Greener Journal of Agronomy, Forestry and Horticulture

ISSN: 2354-2306

Submitted: 05/05/2016
Accepted:09/05/2016
Published: 07/06/2016

DOI: http://doi.org/10.15580/GJAFH.2016.1.050616086

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Research Article (DOI: http://doi.org/10.15580/GJAFH.2016.1.050616086)

Effects of Different Sowing Methods on the Germination, Early Growth and Yield of *Echinops giganteus*

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ABSRACT

Background: Investigations were carried out on the effect of different sowing methods on seed germination, early seedlings growth and yield of E. giganteus. Seeds sowing methods is an important parameter that influence germination, early growth and yield of most crops species. Many authors have used several methods in this domain such as broadcasting, sowing single, sowing triple, drilling and variation in distance of sowing.

Methods: The sowing methods used were broadcasting (BC), sowing single (SS) and sowing triple (ST) respectively. The experiment was laid out in a split plot Complete Randomized Design (CRD) with 300 seeds for each sowing methods and three replicates. Seeds were sown on prepared germination beds with respect to various sowing methods. The plot was cleared, ploughed and partitioned following systematic random sampling. The plot was treated with a systemic fungicide and nematicide prior to sowing of seeds. Germination was monitored daily for a period of one month and data on latent period, germination percentage and germination speed was collected. Early growth parameters such as shoot height (H), collar diameter (CD), number of leaves (NL), root length (RL) and plant yield were measured every two weeks from the 11th to the 17th week.

Results: Germination commenced on the 5th day for seeds that were sown single and triple. Seeds broadcast started germinating from the 8th and 11th day. The germination period ranged from 5 to 20 days. Sowing methods significantly affected the cumulative germination percentage and plant yield ($p<0.05$).

Conclusion: Seeds sown triple had the highest germination percentage and plant yield. The germination speed, plant height, collar diameter, number of leaves and root length were not significant in all the sowing methods. Germination of E. giganteus seeds can be done based on the information given in this study.

Keywords: *Echinops giganteus*, germination, seeds, sowing methods.

LIST OF ABBREVIATIONS

ABS: Access and Benefit Sharing
BC: Broadcast
CD: Collar Diameter
PDB: Plant dry biomass
PFB: Plant fresh biomass
BP: Biomass Produced
CBD: Convention on Biodiversity
IRAD: Institute of Agricultural Research for and Development.
MAT: Mutual Agreement Term.
NGO: Non-Governmental Organisation.
NTFP: Non-Timber Forest Product
RL: Root Length
SS: Sowing Single
ST: Sowing Triple
WAS: Weeks after sowing.

INTRODUCTION

Seed germination and early seedling growth phases are considered critical for raising successful crop stand density and consequently the yield of resultant crop (Hossain *et al*., 2005). It is indicated that seed germination, seedling growth and survival percentage are governed by many intrinsic and extrinsic factors and are species specific (Murali, 1997; Gunaga *et al*., 2011). Therefore studies on factors that affect germination, survival percentage and seedling growth for a particular plant species are required.

The genus *Echinops* is of the *Asteraceae* family and consist of about 120 species distributed world-wide (Garnatje *et al*., 2004). The species *Echinops giganteus* is a perennial deciduous herb endemic to Cameroon and Nigeria. In Cameroon it has been discovered in three regions namely West, North West and South West (Mane and Nature, 2013). It is semi-woody at the base, pubescent and with a height of 1.20m.It has alternate, oblong, lanceolate, pinnately lobed leaves with very pointed acumen at the end of each lobe and the under surface of the leaves are greyish. The inflorescence is ball-like surrounded by bracts and scales with whitish florets, pointed style, hairy achene, pubescent with tiny tuft of whitish silk at the summit (Abdou *et al.,* 2012). The inflorescence and roots of several *Echinops* species have been traditionally employed in the Ethiopian, Cameroonian and Chinese folk medicine in the treatment of haemorrhoids and disorders related to the reproductive system due to their phytochemical properties (Menut *et al*., 1997). The root is highly exploited as a spice in culinary preparations and is commercialised in local markets (Noumi, 1984). It enriches the diet of man with carbohydrates, proteins, lipids, vitamins (carotenoids, ascorbic acid, vitamin E) and essential minerals such as calcium, iron, phosphorous and magnesium (Tchiegang and Mbougueng, 2010; Abdou *et al* 2012). The plant is also used to treat heart and gastric troubles (Tene *et al*., 2004). It has also been found to exhibit cytotoxicity (Kuete *et al*., 2011) and antibacterial (Fankam *et al*., 2011) properties, thus provide baseline information for its potential use in medicine.The root has aromatic properties and has been collected and distilled to obtain essential oil which is used in synergy with those from other plants to eradicate weevils in stored grains (Ngamo *et al*., 2007; Pérez *et al*., 2010). *E. giganteus* has been designated a non-forest timber product (NTFP) in the Congo Basin and the part exploited is the root (Tchatat, 1999, thus its propagation potentials is paramount for sustainability.

