International Journal of Chemical Studies

P-ISSN: 2349–8528
E-ISSN: 2321–4902
IJCS 2018; 6(6): 1608-1614

Received: 21-09-2018
Accepted: 24-10-2018

Karma Gyalpo Bhutia
Department of Forest Products, College of Forestry, Dr. Y.S. Parmar University of Horticulture and Forestry, Nauni, Solan, Himachal Pradesh, India

Meenu Sood
Department of Forest Products, College of Forestry, Dr. Y.S. Parmar University of Horticulture and Forestry, Nauni, Solan, Himachal Pradesh, India

Pempa Lamu Bhutia
ICAR, Indian Institute of Soil and Water Conservation, Dehradun, Uttarakhand, India

Correspondence
Karma Gyalpo Bhutia
Department of Forest Products, College of Forestry, Dr. Y.S. Parmar University of Horticulture and Forestry, Nauni, Solan, Himachal Pradesh, India

The effect of different planting time and harvesting schedules on growth and yield of *Acorus calamus*

Karma Gyalpo Bhutia, Meenu Sood and Pempa Lamu Bhutia

Abstract
An experiment was conducted to study the effect of different planting time and harvesting schedules on growth and yield of *Acorus calamus*. The experiment was conducted at the experimental field of the Department of Forest Products, College of Forestry, Dr. YS Parmar University of Horticulture and Forestry, Nauni, Solan (H.P.) during the year 2016-17. The study comprised of six treatments *viz*., planting in March and harvesting after 12 months (P_1H_1), planting in March and harvesting after 18 months (P_1H_2), planting in July and harvesting after 12 months (P_2H_1), planting in July and harvesting after 18 months (P_2H_2), planting in November and harvesting after 12 months (P_3H_1) and planting in November and harvesting after 18 months (P_3H_2). The experiment was laid out in randomized block design with three replications. Data regarding growth parameters such as plant height, number of leaves/plant, leaf length and leaf width; rhizome yield components such as rhizome length, rhizome with, rhizomes weight/plant and rhizome yield were recorded. Significantly higher plant height (55.92 cm), number of leaves/plant (15.34), leaf length (50.02 cm), leaf width (1.38 cm), rhizome length (15.44 cm), rhizome width (1.21 cm), rhizomes weight/plant (28.28 g) and rhizome yield (31.42 q/ha) were recorded when crop was planted in July compared to March and November planting. Crop harvested after 18 months of planting recorded significantly higher plant height (57.26 cm), number of leaves/plant (14.47), leaf length (50.37 cm), leaf width (1.39 cm), rhizome length (15.41 cm), rhizome width (1.22 cm), rhizomes weight/plant (29.74 g) and rhizome yield (33.05 q/ha) compared to harvested after 12 months of planting.

Keywords: *Acorus calamus*, planting time, harvesting schedules, growth parameters, yield

