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Effect of spacing and FYM on growth and yield of sweet flag (*Acorus calamus* L.)

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Abstract
Sweet flag (*Acorus calamus* Linn.) that belongs to family Araceae, is an important medicinal and aromatic plant. The field experiment for three consecutive years with 9 treatments, three levels of spacing *viz*., S1 – 60 x 30cm, S2 – 60 x 45 cm and S3 – 60 x 60 cm and three levels of farm yard manure viz., F1– FYM 5 t/ha, F2– FYM 10 t/ha and F3 – 15 t/ha was laid in factorial randomized block design with three replications. The results of the experiment indicated that the application of FYM 15 t/ha in combination with plants at a spacing of 60 x 30 cm recorded significantly higher growth and yield compared to other treatments.

Keywords: *Acorus calamus*, FYM, growth, yield

Introduction
India is bestowed with various kinds of medicinal plants with an ability to cure several ailments of human being. One among them is *Acorus calamus* also called as sweet flag, is a species of flowering plant, a tall wetland monocot of the Araceae family, in the genus Acorus. It is native to Central Asia, North America and Eastern Europe and claimed to possess number of health benefits that can be attributed to the makeup of the plant (Gilani *et al*., 2006) [1]. Indian systems of medicine, such as Ayurveda, Siddha and Unani use the rhizomes of this plant widely in the treatments of human ailments (Meena *et al*., 2010) [2]. Studies on chemical composition of *Acorus* spp. have revealed that α- and β-asarones are the major active components (Geng *et al*., 2010) [3]. Moreover, it have been reported to hold several biological activities *viz*., antifungal (Lee, 2005) [4], antibacterial (Phongpaichit *et al*., 2005) [5] and antihelmintic activities (Devi and Ganjewala, 2009) [6].
Recognizing the several medicinal properties of *Acorus*, the rural people dwelling nearby forest harvests the crop indiscriminately for their livelihood. In view of this, the Government of India established the Medicinal Plants Board to develop, promote and regulate the sector for maximizing the benefits to the people as well as to ensure ecological growth. On the other hand, the farmers are also forced to shift towards cultivation of medicinal plants that being less risky in terms of incidence of pests, diseases, price fluctuations, along with high potential to get good income flow when compared to the traditional crops. On this backdrop, the medicinal crops gained its momentum in cultivation and it necessitated to standardize the production technology of *Acorus calamus* for sustainable growth and production. Keeping the above in view, the present investigation was carried out to study the "Effect of Spacing and FYM on Growth and Yield of Sweet Flag (*Acorus calamus* L.)".

Materials and Methods
The experiment was carried out in the All India Coordinated Research Project (AICRP) on Medicinal & Aromatic Plants & Betelvine, Dr. YSRHU, Venkataramannagudem for three consecutive years. The experiment was laid out in factorial Randomized Block Design as per the procedure outlined by Gomez and Gomez (1984) [7] with three levels of FYM and spacing as treatments. Thus, the total number of treatment combinations was 9, with three replications. The control was also maintained. The treatment consists of FYM (F1- FYM 5t/ha, F2- FYM 10t/ha and F3- 15t/ha) and Spacing (S1- 60 x 30 cm, S2- 60 x 45 cm, S3- 60 x 60 cm). Forty five days old vigorous healthy uniform size seedlings were transplanted at various spacing

level in the main field in the month of June. Rhizomes were cut about 4cm long and planted to initiate sprouting. Sprouted rhizomes were planted in a particular spacing at about 4 cm planting depth, light irrigation was given soon after transplanting. Weeding was carried out at 3, 5, and 7 months after planting. Organic manure, FYM was imposed basally. The crop was harvested after 10 months of planting. Weeding and earthing up was done during the crop period to control the weeds. The observations on growth parameters *viz*., Leaf length and width, number of leaves, difference in leaf emergence were recorded at the time of harvest, yield parameters viz., Rhizome length, width and weight and yield were recorded after harvest. Economics for the crop growth and yield was analysed based on benefit cost ratio. All the observations recorded were subjected to statistical analysis.

Results and Discussion

Independent effect of Spacing and Farm Yard Manure

The pooled results of three years revealed that all the treatments showed significant variation in growth and yield (Table 1 & 2).

