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Vol. 12(20), pp. 1713-1726, 18 May, 2017
DOI: 10.5897/AJAR2015.10513
Article Number: 25E687C64222
ISSN 1991-637X

http://www.academicjournals.org/AJAR

African Journal of Agricultural Research

Full Length Research Paper

Intercropping of sweet flag (*Acorus calamus* L.) with early and late maturing cultivars of rice (*Oryza sativa* L.)

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Received 12 October, 2015; Accepted 9 December, 2015

Field experiments were conducted to explore possibility of introducing *Acorus calamus* (Sweet flag) under rice ecosystem either as an Intercrop or main crop for optimizing maximum return. In the first experiment, Sweet flag was intercropped with two rice cultivars early IR-64 and late MTU-7029 "Swarna" in additive series where sweet flag was introduced between two normal rows of rice and in replacement series where sweet flag was planted with rice in 1:1 ratio at 20, 30 and 40 cm spacing and were compared with sole crops after one year. Further, in the second experiment, Sweet flag was intercropped only with early maturing variety (IR-64) in 20 cm spacing with a crop cycle of 1 and 1.5 year to evaluate comparative performance of Intercrops and sole crops. Results revealed that intercropping of sweet flag with rice had a significant effect on yield and yield attributing characteristics of both crops. Numbers of effective tillers in rice were increased with widening the space between intercrops as compare to sole crop of rice, while, rhizome length and width of sweet flag registered highest in sole crop and showed declined trend with decreasing spacing of intercrops. Intercropping of Sweet flag with early and late maturing cultivars of rice did not give significant effect on rhizome yield of sweet flag. Sole crop of sweet flag with a crop cycle of one year was found to be superior and gave significantly maximum equivalent yield (233.75 q ha^{-1}). Whereas, EQY of rice recorded from different series of intercropping were significantly at par. The inclusion of sweet flag with paddy decreased the rice yield with increasing spacing. In contrast, rhizome yield of sweet flag was in opposite trend and increased with increasing spacing from to 20 to 40 cm. Gross return and net profit incurred more from all series of intercropping compared to rice as sole crop irrespective of both early and late maturing cultivars of rice. Sweet flag planted as sole crop incurred highest gross return (Rs 248820.00 ha^{-1}) and net profit (Rs 187320.00 ha^{-1}) among different treatments. Data of another experiment revealed that sole crop of sweet flag taken for one and 1.5 year gave maximum equivalent yield (EQY) of 229.54 q ha^{-1} and 347.83 q ha^{-1} respectively. Intercropping of Sweet flag with rice found to be economical when it was grown as sole crop for a period of one year after rice harvest with 1.5 year of crop cycle (EQY253.23 q ha^{-1}). Sweet flag planted in between rows of rice and allowed to grow even after rice harvest for one year gave EQY of 268.06 q ha^{-1} and at par with inter cropping of sweet flag at spacing of 20 cm with a crop cycle of 1.5 years (253.23 q ha^{-1}). Moreover, equivalent yield of rice calculated from different treatments was higher as compared to grain yield of sole cop of rice. Maximum gross return of Rs 431472.00 ha^{-1} and net profit of Rs 364972.00 ha^{-1} incurred from sweet flag taken as sole crop for a period of 1.5 years. All series of intercropping with crop cycle of 1.5 years were superior in terms of getting higher net profit.

Key words: Intercrop, equivalent yield, cost benefit ratio, sweet flag.

INTRODUCTION

Paddy (*Oryza sativa* L.) is a major staple food in Asia covers 60 million hectares with about 225 million tons of production account 37.5% of the global area and 32% of global production. This is predominantly grown in wetland and waterlogged condition since long time because of the lack of other alternative high promising crop during kharif season (Monsoon cultivation) in high moisture regime soil. However, paddy is one of the most important food crops with high income and common in India and in Asia in all groups of farmers. Since last decade, the yield of paddy is almost constant due to delayed in monsoon, infestation of disease, pest and degradation in organic manure and in other soil nutrient stocks. In the recent years farmers applying inappropriate doses of inorganic fertilizers and pesticides that are not only made the paddy cultivation non-profitable but also affect soil health (Foley et al., 2005). Due to higher cultivation cost and relatively low profit from paddy cultivation, several pulses, oil seeds and vegetables had tried as main crops and intercrops with paddy ecosystem but none of the crops was found suitable for economic point of view than paddy alone due to higher moisture level for longer period in paddy fields. This situation can be efficiently utilized by taking other crops, which can be grown at higher moisture level or under continuous submergence conditions either as inter crops with paddy or as main crop. Intercropping is the simultaneous growing of two or more crops in the same field to increase total productivity per unit area through maximum utilization of land, labour and growth resources (Takim, 2012). Yield of intercropping are often higher due to efficient use of water, light and nutrients than sole cropping system (Li et al., 2006).