Introduction
Acorus calamus is an important medicinal plant species commonly known as ‘‘Sweet flag’’ and belonging to family Acoraceae. It is a perennial herb with a creeping and much branched aromatic rhizome (Kapoor, 1990) [1]. The plant is found in the northern temperate and subtropical regions of Asia, North America, and Europe. This plant prefers swampy or marshy habitats. It is found in marshes, wild or cultivated, ascending the Himalayas up to 1800 m in Sikkim. It is cultivated throughout India in the marshy tracts of Kashmir, Sirmaur (Himachal Pradesh), Manipur, in Nagahills and in the Koratagere taluka of Karnataka state in peninsular India (Raja *et al*., 2009) [1]. It possesses sword-shaped, long slender leaves that fan out from a pinkish base and grow up to 1.5m in length (Mukherjee *et al*., 2007) [3]. The flowers are very rarely grown in this plant if grown than it is about 3-8cm long, cylindrical in shape greenish brown in color and covered with the multitudes of rounded spikes. They are small, sessile, densely packed and 5-10 cm of spadix on all sides (Archana *et al*., 2015) [4]. The rhizomes are branched, possess strong aromatic odour, bitter in taste, light-brown or occasionally orange-brown in color, cylindrical to flat with distinct nodes and internodes (Anonymous, 2001) [5]. Sweet flag finds its use in the Ayurvedic system of medicine, where it is used for the treatment of epilepsy, hysteria, insomnia, melancholia, neurosis, loss of memory and remittent fevers (Kirtikar and Basu, 1956) [6]. Ethanolic extract of rhizome of this plant possesses sedative, analgesic, moderately hypotensive and respiratory depressant properties (Agarwal *et al.*, 1956) [7]. The rhizome possess an essential oil, which is a unique source of oxygenated sesquiterpenes of great structural variety and responsible for significant antibacterial, antifungal, and insecticidal properties (Vassi and Patel, 1987) [8]. Extractives of *A. calamus* rhizome are widely used in pharmaceuticals and traditional systems of medicines for a number of ailments and in perfumes (Raja *et al*. 2009) [1].

Sweet flag rhizome is widely used as anti-inflammatory agent in the Indian systems of medicine, such as Ayurveda, Siddha and Unani (Meena *et al.*, 2010) [10]. Various extracts of *A. calamus* have anti-diabetes, anti-proliferative, immunosuppressive, hypolipidemic and anti-carcinogenic effects and the rhizomes and leaves were found to possess anti-carcinogenic activity in human lymphocytes (Mehrotra *et al*., 2003) [11]. It is also frequently used as nerve tonic and as an emetic (Baquar, 1989) [12]. It is used in remittent fever, colic pain, inflammation, dyspepsia, diarrhea, flatulence and asthma (Kapoor, 1990) [1]. It is usually used as a decoction at a dose of 1-3 g or 2-7 gas powdered rhizome (Duke, 2002) [13]. In Western herbal medicine, the herb is chiefly employed for digestive problems such as gas, bloating, colic and poor digestive function (Balakumbahan *et al*., 2010) [14]. It is one of the common items in the international drug market where the raw material is obtained from the natural wild populations (Caius, 1986) [15].

Sweet flag comes up in almost all types of soil with sufficient moisture or irrigation. Plenty of sunshine should be available to the plant during its growth and after harvesting for drying the rhizomes. Temperature ranging from 10 to 38°C and annual rainfall between 70 and 250 cm are best suited. This species comes up well in clayey loams, sandy loams and light alluvial soils of river banks (Balakumbahan *et al*., 2010) [14]. It can also be grown in waterlogged or marshy soils. Such field is irrigated and tilled with green manure before planting. The rhizome (previous year's) along with bud is cut into pieces and the cut pieces of rhizome with bud is planted in the fine sand mixed soil at 30 cm apart (Imam *et al*., 2013) [16].

The possibility of optimizing rhizome yield of *A. calamus* by manipulation in the time of planting and harvesting as well as maintaining proper plant spacing (Tiwari *et al*., 2012) [12]. Since environmental factors explicitly affect growth, development and yield of medicinal herbs, investigating the effect of these factors, *e.g.*, planting time and harvesting schedules, on medicinal herbs is critically important. Therefore, to harvest the maximum yield of a crop introduced in a certain region, its interaction with agronomic, genetic and climatic factors must be examined (Moosavi *et al*., 2015) [18].

Keeping in view the importance of cultivation of *A. calamus*, and on these agronomic

aspects in Himachal Pradesh, the present study was conducted with the aim to study the effect of different planting time and harvesting schedules on growth and yield of *Acorus calamus*.