The results of the experiment showed variation in spacing had non-significant effect on the plant height and difference in leaf emergence of *A. calamus*. However, number of leaves per plant, leaf width, rhizome length, width, weight and yield varied significantly due to different planting space. This finding is similar to previous report of Krishnamurthy and Kasture (2015) [8]. The widest spacing of 60 x 60 cm registered the highest value in term of rhizome quality *viz*., rhizome width (6.76 cm) and weight (53.44g/pl.) while the closer spacing of 60 x 30 cm registered the highest value in term of rhizome yield (22.12 q/12m^2) (Table 1). The observation of maximum rhizome width and weight under the widest spacing might be ascribed to the enhanced extension and growth of rhizomes due to maximum underground space available at the fullest (Hossain *et al*., 2005) [9]. The highest number of leaves per plant registered in plants at highest spacing of 60 x 60 cm and this may be due to increased sprouts from the buds present in rhizomes (Singh *et al*., 2006) [10]. Further, increased biomass accumulation as a result of better availability of growth promoting factors such as soil moisture, plant nutrients and light might simultaneously yielded higher weight of rhizome (Tiwari *et al*., 2012) [11]. The maximum rhizome yield in case of 60 × 30 cm spacing attributed to the function of higher plant density per unit area resulting in a higher number of rhizome productions. Planting in 60 cm × 30 cm spacing yielded 22.12 q/12m^2, which is equivalent to18432 qha-^{1}. This is in corroboration with the finding of Krishnamurthy and Kasture (2015) [8], who stated that significantly higher yield was obtained under closer spacing than that of wider spacing and that this might be due to lesser weed growth under closer spacing of *Acorus calamus*.

The growth parameters like plant height (54.88 cm) and leaf width (4.58 cm) registered maximum in plants applied with FYM 15t/ha while number of leaves (86.88), leaf length (44.08 cm) and difference in leaf emergence (2.32) recorded with FYM 10t/ha. Significantly highest yield parameters *viz*. rhizome width (6.76 cm), weight (52.30 g) and yield (19.02 q/12m^2) recorded with FYM 15t/ha when compared to other treatments (Table 2). It was noticed that the growth and yield parameters increased with increased level of FYM. Similar results were reported by Datta *et al*. (2009) [12]. It could be inferred that the increased yields from FYM application can be attributed to the maximum availability of macro and micro plant nutrients throughout the growth phase, resulting better growth and yield of the crop (Singh *et al.*, 2002) [13]. Increased yield parameters on application of increased level of FYM might be also due to enhanced canopy photosynthesis through increased vegetative growth of crop (Rahman *et al.*, 2004) [14].

Table 1: Effect of spacing on growth and yield of *Acorus calamus* (pooled data for three consecutive years)

Treatments	Plant height (cm)	No. of lvs.	Leaf Length (cm)	Leaf width (cm)	Diff. in Leaf Emergence (cm)	Rhiz. Length (cm)	Rhiz. Width (cm)	Rhiz. weight/pl (g)	Rhiz. Yield (q/12m^2)
60 x 30 cm	52.11	64.35	39.86	3.84	2.33	33.96	5.13	45.35	22.12
60 x 45 cm	53.76	87.09	45.41	3.48	2.36	39.07	6.66	51.21	15.49
60 x 60 cm	54.03	86.15	43.52	4.03	2.24	37.73	6.76	53.44	15.30
CD	NS	10.08	3.37	0.36	NS	4.14	1.39	3.18	2.32
CV%	2.85	6.00	3.70	4.49	2.60	5.28	10.51	3.00	6.18

Table 2: Effect of various levels of FYM on growth and yield of *Acorus calamus* (pooled data for three consecutive years)

Treat.	Plant height (cm)	No. of lvs.	Leaf Leng (cm)	Leaf width (cm)	Difference in Leaf Emergence (cm)	Rhiz. Length (cm)	Rhiz. Width (cm)	Rhiz. weight/pl (g)	Rhiz. Yield (q/12m^2)
FYM 5t/ha	51.13	71.64	41.00	3.07	2.31	35.70	5.53	47.49	15.26
FYM 10 t/ha	53.88	86.88	44.08	3.70	2.32	35.87	6.26	50.42	18.63
FYM 15 t/ha	54.88	79.07	43.72	4.58	2.30	39.10	6.76	52.30	19.02
CD	NS	10.08	3.37	0.36	NS	NS	1.50	3.18	2.32
CV%	2.85	6.00	3.70	4.49	2.60	5.29	10.51	3.00	6.18

Interaction effect of Spacing and Farm Yard Manure

Considering the interaction between the spacing and FYM, it was observed that the treatment involving Spacing 60 x 30 cm in combination with FYM 15t/ha recorded higher growth and yield parameters (Table 3). Spacing x Manures interaction exhibited a significant influence on growth and yield parameters of *Acorus calamus*. The cumulative effect of higher nutrients content of FYM & closer spacing might have influenced the growth & yield. The reason for better growth might be due to greater absorption & translocation of nutrients, better simulation of root system and increased plant population per unit area (Baligar *et al*., 2001) [15].