Presently, there is an increasing interest among farmers towards medicinal plants as this are fetching higher income than other agricultural crops due to high demand and short supply from their natural growing areas. These species may be one of the alternative crops of paddy and may improve the economic return to farmers through crop rotation. Moreover, introduction of such medicinal plant as intercrop in paddy field may render multiple outputs through diversification, which will be helpful to conserve resources and rehabilitate degrading paddy fields. *Acorus calamus* L. (Sweet flag) is one such medicinal plant species which requires littoral environment, ability to withstand under stress aeration and grow efficiently either in submerged conditions or under high soil moisture condition (Tiwari et al., 2011). This species belongs to family Araceae with creeping rhizome commonly found on the banks of streams in swampy marshy places throughout India. It is found across globe up to 1800 m in Europe, Russia, China, Indonesia, Japan and the northern United States (Balakumbahan et al., 2010). Sweet flag has a very long history of medicinal use in Chinese and Indian herbal traditions (Gualtiero Simonetti, 1990). Commercially, the plant rhizome harvest and used widely in modern herbal medicine as its sedative, laxative and diuretic and carminative properties. In addition, the rhizome contains essential oil, which is a unique source of oxygenated sequiterpenes and responsible for antimicrobial, antifungal, insecticidal, anti-spasmodic, carminative, antihelmintic, aromatic, expectorant, nauseate, nervine, sedative, stimulant properties (Mukherjee et al., 2007). It was also used for the treatment of epilepsy, mental ailments, chronic diarrhea, dysentery, bronchial catarrh, intermittent fevers, glandular and abdominal tumors. The alcoholic extract of *A. calamus* exhibits potent antiviral activity against herpes viruses, which is HSV-1 and HSV-2. Due to its varied uses, there is a high demand for the plant in the international drug market. McAlpine and Warrier (1996) reported that sweet flag belongs among the endangered medicinal plants needs immediate conservation.

A. calamus is a most important wetland species mature in one year and may yield 8 to 16 tons of rhizomes in a ha land under different situations (Tiwari et al., 2012). This is commonly propagated through vegetative cutting of rhizome in a wide range of soils and climates. This species forms a shallow and compact network of rhizomes that prevents the existence of most other species (Hejny and Husak, 1978; Dykyjova, 1980). Moreover, *Acorus* displays efficient use of nutrients (N) by their uptake and internal cycling (Weber and Bandle, 1996). These characteristics have profound advantages for invasion of *Acorus* and its competition with other wetland plant species (Weber and Brandle, 1996). With increasing eutrophication in *A. calamus* field, the total amount of nitrogen not only increases, but the proportion of inorganic forms of nitrogen available for plants is also changed in the substrate (Vojtiskova et al., 2004) and total P is accompanied by its higher availability in the eutrophic water (Vojtiskova et al., 2001; Tiwari et al., 2011).

Keeping in mind the above perspectives of intercropping, the present study was undertaken aiming to find out the appropriate spacing between paddy and sweet flag based on vegetative growth, yield components and yield of both crops. Experiments conducted under present study were aimed to get significant findings on introducing sweet flag with a recommended period of crop cycle as an inter crop or sole crop under rice eco