Several studies have been carried out on the effects of sowing methods on germination and growth performance of some plant species. Anjah *et al*., (2015a) reported that sowing methods had no significant effect on the germination and early growth of *Aframomum melegueta* in different growth media and varying temperature. Jehan *et al*., (2006) affirm that ridge planting affected growth and yield of *Zea mays* under different levels of fertilizer. It is important to plant accurately in order to achieve good germination, emergence and high plant population (Srivastava *et al*., 2006). The depth of sowing is important in maximising the potential of seedling emergence and crop yield. Uniform seed spacing and depth result in better germination and emergence and increase yield by minimizing competition between plants for available light, water, and nutrients (Karayel and Özmerzi, 2008).

Despite its socio-economic and pharmacological importance, knowledge on its propagation is still lacking. This study was aimed at investigating the possible seed sowing methods that will promote successful germination, early growth and yield of *Echinops giganteus*.

MATERIALS AND METHODS

Study Site

This study was carried out at the Institute of Agricultural Research for Development (IRAD) Bambui, Tubah Sud Division. IRAD Bambui is found in the Western Highlands and is the head quarter of Agro-ecological zone III in Cameroon. It is between latitudes 6 ^{0} 5' and 6 ^{0} 50' N and longitude 10 ^{0} 5' W and at an altitude of 1600m above sea level with an average minimum temperature of 14 ^{0}C and an average maximum temperature of 24.6 ^{0}C. The zone has two seasons, the dry season from November to February and the rainy season from March – October. Annual rainfall in this centre is about 2237mm distributed between mid- March and mid-November with a peak in July and August (Suh *et al*., 2015).

Preparation of Plot

A plot of 400 m^2 was cleared of all existing vegetation using a well sharpened cutlass. The coordinates of the four corners of the plot were taken using a GPS. This was followed by partitioning into the different main plots of 6m X 3m using 3m strips of plank. There were a total of nine main plots separated 30cm from each other. Tilling was carried out on the whole plot using hoes. Soil sterilisation was done using fungicide "calomil" and nematicide "bastion super". One sachet of calomil was mixed in 15litres of water and applied on plot using a sprayer of mark "matabi" while the nematicide was sprinkled on the plot manually with the hand. Nails were placed on the strip of plank 30cm apart and ropes tied from one end of the main plots to the other for demarcation. Sowing spot along the ropes were marked with red ink 30cm apart. Experimental design used was split plot complete randomized design (CRD)

Seed Collection and Viability Test

Seeds were collected on the 1st of February 2015 at Mbarenka Lebialem Division Western Highland of Cameroon. Mature fruits were collected from the mother plant growing in the wild, dried for two weeks under natural sunlight and preserved in polythene bags for later extraction of seeds. Three thousand mature seeds with grains were selected from the numerous seeds preserved. Three hundred seeds were randomly selected from three thousand selected seeds and subjected to a viability test by floatation method. The procedure permits the estimation of percentage of viable seeds in a lot. The seeds were placed in a bucket of water at room temperature (Wamegni, 1991; Schaal, 2000). The seeds that sunk down were classified as viable seeds, while those that floated were classified as non-viable.

Sowing Methods

Three sowing methods used were broadcasting (BC), sowing single (SS) and sowing triple (ST). These methods were chosen based on the ecology of the plant and to see if their variation may influence germination.

Sowing of Seeds Nursery Care

Seeds were sown in each plot according to the three sowing methods namely: broadcast (BC) that involved twenty seeds, sowing single (SS) involving twenty seeds and sowing triple (ST) that equally involved sixty seeds. Seeds broadcast were randomly spread throughout the plot. Seeds were sown at equidistance of 30cm by 30cm apart for SS, ST at uniform depth. Sowing methods were identified by labels using a bold marker. After sowing, weeding was done twice a month manually for seventeen weeks. The area was protected from domestic animals and other intruders. Germination was monitored daily for data collection.

DATA COLLECTION

The parameters measured were: Latent Period of germination (LP), Cumulative Germination Percentage (GP), Germination Speed (GS), Height of Shoot (H), Number of Leaves (NL), Collar Diameter (CD), Root Length (RL) and yield respectively.

Latent period of germination, germination percentage and germination speed were monitored daily after sowing for one month. For latent period, which is number of days taken for the first seed to germinate (Ahoton *et al.*, 2009), forty five seeds were randomly selected in each sowing methods and carefully observed for radicle emergence from the seed structures. Germination speed was based on counting the number of plumules that emerged while germination percentage was the total number of seeds that germinated at the end of observation in each sowing methods. The formulae below were adapted:

Germination Speed (GS): This is the average time for germination to occur,

$GS = \sum i\ n{=}1\ n_1/1{+}n_2/2{+}n_3/3....{+}n_x/x$ (Singh *et al.*, 2010).

Where $n_1 = n_x$ number of seeds germinated at day i (I = 1, 2, 3……x). i = number of days.

Germination Percentage (GP) = n ÷ N x 100 (Niang *et al.*, 2010).

Where N = $total\ number\ of\ seed$s $that\ were\ planted$ and n= $number\ of\ seeds\ that\ germinated$.

