirre, P.: 2007. African leafy vegetables: Their role in the World Health Organization’s global fruit and vegetables initiative. Plant Food 7: 3-5.
20. Souty, N. and Rode, C.: 1993. Emergence of sugar beet seedlings from under different obstacles. Agronomy J. 2: 213 – 221.
21. Tamet, V., Boiffin, J., Durr, C. and Souty, N.: 1996. Emergence and early growth of an epigeal seedling (*Daucus carota*): influence of soil temperature, sowing depth, soil crusting and seed weight. Soil Tillage Research 40:25-38
22. Yagmur, M. and Kaydan, M.: 2009. The effects of different sowing depth on grain yield and some grain yield components in wheat (*Triticum aestivum* L.) cultivars under dryland conditions. Afr. J. Biotechnology 8:196 – 20

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