International Journal of Ecology and Environmental Sciences 46 (1): 1-6, 2020
ISSN: 0377-015X (Print); 2320-5199 (Online)

Growth, Yield and Economics of *Acorus calamus* L. as Influenced by Different Node Cuttings under Mid-Hill Conditions of Himachal Pradesh

Karma Gyalpo Bhutia[1] *, Meenu Sood[1#], Vinod Kumar[2], Pempa Lamu Bhutia[3] and Pradeepen Rai[4]

[1]*Department of Forest Products, Dr. Y.S. Parmar University of Horticulture and Forestry, Nauni, Solan-173230, Himachal Pradesh, India*
Email karmagbhutia29@gmail.com; # Email meenusood09@gmail.com

[2] *Rani Lakshmi Bai Central Agricultural University, Jhansi 284003, UP India.* Email: dilman.vinod@gmail.com

[3] *ICAR-Indian Institute of Soil and Water Conservation, Regional Centre, Chandigarh 160019, India.* Email bhutiapempa89@yahoo.in

[4] *Forest Ecology and Climate Change Division, Rain Forest Research Institute, Jorhat-785001, Assam, India.* Email pradeependilpali@gmail.com

* Corresponding author; Present address: *Forest Ecology and Climate Change Division, Rain Forest Research Institute, Jorhat-785001, Assam, India*

ABSTRACT

An experiment was conducted to study the effect of different node cuttings on growth, yield and economics of *Acorus calamus* L. The experiment was conducted at the experimental field of the Department of Forest Products, College of Forestry, Dr. Y S Parmar University of Horticulture and Forestry, Nauni, Solan (H.P.) during the year 2016-17. The study comprised of three different node cuttings *viz*., one node cutting (N_1), two node cutting (N_2) and three node cutting (N_3). The experiment was laid out in randomized block design with six replications. Data regarding growth and yield parameters such as plant height, number of leaves/plant, leaf length, leaf width, number of nodes/rhizome, rhizome length, rhizome diameter, fresh rhizome weight, dry rhizome weight, estimated fresh rhizome yield, estimated dry rhizome yield, essential oil content in fresh rhizome and estimated essential oil yield were recorded and economics was calculated. Among different node cuttings, three node cutting (N_3) significantly gave higher plant height (52.13 cm), number of leaves/plant (19.16), leaf length (48.10 cm), number of nodes/rhizome (24.82), rhizome length (12.21 cm), fresh rhizome weight/plant (28.13 g), dry rhizome weight/plant (13.78 g), estimated fresh rhizome yield (3.125 Mg ha), estimated dry rhizome yield (1.532 Mg ha) and estimated essential oil yield (16.80 kg/ha) than one node cutting (N_1) and two node cutting (N_2) whereas maximum benefit cost ratio was obtained in one node cutting (1.80) as compared to two node cutting (0.93) and three node cutting (0.79).

Key Words: *Acorus calamus*; Medicinal and Aromatic Plants; Himalayas; Essential Oil; Economics.

INTRODUCTION

Acorus calamus L. (Family: Acoraceae), commonly known as Sweet Flag, is a semi-aquatic, perennial, aromatic herb with creeping rhizomes that can grow up to 2 m tall (Divya et al. 2011). Native of Central Asia as well as Eastern Europe and also indigenous to the marshes of the mountains of India (Rungta 2012). In India, it is found in marshes, wild or cultivated, ascending the Himalayas up to 1800m in Sikkim and higher altitudes of Himachal Pradesh, Uttarakhand, Jammu and Kashmir and North Eastern States (Chauhan 1999, Kapoor 2001). This plant has thick and erect leaves which are very similar in appearance to those of an iris, but with edges that are crimped (Anonymous 2001). Rhizomes are cylindrical or may be compressed about 1.5 cm in diameter, smooth and whitish pink in colour (Chauhan 1999). Plants very rarely flower or set fruit, but when they do, the flowers are 3-8 cm long, cylindrical in shape, greenish brown and covered in a multitude of rounded spikes. The fruits are small and berry like, containing few seeds (Tiwari et al. 2010).