Material and Methods

The present investigation was carried out 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 MSL. Climate of the experimental area is hot during summer. The maximum temperature was 30.5 ^{0}C in May in the year 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 temperature 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. While there was no rainfall in October and November 2016 as well as in October 2017. The experiment was laid out in Randomized Block Design (RBD) in open conditions with 6 treatments *viz*., planting in March and harvesting after 12 months (P_1H_1), planting in March and harvesting after 18 months (P_1H_2), planting in July and harvesting after 12 months (P_2H_1), planting in July and harvesting after 18 months (P_2H_2), planting in November and harvesting after 12 months (P_3H_1) and planting in November and harvesting after 18 months (P_3H_2) which were replicated three times. Healthy rhizomes were used for planting material collected from surrounding areas. 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) [19].

Results

Plant height (cm)

Analysis of variance showed that the plant height was significantly influenced by planting time, harvesting schedules and their interactions (Table 1). Crop planted in July (P_2) recorded maximum plant height (55.92 cm) and followed by (52.67 cm) planted in March ($P_{1)}$ and (49.48 cm) planted in November ($P_{3)}$. The maximum plant height (57.26 cm) was recorded in crop harvested after 18 months of planting ($H_{2)}$ and minimum (48.12 cm) was recorded in crop harvested after 12 months of planting ($H_{1)}$. Among interaction effects between planting time and harvesting schedules, the maximum plant height was observed in P_2H_2 (59.42 cm) which was statistically at par with P_1H_2 (58.74 cm) and minimum plant height was recorded in P_3H_1 (45.33 cm) which was at par with P_1H_1 (46.61 cm).

Number of leaves/plant

Analysis of data revealed that the number of leaves/plant was significantly affected by planting time and harvesting schedules while their interaction was found non-significant (Table 2). Crop planted in July ($P_{2)}$ recorded maximum number of leaves/plant (15.34) and was followed by (12.89) planted in March ($P_{1)}$ and (10.69) planted in November (P_3). The maximum number of leaves/plant (14.47) was recorded in crop harvested after 18 months of planting ($H_{2)}$ and minimum (11.48) was recorded in crop harvested after 12 months of planting ($H_{1)}$.

Leaf length (cm)

The data presented in Table 3 showed that the leaf length was significantly influenced by planting time, harvesting schedules and their interactions. Crop planted in July (P_2) recorded maximum leaf length (50.02 cm) and followed by (46.49 cm) planted in March ($P_{1)}$ and (42.13 cm) planted in November ($P_{3)}$. The maximum leaf length (50.37 cm) was recorded in crop harvested after 18 months of planting ($H_{2)}$ and minimum (42.06 cm) was recorded in crop harvested after 12 months of planting ($H_{1)}$. In case of interaction effects between planting time and harvesting schedules, the maximum leaf length was observed in P_2H_2 (53.29 cm) which was statistically at par with P_1H_2 (52.61 cm) and minimum leaf length was recorded in P_3H_1 (39.05 cm) which was at par with P_1H_1 (40.37 cm).

Leaf width (cm)
Analysis of variance showed that the leaf width was significantly influenced by planting time and harvesting schedules while their interaction was found non-significant (Table 4). Crop planted in July (P_2) recorded maximum leaf width (1.38 cm) which was statistically at par with (1.36 cm) planted in March ($P_{1)}$ and minimum (1.28 cm) was recorded when planted in November ($P_{3)}$. The maximum leaf width (1.39 cm) was recorded in crop harvested after 18 months of planting ($H_{2)}$ and minimum (1.29 cm) was recorded in crop harvested after 12 months of planting ($H_{1)}$.

Rhizome length (cm)
Analysis of variance showed that the rhizome length was significantly influenced by planting time, harvesting schedules and their interactions (Table 5). Crop planted in July (P_2) recorded maximum rhizome length (15.44 cm) and followed by (12.03 cm) planted in March ($P_{1)}$ and (10.14 cm) planted in November ($P_{3)}$. The maximum rhizome length (15.41 cm) was recorded in crop harvested after 18 months of planting ($H_{2)}$ and minimum (9.66 cm) was recorded in crop harvested after 12 months of planting ($H_{1)}$. Among interaction effects between planting time and harvesting schedules, the maximum rhizome length was observed in P_2H_2 (19.38 cm) and minimum rhizome length was recorded in P_3H_1 (8.12 cm) which was at par with P_1H_1 (9.37 cm).