Table 3: Effect of spacing and FYM on growth and yield of *Acorus calamus* (pooled data for three consecutive years)

Treatments	Plant height (cm)	No. of lvs.	Leaf Leng. (cm)	Leaf width (cm)	Diff. in Lf. Em.	Rhiz. length (cm)	Rhiz. width (cm)	Rhiz. Wt./pl (g)	Rhiz. yield (q/ha)
T_1 – 60 x 30 cm + FYM 5 t/ha	49.66	52.73	35.29	2.85	2.30	34.17	4.52	42.70	13.28
T_2 – 60 x 30 cm + FYM 10 t/ha	52.70	75.22	42.33	3.09	2.44	33.94	5.32	43.58	22.52
T_3 – 60 x 30 cm + FYM 15 t/ha	53.96	65.10	41.95	5.58	2.27	33.63	5.54	49.77	**26.57**
T_4 – 60 x 45 cm + FYM 5 t/ha	52.70	86.18	45.09	2.34	2.39	36.58	5.00	42.78	15.41
T_5 – 60 x 45 cm + FYM 10 t/ha	54.74	91.29	46.00	4.10	2..32	35.87	6.66	59.26	16.00
T_6 – 60 x 45 cm + FYM 15 t/ha	53.85	83.80	44.26	4.01	2.36	44.77	7.44	51.60	16.06
T_7 – 60 x 60 cm + FYM 5 t/ha	51.03	76.00	42.62	4.02	2.57	36.50	6.17	56.38	13.10
T_8 – 60 x 60 cm + FYM 10 t/ha	54.21	94.13	43.04	3.91	2.18	37.81	6.82	48.43	15.37
T_9 – 60 x 60 cm + FYM 15 t/ha	56.85	88.32	44.89	4.17	2.29	38.89	7.30	55.53	17.44
CD	NS	2.76	NS	0.63	NS	NS	NS	5.51	4.20
CV%	4.93	10.39	6.44	7.92	4.26	9.16	18.57	5.20	11.36

Cost: benefit ratio is an important and ultimate factor which decides the optimum levels of inputs used, yield and returns of any crop. The cost: benefit ratio worked out for pooled data (Table 4) indicated that the plants with a spacing of 60 x 30 cm and provided with FYM 15t/ha recorded maximum net returns (1.25). Similarly, the highest cost: benefit ratio (1: 3.08) was derived from the same treatment and the least value of 1: 1.86 was found in treatment receiving FYM 5 t/ha only (Table 4). The increase in cost: benefit ratio was mainly due to the increased rhizome yield which contributed to these values. The application of higher level of FYM with closer spacing of planting helped in increasing the yields. Similar results were reported by Kalyanasundaram *et al*. (2008) [16] in sweet flag.

Table 4: Economics of *Acorus calamus* at various levels of spacing and FYM (pooled data for three consecutive years)

Treatments	Cost of cultivation (Rs. In lakhs/ha)	Yield/ha (q/ha)	Gross income (Rs. In lakhs/ha)	Net returns (Rs. In lakhs/ha)	BCR
T_1 – 60 x 30 cm + FYM 5 t/ha	0.5	13.28	0.93	0.43	1.86
T_2 – 60 x 30 cm + FYM 10 t/ha	0.6	22.52	1.57	0.97	2.62
T_3 – 60 x 30 cm + FYM 15 t/ha	0.6	26.57	1.85	1.25	3.08
T_4 – 60 x 45 cm + FYM 5 t/ha	0.5	15.41	1.07	0.57	2.14
T_5 – 60 x 45 cm + FYM 10 t/ha	0.6	16	1.12	0.52	1.87
T_6 – 60 x 45 cm + FYM 15 t/ha	0.6	16.06	1.12	0.52	1.87
T_7 – 60 x 60 cm + FYM 5 t/ha	0.5	13.1	0.92	0.42	1.84
T_8 – 60 x 60 cm + FYM 10 t/ha	0.6	15.37	1.07	0.47	1.78
T_9 – 60 x 60 cm + FYM 15 t/ha	0.6	17.44	1.22	0.62	2.03

Conclusion

The study revealed that highest growth and yield of *Acorus calamus* were recorded in the plants at a spacing of 60 x 30 cm with an application of FYM 15t/ha. Increased cost benefit ratio also obtained with the same treatment. Further, it is advised to follow organic cultivation in the production of medicinal plants for the well-being of the soil, environment and humans.

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