Sweet flag has a rich history dating back to early Greek and Roman medicine. In addition to its medicinal uses, sweet flag was the subject of superstition and poetry. Its leaves, rhizomes and its essential oil possess a wide range of pharmacological activities like anti-spasmodic, antioxidant, carminative, antidiabetes, anti-proliferative, immunosuppressive, hypolipidemic, mito-genic and anticarcinogenic etc (Devi and Ganjewala 2011). The rhizomes are widely used in many ailments like epilepsy, mental ailments, chronic diarrhoea, dysentery, bronchial catarrh, intermittent fevers and glandular, abdominal tumours, kidney and liver troubles, rheumatism, sinusitis and eczema. Mature leaves of this plant act as an insect repellant when cut up and stored in dry foods. In the Vedic periods, it was used as a rejuvenative agent for the brain and nervous systems which stimulates the power of self expression and intelligence (Singh et al. 2011). The fragrant leaves having smell of tangerine or citrus, were used on the floors of homes and churches to remove disagreeable odours and pests. The plant was initially distributed from the native range thorough trade and commerce. The rhizome was subsequently cultivated and plant spread by vegetative means (Greve 1971). The essential oils obtained from the rhizome are used medicinally, as flavouring in alcoholic beverage, as fragrant essences in perfume, sacred oil and for insecticidal properties (Bisht and Bhatt 2014).

Due to an increase in demand for medicinal use, it has been unscientifically and indiscriminately harvested from wild which resulted into rapid decreased in the wild population. Therefore, now it has been reported as an endangered species (Shetty and Shruthi 2015). This catastrophic decrease of sweet flag populations necessitates an immediate conservation of its genetic resources through its cultivation to meet the demand of raw materials. Sweet flag being a rhizomatous crop, rhizome sizes or different node cuttings have significant influence on growth and yield of the crop. No study has been conducted on node cuttings of *A. calamus* to assess their effects on growth, yields and economics so far.

Keeping in mind the above perspectives, the present investigation has been undertaken with the main objective to study the effect of different node cuttings on growth, yields and economics.

EXPERIMENTAL AREA

The present investigation was conducted in the experimental field of the Department of Forest Products, College of Forestry, Dr. Y S Parmar University of Horticulture and Forestry, Nauni, Solan (H.P.) during the year 2016-17. The experimental field is located at $30^0$52'N latitude and 70^0 11'E longitude and at an altitude of 1250 m above Mean Sea Level. Climate of the experimental area is hot during summer. The maximum temperature was 30.5 ^{0}C in May in 2016 and 30.5 ^{0}C in May 2017 during the study period. On the other hand winters were cold and accompanied by frost for few weeks. During the study period, the minimum tempe-rature was as: 2.3 ^{0}C in January 2016 and 3.1 ^{0}C in January 2017. The area gets most of the rainfall during monsoon and spring season. The maximum rainfall was 164.1 mm in August 2016 and 233.8 mm in August 2017 during the study period. There was no rainfall in October and November 2016 as well as in October 2017.

MATERIAL AND METHODS

The experiment was laid out in Randomized Block Design (RBD) in open conditions with 3 treatments *viz.*, one node cutting (N_1), two node cutting (N_2) and three node cutting (N_3) which were replicated six times. Healthy rhizomes were used as a planting material collected from surrounding areas of the experimental site. The rhizomes were planted in the field beds of size 1.8m x1.8m at 30x30 cm spacings. Irrigation was done till the establishment of plants and thereafter plants were left to grow under rainfed condition. The field was kept weeds free by doing manual weeding operation. Data on different growth and yield parameters were recorded for at least five plants per replication at harvesting time and has been reported as average. The mean data collected for various parameters were subjected to simple statistical analysis. The standard error was determined by the method given by Gomez and Gomez (1984).

RESULTS AND DISCUSSION

Growth and Yield Parameters of *A. Calamus* L.