Rhizome width (cm)
Analysis of data revealed that the rhizome width was significantly affected by planting time and harvesting schedules while their interaction was found non-significant (Table 6). Crop planted in July ($P_{2)}$ recorded maximum rhizome width (1.21 cm) which was statistically at par with (1.19 cm) planted in March (P_1) and minimum (1.17 cm) was recorded when planted in November (P_3). The maximum rhizome width (1.22 cm) was recorded in crop harvested after 18 months of planting ($H_{2)}$ and minimum (1.15 cm) was recorded in crop harvested after 12 months of planting ($H_{1)}$.

Rhizome weight (g/plant)
The data presented in Table 7 showed that the rhizome weight/plant was significantly influenced by planting time, harvesting schedules and their interactions. Crop planted in July (P_2) recorded maximum rhizome weight/plant (28.28 g) and followed by (25.25 g) planted in March ($P_{1)}$ and (21.09 g) planted in November ($P_{3)}$. The maximum rhizome weight/plant (29.74 g) was recorded in crop harvested after 18 months of planting ($H_{2)}$ and minimum (20.00 g) was recorded in crop harvested after 12 months of planting ($H_{1)}$. In case of interaction effects between planting time and harvesting schedules, the maximum rhizome weight/plant was observed in P_2H_2 (33.85 g) and minimum rhizome weight/plant was recorded in P_3H_1 (17.77 g).

Rhizome yield (q/ha)
Analysis of variance showed that the rhizome yield was significantly influenced by planting time, harvesting schedules and their interactions (Table 8). Crop planted in July (P_2) recorded maximum rhizome yield (31.42 q/ha) and followed by (28.05 q/ha) planted in March ($P_{1)}$ and (23.44 q/ha) planted in November ($P_{3)}$. The maximum rhizome yield (33.05 q/ha) was recorded in crop harvested after 18 months of planting ($H_{2)}$ and minimum (22.22 q/ha) was recorded in crop harvested after 12 months of planting ($H_{1)}$. Among interaction effects between planting time and harvesting schedules, the maximum rhizome yield was observed in P_2H_2 (37.61 q/ha) and minimum rhizome yield was recorded in P_3H_1 (19.74 q/ha) which was at par with P_1H_1 (21.69 q/ha).

Table 1: Effect of different planting time and harvesting schedules on plant height of *Acorus calamus*.

Plant height (cm)			
Harvesting Schedule / Planting Time	**Harvesting after 12 months (H_1)**	**Harvesting after 18 months (H_2)**	**Mean**
Planted in March (P_1)	46.61	58.74	52.67
Planted in July (P_2)	52.42	59.42	55.92
Planted in November (P_3)	45.33	53.62	49.48
Mean	48.12	57.26	

	$CD_{0.05}$
Planting time (P)	1.02
Harvesting Schedules (H)	0.83
P x H	1.44

Table 2: Effect of different planting time and harvesting schedules on number of leaves/plant of *A. calamus*.

No. of leaves/ plant			
Harvesting Schedule / Planting Time	**Harvesting after 12 months (H_1)**	**Harvesting after 18 months (H_2)**	**Mean**
Planted in March (P_1)	11.54	14.24	12.89
Planted in July (P_2)	13.15	17.53	15.34
Planted in November (P_3)	9.74	11.63	10.69
Mean	11.48	14.47	

	$CD_{0.05}$
Planting time (P)	1.46
Harvesting Schedules (H)	1.19
P x H	NS

Table 3: Effect of different planting time and harvesting schedules on leaf length of *A. calamus*.