Height of shoot (H) and collar diameter (CD) were measured after every two weeks from the eleventh week for a period of 6 weeks. Twenty seven seedlings were randomly selected in each plot and tagged for data collection throughout the experiment. Thus a total of 207 plants were tagged. Height was measured using a metre rule from the base of the stem to the apex of the stem while collar diameter was measured 10cm above the ground using a calliper. Number of leaves on the stem was counted with respect to duration. At the 17th week, the seedlings were uprooted for measurement of root length and biomass. The root length was equally measured with a metre rule. Plant materials were separated into roots, stems and leaves and grouped with respect to planting method and fresh weight taken with an electronic balance (Mettler PE, 2000). The plant materials were put in envelops and transported in polythene bag to the Soil and Environment Laboratory at the University of Dschang for biomass measurement. In the laboratory, the plant materials were dried in an oven at 60 ^{0}C until a constant dry mass was obtained. When plant materials were removed from the oven, the dry biomass was calculated as follows.

BP = (Ldw + Sdw) + Rdw (Anjah *et al.*, 2015 b)

Where: BP = Biomass Produce
Ldw =Leaves dry weight; Sdw = Stem dry weight and Rdw = Root dry weight

DATA PROCESSING AND ANALYSIS

Germination data (LP, GS and GP) were analysed using Tables and figures. Data on phenology of germination were subjected to the Analysis of Variance (ANOVA) to determine degree of variation between planting methods using the statistical programme STATGRAPHIC where the least significant differences (LSD) between the mean were separated using the Duncan's New Multiple Range Test (DNMRT) at $p \leq 0.5$.

RESULTS

Seeds started germinating five day after sowing and continued for seventeen days after which no further germination was observed in all sowing methods. Out of the 2700 seeds sown, 1167 germinated with an overall percentage of 43.23%.

Latent Period

Radicle emergence from the seed structure after five days for seeds sown single (SS) and Sown triple (ST) while seed broadcast started germinating on the eighth and eleventh day.

Germination Percentage

This was significant in all sowing methods at $p<0.05$. Seed sown triple had the highest germination percentage (60.37) followed by those sown single (37.4) and lastly by seeds broadcast (24.62).

Germination Speed

This was not significant in all sowing methods ($p<0.05$). Seeds sown in groups had the highest germination speed (10.69) followed by seeds broadcast (8.30) and lastly by seeds sown single (5.98).

Plant Height

There was no significant difference in plant height in the sowing methods ($p<0.05$). Despite this, seeds sown in groups had the highest mean seedling of 24.38cm followed by those broadcast with a mean seedling height of 21.17cm and lastly by seeds sown single with a mean height of 20.51cm measured on the 11^{th}, 13^{th}, 15^{th} and 17^{th} week (figure 5). The pattern of evolution in height was similar in all sowing methods between the 11^{th} to the 13^{th} week, 13^{th} to the 15^{th} week, while seeds sown triple had a greater increment from the 15^{th} to the 17^{th} week compared to other sowing methods.

Collar Diameter

There was no significant difference in plant height with respect to sowing or planting method. Seeds sown triple had the highest collar diameter of 0.64cm while seeds sown single and those broadcast had the same maximum collar diameter. The pattern of evolution was uniform for seeds sown triple and seeds broadcast while seeds sown single had an increase between the 15^{th} and the 17^{th} week (figure 6).

Number of Leaves

There was no significant difference in the number of leaves throughout the duration of experiment for sowing methods. Also seedlings resulting from seeds sown triple had the highest number of leaves (4.09) followed by seedlings from seeds sown single and seeds broadcast (figure 7).

Root Length

There was no significant difference between the mean root lengths from one level of sowing method to another at the 95.0% confidence level. Seedlings from seeds sown single and triple had the highest mean root length 14.31 and 14.32cm respectively while seedlings from seeds broadcast had mean root length of 13.95 (figure 8).

Plant Biomass

Plant fresh and dry biomass was significant in all sowing methods. Seedlings from seeds sown triple had the highest fresh and dry biomass followed by those broadcast and least by seeds sown single (figure 9).