Different node cuttings significantly affected most of the growth and yield parameters measured. Plant height was significantly influenced by different node cuttings during the study period is presented in (Table 1). Among different node cuttings, three node cutting (N_3) recorded the highest plant height (52.13 cm) and was followed by N_2 (48.96 cm) and N_1 (47.10 cm) respectively, this may be due to the reason that larger rhizome size contains larger amount of food reserves that encouraged vigorous plant growth which ultimately resulted in a taller plant. This finding is in accordance and in conformity with the findings of Kumar (2005) in ginger, Padmadevi et al. (2012) and Angami et al. (2017) in turmeric.

Number of leaves/ plant was significantly affected by different node cuttings is presented in (Table 1). Plants arising from three node cutting (N_3) gave highest number of leaves/ plant (19.16) among the different node cuttings. It might be due to fact that three node cutting being larger rhizome size having more reserved food material than those smaller rhizomes because of which three node cutting produced more leaves than the other node cuttings. This finding is similar with the findings of Asish and Wamanan (1989), Korla et al. (1989) and Islam et al. (2017) in ginger.

In respect to leaf length, different node cuttings had significant effects on leaf length is presented in (Table 1). Among different node cuttings, three node cutting (N_3) recorded the highest leaf length (48.10 cm) which was followed by N_2 (45.15 cm) and N_1 (43.31 cm). This result is in agreement with the reports of Angami et al. (2017) in turmeric, Asafa and Akanbi (2018) in ginger. The effect of different node cuttings on leaf width was found to be non-significant (Table 1).

Number of nodes/rhizome and rhizome length were significantly affected by different node cuttings are presented in (Table 1). Among different node cuttings, three node cutting (N_3) recorded maximum number of nodes per rhizome (24.82) which was followed by N_2 (22.28) and N_1 (20.56). This result is in consensus with the report of Asafa and Akanbi (2018) in ginger. Highest rhizome length (12.21 cm) was also recorded in three node cutting (N_3) which was followed by N_2 (9.58 cm) and N_1 (8.92 cm). The significant increased in rhizome length with an increase in number of node cuttings might be ascribed due to increase in number of node or rhizome size used for planting. This result is in accordance with the previous findings of Hailemichael and Tesfaye (2008) and Mahender et al. (2015) in ginger. However, rhizome diameter did not affect by different node cuttings (Table 1).

Fresh rhizome weight/plant, dry rhizome weight/ plant, estimated fresh rhizome yield, estimated dry rhizome yield and estimated essential oil yield were significantly affected by different node cuttings are presented in (Table 2). Among different node cuttings, three node cutting (N_3) recorded the highest fresh rhizome weight/plant (28.13 g), dry rhizome weight/plant (13.78 g), estimated fresh rhizome yield (31.25 q/ha), estimated dry rhizome yield (15.32 q/ha) and estimated essential oil yield (16.80 kg/ha) while non-significant difference among different node cuttings on essential oil content in fresh rhizome was observed. Rhizome weight/plant, estimated rhizome yield and estimated essential oil yield increased with an increase in number of nodes or rhizome size. This may be due to the fact that larger size rhizome contains more food reserves and showed vigorous growth which resulted in producing maximum yield as compared to smaller size rhizomes. These findings agree with the previous reports of Monnaf et al. (2010), Sengupta and Dasgupta (2011) and

Table 1. Effect of different node cuttings on growth of *A. calamus* L.

Treatment	Plant height (cm)	No.of leaves per plant	Leaf length (cm)	Leaf width (cm)	Number of nodes per rhizome	Rhizome length (cm)	Rhizome diameter (cm)
One node cutting (N_1)	47.10	17.29	43.31	1.36	20.56	8.92	1.18
Two node cutting (N_2)	48.96	15.68	45.15	1.39	22.28	9.58	1.20
Three node cutting (N_3)	52.13	19.16	48.10	1.40	24.82	12.21	1.22
$CD_{0.05}$	`1.93	2.29	2.15	NS	2.18	0.50	NS
CV %	3.00	10.12	3.63	1.92	7.43	3.73	2.80
SE±	0.60	0.72	0.68	0.01	0.68	0.16	0.01

Table 2. Effect of different node cuttings on yield parameters of *A. calamus* L.