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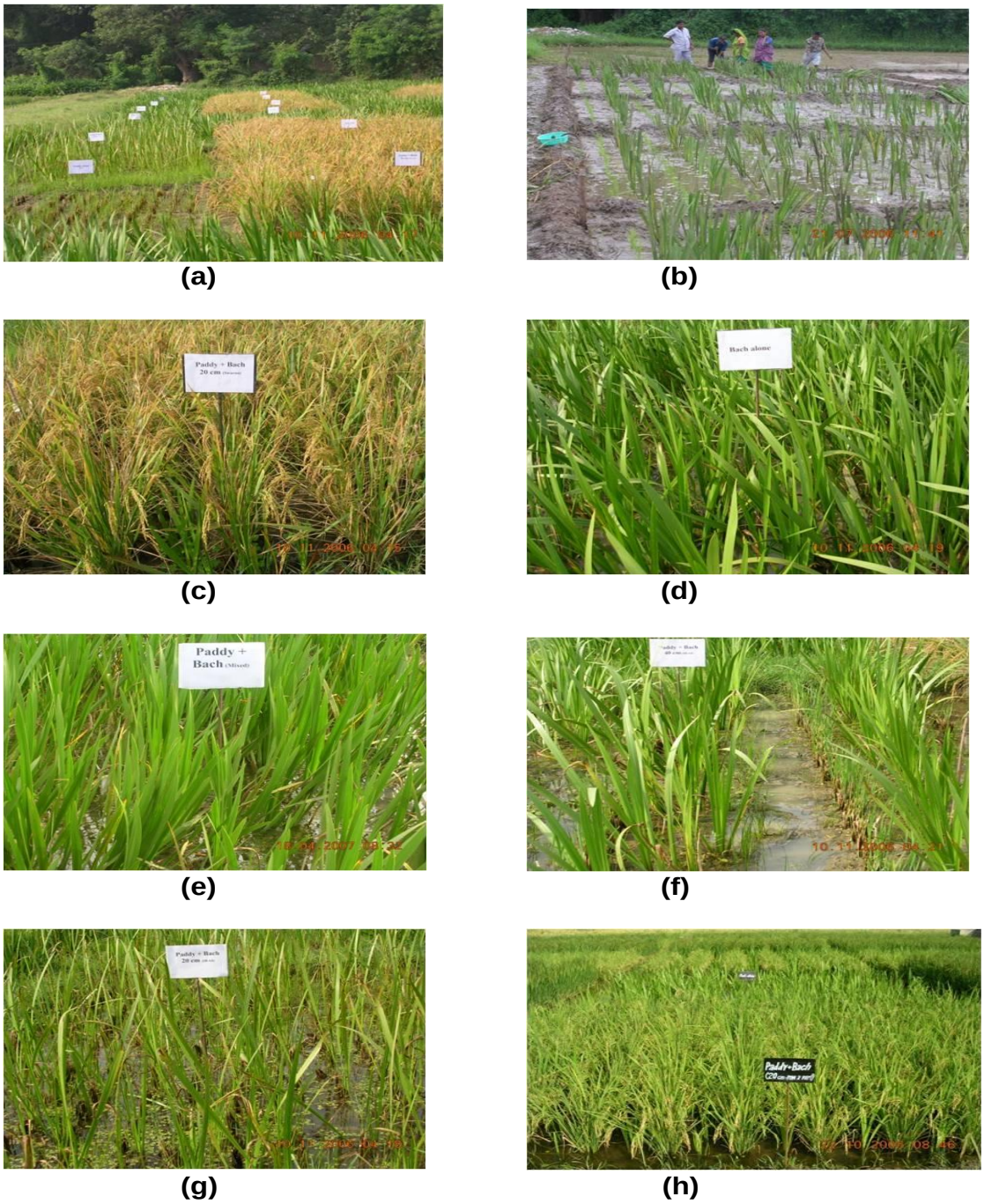

Plate 1. a) Experimental view at maturity stage b) Experimental view at planting stage c) Paddy+ Sweet flag 20 cm d) Sweet flag alone e) Paddy+ Sweet flag mixed f) Paddy+Sweet flag at 40 cm after paddy harvest g) Paddy+Sweet flag at 20 cm after paddy harvest and h) Paddy+Sweet flag at later stage.

system and optimum yield per unit area.