Figures and Tables

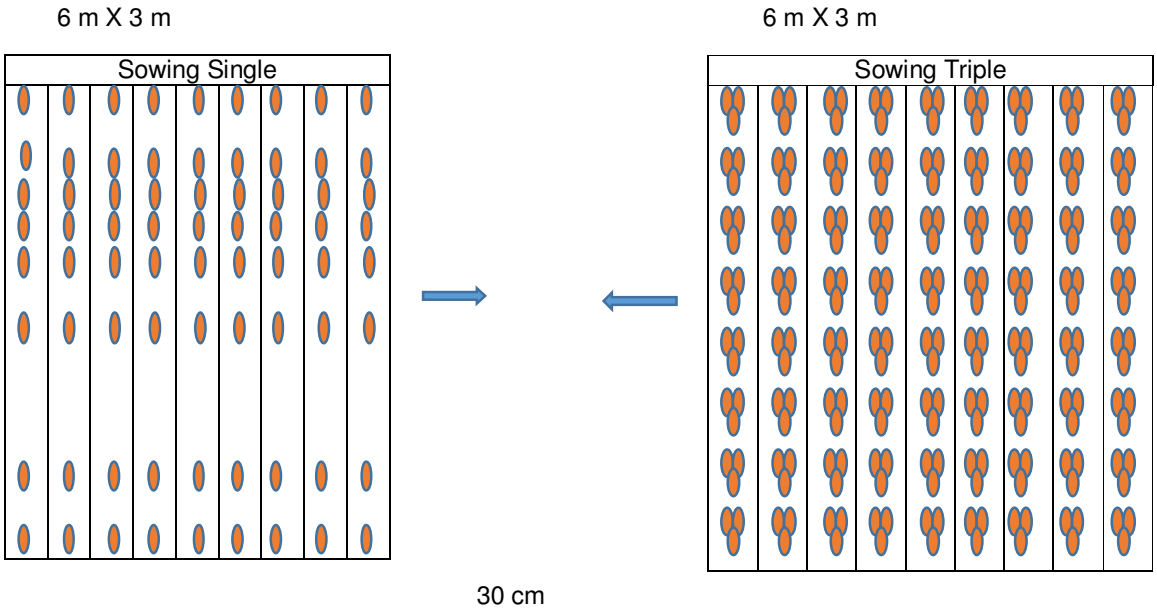

Figure 1: Experimental layout for the germination of *E. giganteus*

Figure 2: Emergence of the radicle from seed structure

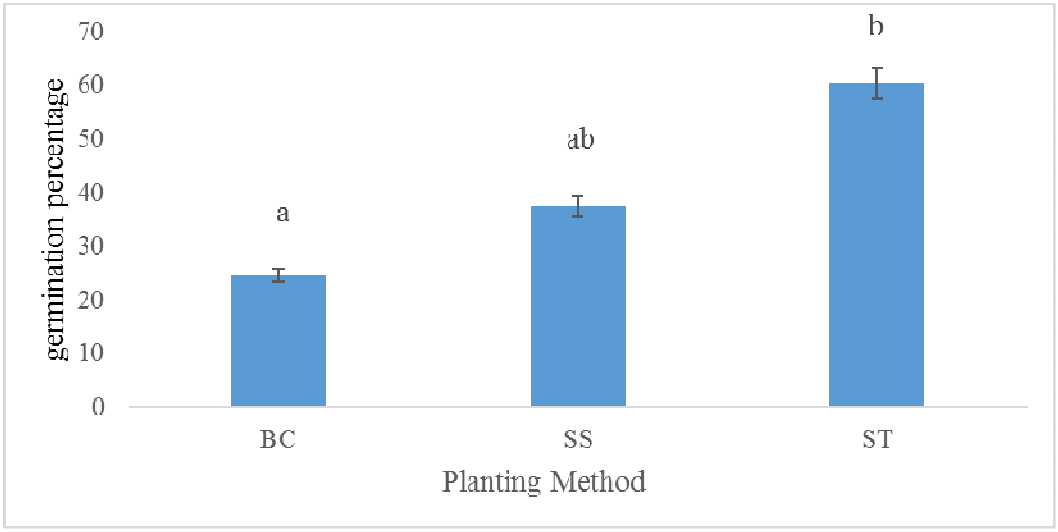

Figure 3: Effects of sowing methods on germination percentage of *Echinops giganteus* seeds