Leaf length (cm)			
Harvesting Schedule / Planting Time	**Harvesting after 12 months (H_1)**	**Harvesting after 18 months (H_2)**	**Mean**
Planted in March (P_1)	40.37	52.61	46.49
Planted in July (P_2)	46.75	53.29	50.02
Planted in November (P_3)	39.05	45.21	42.13
Mean	42.06	50.37	

	$CD_{0.05}$
Planting time (P)	2.22
Harvesting Schedules (H)	1.81
P x H	3.14

Table 4: Effect of different planting time and harvesting schedules on leaf width of *A. calamus*.

Leaf width (cm)			
Harvesting Schedule / Planting Time	**Harvesting after 12 months (H_1)**	**Harvesting after 18 months (H_2)**	**Mean**
Planted in March (P_1)	1.30	1.41	1.36
Planted in July (P_2)	1.32	1.44	1.38
Planted in November (P_3)	1.26	1.31	1.28
Mean	1.29	1.39	

	$CD_{0.05}$
Planting time (P)	0.03
Harvesting Schedules (H)	0.02
P x H	NS

Table 5: Effect of different planting time and harvesting schedules on rhizome length of *A. calamus*.

Rhizome length (cm)			
Harvesting Schedule / Planting Time	**Harvesting after 12 months (H_1)**	**Harvesting after 18 months (H_2)**	**Mean**
Planted in March (P_1)	9.37	14.69	12.03
Planted in July (P_2)	11.50	19.38	15.44
Planted in November (P_3)	8.12	12.16	10.14
Mean	9.66	15.41	

	$CD_{0.05}$
Planting time (P)	1.36
Harvesting Schedules (H)	1.11
P x H	1.92

Table 6: Effect of different planting time and harvesting schedules on rhizome width of *A. calamus*.

Rhizome width (cm)			
Harvesting Schedule / Planting Time	**Harvesting after 12 months (H_1)**	**Harvesting after 18 months (H_2)**	**Mean**
Planted in March (P_1)	1.15	1.22	1.19
Planted in July (P_2)	1.17	1.24	1.21
Planted in November (P_3)	1.14	1.19	1.17
Mean	1.15	1.22	

	$CD_{0.05}$
Planting time (P)	0.02
Harvesting Schedules (H)	0.02
P x H	NS

Table 7: Effect of different planting time and harvesting schedules on rhizome weight of *A. calamus*.

Rhizome weight (g/ plant)			
Harvesting Schedule / Planting Time	**Harvesting after 12 months (H_1)**	**Harvesting after 18 months (H_2)**	**Mean**
Planted in March (P_1)	19.53	30.97	25.25
Planted in July (P_2)	22.71	33.85	28.28
Planted in November (P_3)	17.77	24.42	21.09
Mean	20.00	29.74	

	$CD_{0.05}$
Planting time (P)	1.84
Harvesting Schedules (H)	1.50
P x H	2.60

Table 8: Effect of different planting time and harvesting schedules on rhizome yield of *A. calamus*.

Rhizome yield (q/ ha)			
Harvesting Schedule / Planting Time	Harvesting after 12 months (H_1)	Harvesting after 18 months (H_2)	Mean
Planted in March (P_1)	21.69	34.41	28.05
Planted in July (P_2)	25.23	37.61	31.42
Planted in November (P_3)	19.74	27.13	23.44
Mean	22.22	33.05	