Treatments	Rhizome weight (g plant^{-1})		Rhizome yield (q/ha)		Oil content (%)	Essential oil yield
	Fresh	Dry	Fresh	Dry	(% fresh wt)	(kg ha^{-1})
One node cutting (N_1)	21.84	10.48	24.26	11.65	0.47	11.51
Two node cutting (N_2)	23.04	11.06	25.60	12.29	0.50	12.93
Three node cutting (N_3)	28.13	13.78	31.25	15.32	0.54	16.80
$CD_{0.05}$	3.64	1.75	4.04	1.95	NS	3.77
CV %	11.47	11.41	11.47	11.43	15.65	21.06
SE±	1.14	0.55	1.27	0.61	0.03	1.18

Table 3. Economics of cultivation, yield, gross income and benefit cost ratio of *A. calamus* L.

Treatments	Cost of cultivation Rs ha	Dry rhizome yield kg ha	Average Price Rs kg	Gross Income Rs ha	Net Income Rs ha	Benefit cost ratio
One node cutting (N_1)	35,356	1165	85	99,025	63,669	1.80
Two node cutting (N_2)	54,023	1229	85	1.04,465	50,442	0.93
Three node cutting (N_3)	72,773	1532	85	1,30,220	57,447	0.79

Mahender et al. (2015) in ginger. Muruga-nandam and Mohideen (2007) also reported similar results in *Gloriosa superba* where they found that the plants raised from 51-70 g tubers recorded the highest seed yield with favourable pod characters compared to 31-50 g and less than 30 g. These results also correspond with the earlier findings of Mahender et al. (2015) in Ginger and Kumar and Gill (2010) in Turmeric where they reported that the higher essential oil yield in plants arising from three node cutting (N_3) is due to higher rhizome yield obtained from three node cutting.

Economics of *A. Calamus* L. Cultivation

Cost and return are two most important indicators to evaluate the economic feasibility of an activity. The cost of cultivation of *A. calamus,* under different treatments was estimated and presented in Table 3. It can be inferred from the table that the cost of cultivation among different treatments varied from Rs.35,356 (N_1) to Rs.72,773 (N_3). In order to decide about the best economic treatment benefit-cost ratio over variable cost were estimated and results have been presented in Table 3. Treatment-wise yield of dry rhizomes varied from 1165 kg/ha (N_1) to 1532 kg/ha (N_3) among different treatments. An average price of Rs 85 per kg was assumed for the present analysis.

Since the rhizome is the planting material as well as the economic yield of *A. calamus,* therefore, it is necessary to consider the size of the planting material that is economically feasible to the grower. In present investigations maximum benefit-cost ratio (1.80) was observed in one node cutting (N_1) and minimum was recorded in three node cutting (N_3) (0.79) despite of giving maximum rhizome yield. This may be due to higher cost of cultivation involved for the planting material.

Present findings are in consensus with the findings of Ghosh and Hore (2011), they reported that maximum cost of cultivation (Rs. 81,365) and gross return (Rs.1,51,177) was recorded with bigger seed rhizome as planting material whereas maximum net return (Rs. 74,884) and benefit : cost ratio (1.10) was recorded with smaller seed rhizome in ginger. Hossain et al. (2011) reported that the maximum benefit cost ratio of 5.09 with large sized ¼ th cut tuber followed by small sized whole tubers, whereas minimum benefit cost ratio of 2.08 was recorded with large sized whole tubers in potato. These results are also in agreement with the present findings. Cost of cultivation as well as returns were higher when elephant-foot yam was grown with bigger size of planting material. However, maximum benefit:cost ratio was associated with small size planting material (Ghosh et al. 2008). Datta et al. (2017) reported that higher cost of cultivation (Rs.84,038) and gross return (Rs.1,56,246) were obtained from rhizome size (30-35 g) as compared to cost of cultivation (Rs.71,118) and gross return (Rs.1,468,86) from rhizome size (20-25 g) whereas higher net return (Rs.75,767) and benefit-cost ratio (2.06) were obtained from rhizome size (20-25 g) compared to net return (Rs.72,2080) and benefit-cost ratio (1.85) obtained from rhizome size (30-35 g) in ginger which are in line with the present findings.