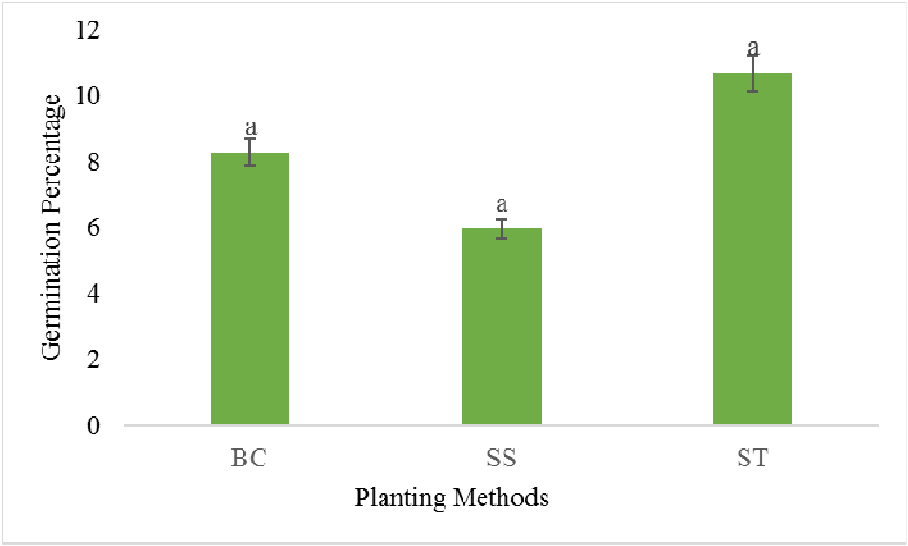

Figure 4: Effects of sowing methods on germination speed of *E. giganteus* seeds

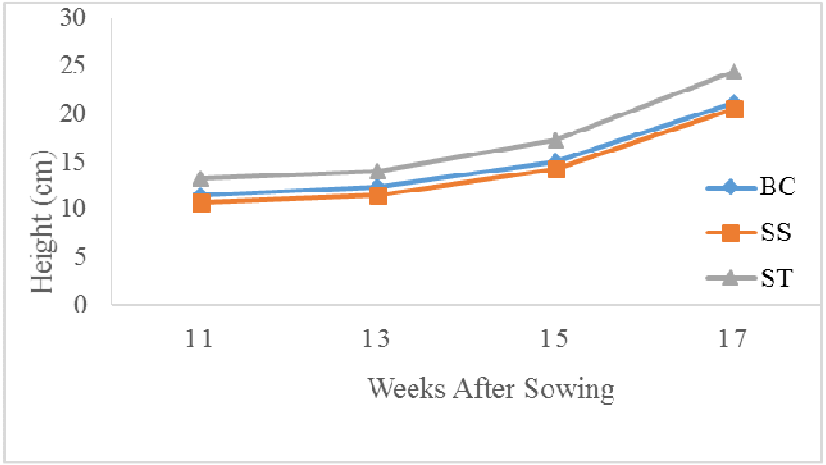

Figure 5: Effects of sowing methods on plant height

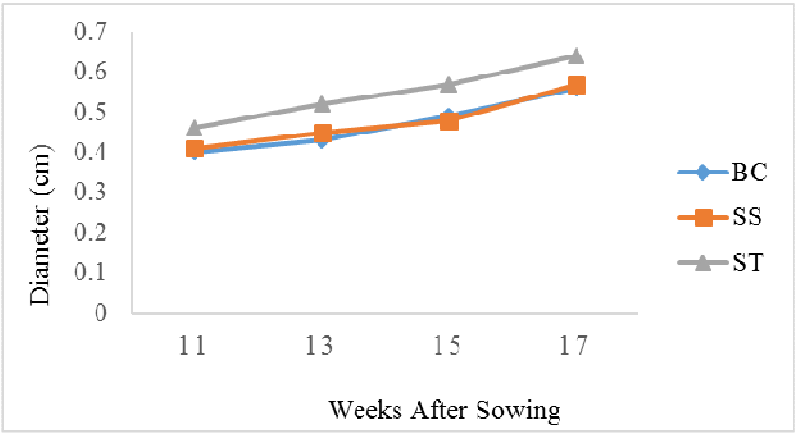

Figure 6: Effects of sowing methods on collar diameter

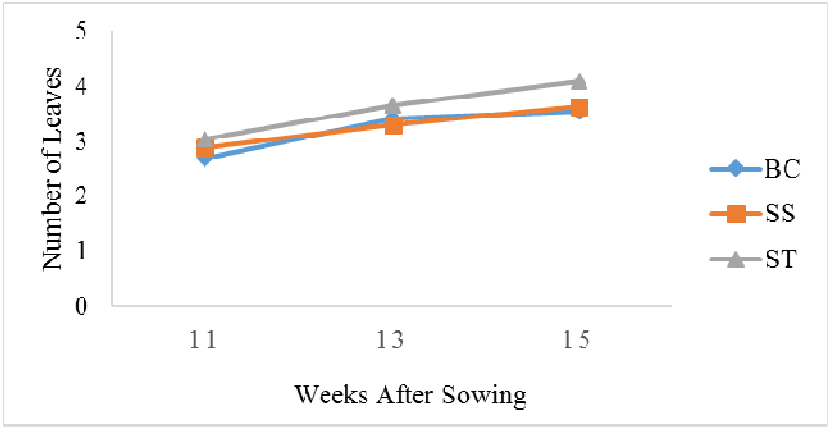

Figure 7: Effects of sowing methods on collar diameter

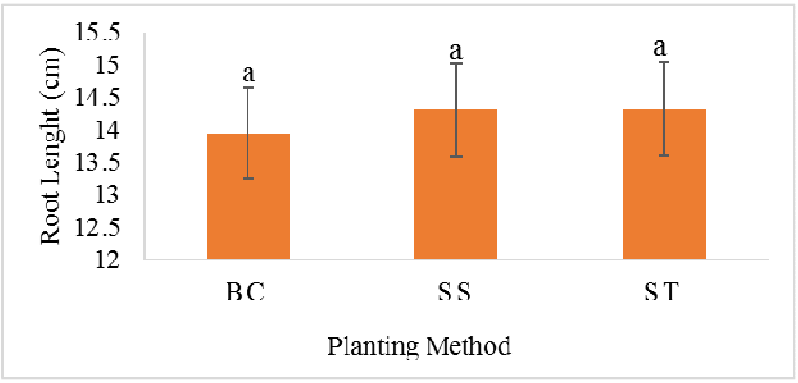

Figure 8: Effects of sowing methods on root length

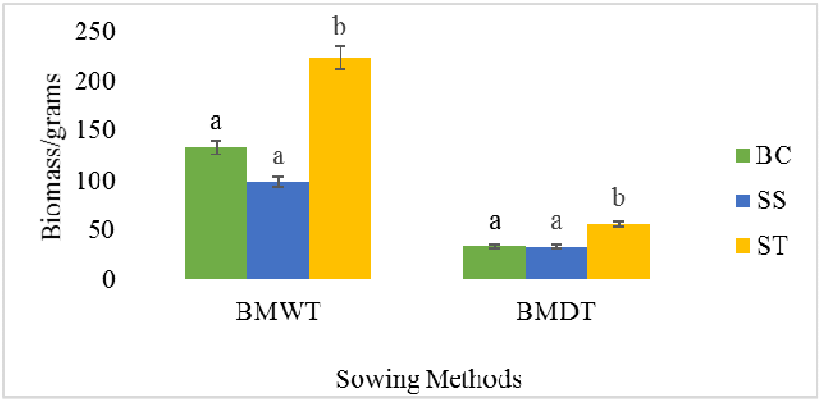

Figure 9: Effects of sowing methods on plant fresh and dry biomass

Tables

Tables 1: Cumulative germination percentage and germination speed in all planting methods

Planting	2d	5 d	8 d	11 d	14 d	17d	20 d	23 d	26 d	29 d	total	Germination %	Germination Speed
BC	0	2	40	73	116	149	165	173	173	173	173	32.04	8.30
SS	0	16	36	77	143	179	193	202	202	202	202	37.40	5.98
ST	0	45	81	149	237	287	312	326	326	326	326	60.37	10.69

Table 2: Mean plant height of seedlings in different planting methods

Planting	H11	H13	H15	H17
BC	11.50±0.98^{a}	12.29±0.98^{a}	15.01±1.25^{a}	21.17±1.84^{a}
SS	10.72±0.88^{a}	11.52±0.88^{a}	14.28±1.12^{a}	20.51±1.65^{a}
ST	13.21±0.89^{a}	14.04±0.90^{a}	17.25±1.18^{a}	24.38±1.79^{a}
F(p)	1.92(0.1539)	1.94(0.1501)	1.7(0.1886)	1.38(0.2579)

Table 3: Mean collar diameter of seedlings in different planting methods

Planting	CD11	CD13	CD15	CD17
BC	0.40±0.04^{a}	0.43±0.04^{a}	0.49±0.04^{a}	0.56±0.05^{a}
SS	0.41±0.03^{a}	0.45±0.03^{a}	0.48±0.04^{a}	0.57±0.05^{a}
ST	0.46±0.03^{a}	0.52±0.03^{a}	0.57±0.04^{a}	0.64±0.04^{a}
F(p)	0.88(0.4169)	1.30(0.2789)	1.21(0.3034)	0.72(0.4882)

Table 4: Mean root length and plant biomass of seedlings in different planting methods

Planting	RL	BMW	BMD