MATERIALS AND METHODS

Experiment site

The field experiments was carried out at the Experimental Farm of Thakur Chhedilal Barrister College of Agriculture and Research Station, Bilaspur, Chhattisgarh, India during cropping seasons of 2005-06 and 2006-07 (Plate 1). The experimental farm lies in 22°9'12" North latitude and 82° 12'12" East longitude, and at South Eastern Central zone of India with an altitude of 292.3 m MSL. The climate of Bilaspur is sub humid. The air temperature varies from a minimum of about 4.6°C (in December-January) to a maximum of about 45.0°C (in May). The relative humidity ranges from about

12.0% during May to 92.0 during July - August. Average annual rainfall is 1250 mm, of which 82% is received during June to September (Chaure et al., 2007).

Treatments and experimental design

Two experiments were conducted during the years, that is, 2004-2007. In the first experiment, sweet flag was intercropped with two cultivars, that is, early (IR- 64) and late (MTU-7029 "Swarna") of rice in different series of inter cropping. In additive series of inter cropping, sweet flag was planted between two rows of rice without shifting space between two rows of rice (20 cm). Whereas, in replacement series of inter cropping; sweet flag was planted along with rice in ratio of 1:1 at 20, 30 and 40 cm spacing. Rice and sweet flag as sole crops were also included as treatments for evaluation of different series of inter cropping. Low land field having clay loam soil and most suitable for rice cultivation was selected for experimentation. Field was ploughed 2-3 times in the month of May – June. Transplanting system was adopted for planting both rice and sweet flag. Filed was puddle and submerged before transplanting. Farmyard manure was uniformly (1000 kg ha^{-1}) applied at the time of field preparation along with basal dose of inorganic fertilizers, that is, phosphorus and potassium 60: 40 kg ha^{-1}. Whereas, nitrogen 100 kg ha^{-1} was applied in three split doses, that is, 25% after seven days of planting followed by three times at 25% periodical application at an interval of 30 days. Nursery of rice and sweet flag were raised in nursery beds. Seeds of both varieties, that is, IR 64 and MTU 7029 (Swarna) were treated with seed dresser fungicide, that is, Carbendazim 25 SD @ 3 G /kg seed before sowing in nursery beds. Plant saplings of sweet flag were raised from small pieces of rhizomes (5 cm), allowed for sprouting in moistened gunny bags and later on planting in nursery beds. Twenty-one days old seedlings of paddy and 30 days old plant saplings were used for transplantation.

The first field experiment was laid out in all side bunded plots of 6 m × 4 m with three replications under two factor randomized complete block design for two consecutive years, that is, 2005 and 2006. Total seven treatments *viz*. Rice alone; Sweet flag + Rice (mixed) ; Sweet flag + Rice (1:1) at 20 cm row a part , Sweet flag + Rice (1:1) at 30 cm row a part, Sweet flag + Rice (1:1) at 40 cm row a part, sweet flag alone at 30 cm row a part were randomized in three replications. Treatments of intercropping were divided in two series, that is, additive series and replacement series. In additive series of intercropping, sweet flag was transplanted between two rows of rice as Sweet flag + Rice (mixed) whereas, in replacement series of intercropping, one row each of sweet flag and rice were transplanted at spacing of 20, 30 and 40 cm. Rice and sweet flag were kept as sole crops for comparative evaluation of different inter cropping series.

Looking at results of first experiment, second experiment was laid out in all side bounded plots of 6 m × 4 m with three replications under randomized block design for two consecutive years, that is, 2006 and 2007. Sweet flag was intercropped with rice for a crop cycle of one year and 1.5 years. Eight treatments *viz*. rice for two crop seasons (1 year cycle), rice for three crop seasons (1.5 year cycle), sweet flag + rice 1:1 (1 year cycle), sweet flag + rice 1:1 (1.5 years cycle), sweet flag + rice mixed (1 year cycle), sweet flag + rice mixed (1 .5 years cycle), sweet flag sole crop (1 year cycle), sweet flag sole crop (1.5 years cycle). In additive and replacement series of intercropping, rice was taken for one season and thereafter sweet flag was allowed to grow for a period of one crop season and two crop seasons with a crop cycle of 1 year and 1.5 year respectively. In additive series of intercropping, sweet flag was transplanted between two rows of rice (intra row) as Sweet flag + Rice (mixed) for one year and 1.5 years. Whereas, in replacement series of intercropping, one row each of sweet flag and rice were transplanted at spacing of 20 cm for one year and 1.5 years. Rice and sweet flag were taken as sole crops for two and three consecutive crop seasons to study comparative evaluation of different series of intercropping.