CONCLUSION

This study concluded that different node cuttings significantly affected most of the growth and yield parameters of *A. calamus* L. Although the growth and yield parameters of *A. calamus* L. were increased when three node cuttings were used whereas maximum benefit cost ratio was observed in one node cutting. Therefore, our findings from this study suggested that the use of one node cutting is an economically viable option for the cultivation of *A. calamus* L.

ACKNOWLEDGEMENTS

We acknowledge the support and facilities rendered by the Department of Forest Products, Dr. Y.S. Parmar University of Horticulture and Forestry, Solan, Himachal Pradesh, India for conducting this study and also the Ministry of Tribal Affairs, Government of India for providing the financial assistance during the study period.

Conflict of Interest: No actual or potential conflict of interest including any financial, personal or other relationships with other people or organizations is to be declared.

Author Contributions: KG Bhutia and M Sood conceived and designed the experiment, KGBhutia and PLBhutia performed the experiment and documented the data, V Kumar and PRai analysed the data, MSood provided all the materials required in the experiments and all five authors contributed in preparation of the manuscript.

REFERENCES

Angami, T.; Kalita, H.; Touthang, L.; Chandra, A.; Devi, H.L.; Baruah, S.; Bam, B. and Khatoon, A. 2017. Assessing the suitability of turmeric seed rhizome sizes on biometric and qualitative traits under mid hill conditions. Journal of Experimental Biology and Agricultural Sciences 5(5): 631-635.

Anonymous. 2001. The Wealth of India A Dictionary of Indian Raw Materials & Industrial Products: First Supplement Series (Raw Materials). Vol.I. New Delhi, India, National Institute of Science Communication. Pages 28-30.

Asafa, R.F. and Akanbi, W.B. 2018. Growth and rhizome yield of Ginger (*Zingiber officinale* L.) as influenced by propagule size and nitrogen levels in Ogbomoso, Southwestern Nigeria. International Letters of Natural Sciences 67: 35-45.

Asish, R. and Wamanan, P.P. 1989. Effect of seed rhizome size on growth and yield of ginger (*Zingiber officinale* Rosc). Journal of Advancements in Plant Science 2(1): 62-66.

Bisht, A.S. and Bhatt, A.B. 2014. Effect of hormonal and soil treatment on the growth performance of valuable medicinal plant *Acorus calamus* Linn. World Journal of Pharmacy and Pharmaceutical Sciences 3(1): 1156-1168.

Chauhan, N.S. 1999. *Acorus calamus*. In: Medicinal and Aromatic Plants of Himachal Pradesh, Indus Publishing Company, New Delhi. Pages 72-76.

Datta, N.; Ghosh, D.K. and Sarkar, T. 2017. Effect of different seed rate and spacing on yield and economics of ginger (*Zingiber officinale* Rosc) cultivation. International Journal of Current Microbiology and Applied Sciences 6: 1120-1125.

Devi, S.A. and Ganjewala, D. 2011. Antioxidant activities of methanolic extracts of sweet-flag (*Acorus calamus*) leaves and rhizomes. Journal of Herbs, Spices and Medicinal Plants 17: 1-11.

Divya, G.S,; Gajalakshmi, S.; Mythili, N. and Sathiavelu, A. 2011. Pharmacological activities of *Acorus calamus*: A Review. Asian Journal of Biochemical and Pharmaceutical Research 1(4): 57-64.

Ghosh, D.K.; Hore, J.K.; Bandopadhyay, A. and Maji, M.K. 2008. Effect of spacing and seed corm size of elephant foot yam on economics of a coconut based cropping system. Journal of Crop and Weed 4: 15-19.