BC	13.95±1.02^{a}	133.64±18.87^{a}	33.78±4.45^{a}
SS	14.31±1.08^{a}	98.80±14.54^{a}	33.43±3.44^{a}
ST	14.32±1.11^{a}	223.80±26.92^{b}	56.12±7.82^{b}
F(p)	**0.04(0.9610)**	**9.66(0.0002)**	**5.45(0.0061)**

Table 5: Mean germination speed, percentage and number of leaves in all planting methods

Planting	NL11	NL13	NL15	GS	GP
BC	2.70±0.21[a]	3.40±0.30[a]	3.55±0.33[a]	8.30±1.90[a]	24.62±0.06[a]
SS	2.88±0.23[a]	3.30±0.27[a]	3.62±0.29[a]	5.98±1.65[a]	37.40±0.08[ab]
ST	3.04±0.20[a]	3.66±0.28[a]	4.09±0.32[a]	10.69±2.29[a]	60.37±0.11[b]
F(p)	0.63(0.5352)	0.42(0.6605)	0.85(0.4312)	1.43(0.2588)	4.05(0.0306)

DISCUSSION

Seeds that were sown single and triple germinated five days after sowing while those broadcast germinated eight days after sowing. Seeds that were sown germinated earlier maybe because they had sufficient contact with the soil moisture, thus favourable conditions for germination, while those broadcast were exposed and direct environmental hazards delay germination. Sowing methods might have influenced some morphological and physiological changes within the seeds favourable to natural environmental conditions to hasten germination. These results are similar to those of Anjah *et al*., (2015a) who had 7 days for *Aframomum melegueta* subjected to different sowing methods, varying temperature range and growth media. Rehydration causes early emergence due to the fact that all pre-germinative processes for germination had already occurred in seed. These results were similar with the findings of Farooq *et al*., (2009), who evaluated that mobilized antioxidant enzymes with subordinate oxidation in seeds retain seed vigour causing earlier emergence. The germination speed was not significant in all sowing methods.