	$CD_{0.05}$
Planting time (P)	2.04
Harvesting Schedules (H)	1.67
P x H	2.89

Discussion

Results obtained in the present study indicated that planting time and harvesting schedules significantly affected the growth and yield of Sweet flag. Different sowing dates provide variable environmental conditions at same location that potently influence the growth, development and yield stability of crops (Pandey *et al.*, 1981) [20]. Plant height, number of leaves per plant, leaf length, leaf width, rhizome length, rhizome width, rhizome weight per plant and rhizome yield were maximum when the crop was planted in July compared to March and November. The maximum plant height recorded when crop was planted in July might be due to higher rainfall (151.9 mm in July, 87.5 mm in March and 0.0 mm in November) received during the month coupled with conducive temperatures (27.4 ^{0}C in July, 24.2 ^{0}C in March and 25.2 ^{0}C in November) which influenced the plants to grow taller by increasing cell division and cell elongation. This result is in agreement with the finding of Thakur and Agrawal, 2009 reported that the optimum time of planting of Sweet flag is July month. In harmony with the present result, Khan *et al*., 2012 [22] reported that the plant height increased with the advancement of dates from 1 January (T1) to 15 April (T8) in Stevia which might be due to high temperature and more intensity of light.

Maximum plant height was obtained when crop was harvested after 18 months of planting compared to 12 months. This maximum plant height might be due to favourable weather condition and extended duration of harvesting age. This result agreed with the report of Tiwari *et al*., 2012 [12] in Sweet flag. Zigene *et al*., 2012 [23] reported increase in plant height with increasing harvesting age in rosemary. Motsa, 2006 [24] and Blank *et al.*, 2010 [25] also reported increase in plant height of rosescented geranium and basil due to delayed harvesting. The highest number of leaves per plant at July planting might be due to favourable weather conditions prevailed during this time. This finding is in agreement with the result of Khan *et al*., 2012 [22] in Stevia who found that 1 June date of planting showed highest number of leaves per plant due to best favourable environmental condition. Crop harvested after 18 months of planting gave maximum number leaves per plant. This result is in consonance with the study of Abewoy, 2018 [26] who reported that the growth of plants in terms of plant height, spread and number of branches per plant was increased significantly with increase in crop age or delay in harvesting in basil due to longer growth period. The highest leaf length, leaf width, rhizome length and rhizome width were recorded when crop was planted in July as compared to March and November planting. This might be due to favourable weather conditions prevailed during the growth period. This result is similar with the finding of Meena, 2014 [27] in *Lepidium sativum*, who found that the favourable effect of weather on crop growth recorded in sowing during 43 meteorological week as compare to 41, 45 and 47 meteorological week might be due to the fact that 43 meteorological week sown crop received favourable weather conditions in terms of relatively warm temperature during early growth and conducive temperature during flowering, pod formation and seed development stages. This finding is in agreement with the finding of Thakur and Agrawal, 2009 reported that the planting date of 30th July recorded significantly the higher rhizome length (14.4 cm) and girth (1.30 cm) in Sweet flag. Randhawa and Gill, 2010 also reported that the plants transplanted at the end of July gave maximum herb yields in *Ocimum basilicum* L.).

Crop harvested after 18 months of planting recorded highest leaf length, leaf width, rhizome length and rhizome width as compared to harvested after 12 months of planting. These results are in line with the report of Woelore *et al*., 2016 [29] in Ginger. This finding is also in agreement with the finding of Jimayu and Gebre, 2017 [30] reported that the plants harvesting age exerted highly significant influence on leaf length in lemongrass. Kubsad *et al*., 2009 [31] also reported that among the different harvesting stages, the crop harvested at 180 DAS recorded significantly higher root length and root diameter, compared to other harvesting stages (120 DAS and 150 DAS) in Ashwagandha. The highest rhizome weight/ plant and rhizome yield were recorded in July planting compared to March and November planting. These results might be attributed to higher rainfall received during the month coupled with conducive temperatures increased the growth of crop which resulted in development of higher rhizome yield. These findings are in line with the report of Kubsad *et al*., 2009 [31] in Ashwagandha. These results were also in agreement with the report of Thakur and Agrawal, 2009 found that planting in 30th July recorded significantly the higher fresh yield and dry yield in Sweet flag. Crop harvested after 18 months of planting recorded highest rhizome weight/ plant and rhizome yield compared to harvested after 12 months. These results are in consonance with the finding of Tiwari *et al*., 2012 [17] reported that there was a significant increase in rhizome yield and yield-attributing parameters (i.e. rhizome length, rhizome width and rhizome weight) with delay in harvesting from 7

months to 12 months after planting in Sweet flag. These findings are also in agreement with the result of Mastiholi, 2008 who found that harvesting at 160 and 180 DAP produced significantly higher tuber yields over 140 DAP in *Coleus forskohlii* BRIQ.