Ghosh, D.K. and Hore, J.K. 2011. Economics of a coconut-based inter-cropping system as influenced by spacing and seed rhizome size of ginger. Indian Journal of Horticulture 68: 449-452.

Gomez, K.A. and Gomez, A.A. 1984. Statistical Procedures for Agricultural Research. 2nd edition. John Wiley, New York. 680 pages.

Greve, M. 1971. A Modern Herbal. Vol. II. Dover Publications, NewYork. 544 pages.

Hailemichael, G. and Tesfaye, T. 2008. The effect of seed rhizome size on the growth, yield and economic return of ginger (*Zingiber officinale*). Asian Journal of Plant Sciences 7(2): 213-217.

Hossain, M.S.; Zakaria, M.; Hossain, M.M. and Rashid, M.H. 2011. Effect of seed size and cutting methods on yield and profitability of potato. The Agriculturist 9: 54-62.

Islam, M.A.; Naber, M.S.; Fahim, A.H.F. and Kakon, A. 2017. Growth and yield of ginger influenced by different rhizome size and spacing. International Journal of Agricultural Papers 2(1): 24-30.

Kapoor, L.D. 2001. Handbook of Ayurvedic Medicinal Plants, CRC Press, London. 424 pages.

Korla, B.N.; Rattan, R.S. and Dohroo, N.P. 1989. Effect of seed rhizome size on growth and yield in ginger. Indian Cocoa, Arecanut and Spices Journal 13(2): 47-48.

Kumar, B. 2005. Growth and Yield of Turmeric (*Curcuma longa* L.) as Affected by Different Agronomic Practices. Ph.D. Thesis, Department of Agriculture, Punjab Agriculture University, Ludhiana, Punjab. 127 pages.

Kumar, B and Gill, B.S. 2010. Growth, yield and quality of turmeric (*Curcuma longa* L.) as influenced by planting method, plant density and planting material. Journal of Spices and Aromatic Crops 19: 42-49.

Mahender, B.; Reddy, P.S.S.; Sivaram, G.T.; Balakrishna, M. and Prathap, B. 2015. Effect of seed rhizome size and plant spacing on growth, yield and quality of ginger (*Zingiber officinale* rosc.) under coconut cropping system. Plant Archives 15(2): 769-774.

Monnaf, M.A.; Rahim, M.A.; Hossain, M.M.A. and Alam, M.S. 2010. Effect of planting method and rhizome size on the growth and yield of ginger. Journal of Agroforestry Environment Science 4(2): 73-76.

Muruganandam, C. and Mohideen, M.K. 2007. Effect of tuber size on growth, flowering and yield of glory lily (*Gloriosa superba* L.). Plant Archives 7: 187-189.

Padmadevi, K.; JeevaJothi, L.; Ponnuswami, V.; Durgavathi, V. and Rijwana, P.I. 2012. Effect of different grades of rhizomes on growth and yield of turmeric (*Curcuma longa* L.) The Asian Journal of Horticulture 7: 465-467.

Rungta, H. 2012. Antiinflammatory property of sweet flag http//: www. agriinfotech. com/ htm/HERBS/Antiinflammatory.

Sengupta, D.K. and Dasgupta, B. 2011. Effect of weight of planting material on growth and yield of ginger (*Zingiber officinale* Rosc.) in the hilly region of Darjeeling district. Environment and Ecology 29(2): 666-669.

Shetty, G.R. and Shruthi, A.M. 2015. A Review on pharmacology of *Acorus calamus* – An endangered medicinal plant. International Journal of Pharma and Bio Sciences 6: 605-621.

Singh, R.; Sharma, P.K. and Malviya, R. 2011. Pharmacological properties and ayurvedic value of Indian buch plant (*Acorus calamus*): A short review. Advances in Biological Research 5: 145-154.

Tiwari, N.; Chaudhary, A. and Mishra, A. 2010. Ethnopharmacological aspect of *Acorus calamus*: A Review. Pharmacology online 2: 435-445.

Received 26 October 2019
Accepted 12 February 2020