Seedling height, collar diameter, number of leaves and root length were equally not significant in all sowing methods. Matin and Rashid, (2000) reported better height and diameter growth of seedlings of some multipurpose tree species at nursery stages in wet season than semi-wet and dry season. Since the field work took place in the wet season, sowing methods had little or no influence on these early growth parameters. The root length is an important parameter for studying the process of nutrient uptake of plant roots (Mabundza *et al*., 2010). In addition, the use of root length as a parameter encourages the possibility that relationships will be found between root length and development stages of the plant. However, when considering the efficiency of a root system for plant growth, root distribution in the soil profile is the more important factor rather than total root mass (Mabundza *et al*., 2010).

Plant fresh and dry biomass was significant in the sowing methods. Seeds sown triple had the highest fresh and dry biomass followed by seeds broadcast and lastly by seed sown single. Seeds sown triple had the highest plant density which contributed to its highest fresh and dry biomass of seedlings compared to other sowing methods. The dry biomass obtained in this study is similar to those of Anjah *et al*., (2015b) on the effects of organic and inorganic fertilizers on the regeneration of *Ricinodendron heudelotti*. This is also similar with the findings of Hassan *et al*., (2014) who found that narrower spacing increased the plant density and consequently the yield of *Mentha officinalis.*

CONCLUSION AND RECOMMENDATIONS

Results obtained in this experiment indicate that planting methods had a significant role in the germination, growth and development of the species. Seeds sown in groups had the best germination percentage and early growth characteristics followed by those sown single while seeds broadcast were the least. Germination of *E. giganteus* seeds can be done based on the information given in this study. The planting methods adopted in this study can be adopted by farmers in the cultivation of this species

To better the quality of this work the following are recommended:

- Further investigation on the effects of other planting methods on the germination and early growth of *E. giganteus* should be carried out.
- Propagation trials of *E. giganteus* using stem and root cuttings should be carried out.
- Effects substrates on germination, early growth and yield of *E. giganteus* should also be carried out.

COMPETING INTERESTS

The authors have declared no competing interest

AUTHORS' CONTRIBUTIONS

Nkemnkeng F.J[1] and Tacham W.N[2] carried out this work under the supervision of Anjah G. M, the corresponding author. Anjah G. M., designed the experiment and supervised the demarcation of the working site and plots. Nkemnkeng F.J[1] and Tacham W.N[2] collected the data on the field and worked with the statistician to analyze the data. All the authors participated in formatting the paper according to the Greener Journal instructions to author.

ACKNOWLEDGEMENTS

We are grateful to the Department of Plant Biology in the University of Dschang, Cameroon for the provision of space and facilities in the Laboratory for this study. Their financial, technical and guidance is appreciated. We also pay much allegiance to the Institute of Agricultural Research for Development (IRAD) Bambui, Tubah Sub Division for the land they provided for the field work and the equipment they gave for measuring parameters. The farmers of Mbarenka, Lebialem Division of the Western Highland of Cameroon are highly appreciated for the seeds they supplied for this work.

REFERENCES

Abdou B. A., Njintang N. Y., Harquin S. F., Scher J., Montet D. and Mbofung C. M. F., 2012. Proximate Composition, Mineral and Vitamin Content of Some Wild Plants Used as Spices in Cameroon. *Food and Nutrition Sciences*. 3: 423-432.

Ahoton L. E., Adgakpa B. G., Mpo F. M. et Akpo L. E., 2009. Effets des pre-traitements des semences sur la germination de *Prosopis africana* (*Caesalpiniaceae*). *Tropicultura* 4: 33-238.

Anjah G. M., Fotso. E., Tonjock R. K. and Ndikum V. M., 2015. Effects of three pre-treatment techniques on dormancy and Effects of varying temperatures, growth media and sowing methods on the germination of *Aframomum melegueta*. I*nt.J.Curr.Microbiol.App.Sci* 4 (3): 659-665.

Anjah G. M., Tabi F. O and Mvondo A. Z., 2015. Effects of organic and inorganic fertilizer on regeneration of seedlings of *Ricinodendron heudelotti* (Bail) Pierre et Pax. *International Journal of Biological and Chemical Sciences*, x(x): xxx-xxx.

Fankam A. G., Kuete V., Voukeng K. I., Kuiate R. J and Pages J-M., 2011. Antibacterial activities of selected Cameroonian spices and their synergistic effects with antibiotics against multidrug resistant phenotypes. 11: 1472-6882.

Garnatje T., Valle. J., Garcia S., Hidalgo O., Sanz M., Canela M. A. and Siljak-akovlev S., 2004. Genome size in Echinops L. and related genera (*Asteraceae* Cardueae): karyological, ecological and phylogenetic implications. *Biol Cell*; 96 (2):117-24.

Gunaga R. P., Doddabasava D and Vasudeva., 2011. Influence of seed size on germination and seedling growth in *Mammea Suriga*, Karnataka Journal of Agriculture and Science, 24: 415-416

Hassan E. S. K., Salim E. A., and Gaafer M. E. H., 2014. Effect of Spacing and Seasonal Variation on Growth Parameters, Yield and Oil Content of Mint Plants (*Mentha officinalis*). *Journal of Forest Products & Industries*, 3 (2), 71-74

Hossain M. A., Aref M. K., Khan B. M and Rahman M. A., 2005. Effects of seeds treatments on germination and seedling growth attributes of Horitikat (*Terminalia chebuba* Retz.) in the nursery, *International Journal of Agriculture and Biological Sciences*, 1: 135-141.