Conclusion

It is concluded from this study, that planting time and harvesting schedules influenced the growth and yield of *Acorus calamus*. The highest plant height, number of leaves/ plant, leaf length, leaf width, rhizome length, rhizome width, rhizome weight/ plant and rhizome yield were obtained when the crop was planted in July and harvested after 18 months of planting. Therefore, planting of crop in July month and harvesting after 18 months of planting is recommended in order to obtain greater rhizome yield.

References

1. Kapoor LD. Handbook of Ayurvedic Medicinal Plants, CRC Press, Boca Raton, FL, USA, 1990.
2. Raja AE, Vijayalakshmi M, Devalarao G. *Acorus calamus* Linn, Chemistry and Biology. Research Journal of Pharmacy and Technology. 2009; 2:256-261.
3. Mukherjee PK, Kumar V, Mal M, Houghton PJ. Acorus calamus: Scientific validation of ayurvedic tradition from natural resources. Pharmaceutical Biology. 2007; 45(8):651-666.
4. Archana, Sarki N, Pant AK, Prakash O. *Acorus calamus* (Sweet flag): A medicinally important plant. International Journal of Institutional Pharmacy and Life Sciences. 2015; 5(1):232-240.
5. Anonymous. The Wealth of India A Dictionary of Indian Raw Materials & Industrial Products: First Supplement Series (Raw Materials). New Delhi, India, National Institute of Science Communication. 2001; 1:28-30.
6. Kirtikar KR, Basu BD. In: L.M. Basu (Ed.), Indian medicinal plants, Allahabad, India, 1956.
7. Agarwal SL, Dandiya PS, Singh KP and Arora RB. A note on the preliminary studies of certain pharmacological actions of *Acorus calamus.* Journal of the American Pharmacists Association. 1956; 45:655-656.
8. Vassi IG, Patel HC. Comparative Physiology and Ecology. 1987; 12(1):49-51.
9. Raja AE, Vijayalakshmi M, Devalarao G. *Acorus calamus* Linn. Research Journal of Pharmacology and Technology. 2009; 2(2):256-261.
10. Meena A, Rao MM, Singh A, Kumari S. Physicochemical and preliminary phytochemical studies on the rhizome of *Acorus calamus* Linn. Indian Journal of Pathology and Microbiology. 2010; 2:130-131.
11. Mehrotra S, Mishra KP, Maurya R, Srimal RC, Yadav VS, Pandey R, *et al*. Anticellular and immunosuppressive properties of ethanolic extract of *Acorus calamus* rhizome. International Immuno pharmacology. 2003; 3:53-61.
12. Baquar SR. Medicinal and Poisonous Plants of Pakistan, Printas, Karachi, Pakistan, 1989.
13. Duke JA. Handbook of Medicinal Herbs, CRC Press, Boca Raton, FL, USA, 2002.
14. Balakumbahan R, Rajamani K, Kumanan K. *Acorus calamus*: An overview. Journal of Medicinal Plants Research. 2010; 4:2740-2745.
15. Caius JF. The Medicinal and Poisonous Plants of India, Scientific Publishers, Jodhpur, India, 1986.
16. Imam H, Riaz Z, Azhar M, Sofi G, Hussain A. Sweet flag (*Acorus calamus* Linn.): An incredible medicinal herb. International Journal of Green Pharmacy. 2013; 106(65):288-296.
17. Tiwari RKS, Das K, Pandey D, Tiwari RB, Dubey J. Rhizome yield of sweet flag (*Acorus calamus* L.) as influenced by planting season, harvest time, and spacing. International Journal of Agronomy, 2012, 1-8.