Jehan B., Shakee A., Mohammad T., Habib A and Shafi M., 2006. Response of Maize to Planting Methods and Fertilizer Nitrogen. *Journal of Agricultural and Biological Science,* 1 (3): 1-14

Karayel D. and Özmerzi A., (2008). Evaluation of three Depth Control Components on Seed Placement Accuracy and Emergence for a Precision Planter, *Applied Engineering in Agriculture*. 24 (3): 271–276.

Mabundza R. M., Wahome P. K. And. Masariramb M. T., 2010. Effects of Different Pre-germination Treatment Methods on the Germination of Passion (*Passiflora edulis*) Seeds, *J. Agric. Soc. Sci.*, 6 (3): 57-60.

Mane and Nature. 2013: Annual Report on the MAGIC BEHIND "Flavour and Fragrance".

Menut G., Lamaty P., Weyerstahl H., Marschall S. I. and Amvam -Zollo P. H., 1997. Aromatic plants of tropical Central Africa. Part XXXI. Tricyclic sesquiterpenes from the root essential oil of *Echinops giganteus* var. lelyi C. D. Adams. *Flavour Fragrance Journal*. 12 (6): 1026-1099.

Murali K.S., 1997. Patterns of seed size, germination and seed viability of tropical tree species in Southern India, *Biotropica*, 9 (3): 271-279.

Ngamo T. S. L., Ngatanko I., Ngassou M.B., Mapongmestem P. M. and Hance T., 2007. Insecticidal efficiency of essential oils of 5 aromatic plants tested both alone and in combination towards Sitophilus oryzae (L.) (*Coleoptera*: *Curculionidae*). *Res. J.Biol. Sci.*, 2 (1): 75-80.

Niang-Diop. F., Sambou B. and Lykkem A., 2010. Constraintes de regeneration naturelle de *Prosopsis africana*: Facteur affectant la germination des grains. *Institut des Science Anta Diop*. BP: 5005. Daker Fanna, Senegal. 4 (5): 1693-1705.

Noumi E., 1984. Les plantes à épices, à condiments et à aromates du Cameroun. Thèse de Doctorat en Sciences Biologiques, Université de Yaoundé. 22-24.

Pérez S. G., Ramos-López M. A., Zavala-Sánchez M. and Cárdenas-Ortega N. C., 2010. Activity of essential oils as a biorational alternative to control coleopteran insects in stored grains. *Journal of Medicinal Plants Research*. 4 (25): 2827-2835

Schaal B. A., 2000. 'Reproductive capacity and seed size in *Lopimiumtexenis*. *American Journal of Botany*. 6: 703-709.

Singh N. I., Verma A. A. and Chauhan S. G., 2010. Comparative Efficacy of Different Vigour Test Parameters of Pea (*Pisum sativum L*) Seed Testing. Libian Agriculture Res Center J. Int, 1 (5): 332-335.

Suh C., Meka S. S., Ngome A. F., Neba D. A., Kemngwa I. T., Sonkouat A. D. and Njualem D., 2015. Effects of organic and inorganic fertilizers on growth and yield of potato (*Solanum tuberosum* L.) in the western highlands of Cameroon. *Int J. of Development Res*, 05 (2): 3584-3588.

Srivastava A. K., Goering, C. E., Rohrbach, R. P and Buckmaster, D. R., (2006). Engineering Principles of Agricultural Machines, (2nd edn), *American Society of Agricultural and Biological Engineers*, Michigan.

Tchatat M., 1999. Produits Forestiers Autres que le Bois d'œuvre (PFAB): place dans l'aménagement durable des forêts denses humides d'Afrique Centrale. Projet regional de capitalisation et transfert des recherches sur les écosystèmes forestiers de l'Afrique humide. Série FORAFRI. Document 18. Yaoundé.

Tchiégang C. and Mbougueng D., 2010. Composition chimique des épices utilisées dans la réparation du na'a poh et du kui de l'Ouest Cameroun. *Tropicultura*. 23(4):193-200.

Tene M., Tane P., Sondengam. B. L., and Connolly J. D., 2004. "Lignans from the roots of *Echinops giganteus*," *Phytochemistry*, 65 (14): 2101–2105.

Wamegni J., 1991. Etude de la phénologie, des fruits, des graines et de la germination de Fagara macrophylla. Mémoire d'Ingénieur des Eaux et Forêts à l'Université de Dschang. Pp. 50.

Cite this Article: Anjah GM, Nkemnkeng FJ, Tacham WN (2016). Effects of Different Sowing Methods on the Germination, Early Growth and Yield of *Echinops giganteus*. Greener Journal of Agronomy, Forestry and Horticulture, 4(1): 001-011, http://doi.org/10.15580/GJAFH.2016.1.050616086