18. Moosavi SGR, Seghatoleslami MJ, Ansarinia E. Effect of sowing date and plant density on yield and yield components of fennel (*Foeniculum vulgare*). International Journal of Biosciences. 2015; 6:334-342.
19. Gomez KA, Gomez AA. Statistical procedures for agricultural research 2nd edition. John Wiley and Inc, USA, 1984, 680.
20. Pandey BP, Srivastav SK, Lal RS. Genotype X environment interaction in lentil. LENS. 1981; 8:14-17.
21. Thakur A, Agrawal VK. Effect of planting date on yield and essential oil content of rhizomes in sweet flag (*Acorus calamus* L.). Biomed. 2009; 4(1):33-35.
22. Khan AR, Chowdhury SH, Karim MM. Effect of date of planting on the growth and leaf yield of Stevia (*Stevia rebaudiana*). Journal of Bangladesh Agricultural University. 2012; 10(2):205-210.
23. Zigene ZD, Kassahun BM, Ketaw TT. Effects of harvesting age and spacing on leaf yield and essential oil yield of rosemary (*Rosmarinus officinalis* L.). The African Journal of Plant Science and Biotechnology. 2012; 6(1):9-12.
24. Motsa NM. Essential oil yield and composition of rose-scented geranium (*Pelargonium* sp.) as influenced by harvesting frequency and plant shoot age. M.Sc. Thesis, University of Pretoria, Gauteng, South Africa, 2006.
25. Blank AF, de Souza EM, de Paula JW, Alves PB. Phenotypic and genotypic behavior of basil populations. Horticultura Brasileira. 2010; 28(3):305-310.
26. Abewoy D. Influence of harvesting age and genotype on herbage and essential oil yields of sweet basil (*Ocimum basilicum* L.) Thesis Master of Science in Horticulture, School of Graduate Studies, Jimma University College of Agriculture and Veterinary Medicine, at Wondo Genet, Southern Ethiopia, 2018.
27. Meena BK. Effect of sowing durations and stand geometries on growth, productivity and quality of Chandrasur (*Lepidium sativum* L.). Thesis Doctor of Philosophy in Agriculture, Department of Agronomy, Rajasthan College of Agriculture, Maharana Pratap University of Agriculture and Technology, Udaipur, Rajasthan, 2014.
28. Randhawa GS, Gill BS. Transplanting dates, harvesting stage, and yields of french Basil (*Ocimum basilicum* L.). Journal of Herbs, Spices & Medicinal Plants. 2010; 3(1):45-56.
29. Woelore WM, Tesfaye B, Gedebo A. Effects of sett size and spacing on the growth and yield of ginger (*Zingiber officinale* Rosc.) at Areka, Wolaita, Southern Ethiopia. Journal of Natural Sciences Research. 2016; 6(19):1-23.
30. Jimayu G, Gebre A. Influence of harvesting age on yield and yield related traits of lemongrass (*Cymbopogon Citratus* L.) varieties at Wondo genet, southern Ethiopia. Academic Research Journal of Agricultural Science and Research. 2017; 5(3):210-215.
31. Kubsad VS, Palled YB, Mansur CP, Channal HT, Basavaraj N, Koti RV. Performance of ashwagandha (*Withania somnifera* Dunal) as influenced by dates of

sowing and stages of harvesting. Karnataka Journal of Agricultural Sciences. 2009; 22(5):1001-1005.
32. Mastiholi AB. Effect of spacing, time of harvest and NPK levels on growth, yield and quality of medicinal coleus (*Coleus forskohlii* Briq.) under irrigated condition. Thesis Doctor of Philosophy in Agronomy, Department of Agronomy, College of Agriculture, University of Agricultural Sciences, Dharwad, 2008.