Yield and yield attributing characteristics of rice and sweet flag

Yield and yield components of rice

Numbers of effective tillers from each treatment were recorded tagging five plants of rice randomly leaving outer rows of plot and recorded number of effective tillers $plant^{-1}$. Crop was harvested at maturity and grain yield (q ha^{-1}) of rice planted as sole crop for two and three crop seasons was recorded.

Yield and yield components of sweet flag

Rhizome length (cm) $plant^{-1}$ and rhizome diameter (cm) $plant^{-1}$of sweet flag were recorded tagging five plants randomly leaving outer rows of plot at the time of harvesting of rhizome of sweet flag. Rhizomes of sweet flag were dried and yield q ha^{-1} recorded from different treatments.

Equivalent yield (EQY)

The equivalent yield (EQY) was calculated on the basis of market price of rice and sweet flag @ Rs 1200 q^{-1} and Rs 4000 q^{-1} respectively. One year and two years data were analyzed statistically to determine pooled mean and treatment differences of both experiments.

$$Equivalent\ Yield\ of\ Rice = \frac{Rhizome\ yield\ of\ Acorus * Market\ price\ of\ Acorus}{Market\ price\ of\ Rice}$$

Economical analysis: Economics of different series of intercropping taken in both experiments were calculated and net profit estimated subtracting cost of cultivation from gross return from both crops, that is, rice and sweet flag. Cost of cultivation included expenditure in field preparation; planting material, human resources, irrigation, fertilizers, manures and other inter culture operations, that is, weeding, irrigation, harvesting, threshing etc. Gross return was estimated based on equivalent yield to rice obtained from different treatments of intercropping from both experiments and its market price.

RESULTS AND DISCUSSION

Experiment 1

Biometric characteristics

The first experiment conducted on the effect of spacing on sweet flag - grown as intercrops with early (IR-64) and late "Swarna" (MTU- 7029) varieties of rice and also as sole crop are presented in Table 1 and Figures 1 to 6. Data presented in Table 1 and Figure 1 to 6 indicate the significant effect of different series of inter cropping on yield components of rice (effective tillers $plant^{-1}$) and sweet flag (rhizome length and diameter $plant^{-1}$) during both the years, that is, 2004-05 and 2005-06. Whereas, there were no significant differences between varieties of

Table 1. Influence of different series of inter cropping on biometric performance of rice cultivars (IR-64, MTU – 7029) and sweet flag planted at different spacing.

Treatments (A)	Varieties (B)	2004-05			2005-06			Pooled mean		
		No. of effective tillers	Rhizome length (cm)	Rhizome diameter (cm)	No. of effective tillers	Rhizome length (cm)	Rhizome diameter (cm)	No. of effective tillers	Rhizome length (cm)	Rhizome diameter (cm)
Paddy alone	IR 64	12.06	-	-	10.33	-	-	11.19	-	-
	Swarna	11.60	-	-	10.33	-	-	10.96	-	-
Sweet flag + Paddy (mixed)	IR 64	14.00	51.59	1.20	10.73	48.03	1.06	12.36	49.81	1.13
	Swarna	17.40	51.86	1.20	10.73	39.40	1.31	14.06	48.80	1.25
Sweet flag + Paddy at 20 cm	IR 64	12.73	57.60	1.26	15.40	52.03	0.96	14.06	54.81	1.11
	Swarna	12.53	58.20	1.25	15.40	52.50	0.98	13.96	52.18	1.11
Sweet flag + Paddy at 30 cm	IR 64	19.42	64.00	1.42	15.90	62.20	1.74	17.66	63.10	1.58
	Swarna	18.46	71.33	1.43	17.40	60.79	1.33	17.93	66.06	1.38
Sweet flag + Paddy at 40 cm	IR 64	22.86	73.26	1.56	22.60	67.26	1.92	22.73	70.26	1.74
	Swarna	27.00	71.33	1.59	22.20	69.40	1.55	24.60	66.33	1.57
Sweet flag alone	-	-	91.40	1.86	-	69.40	1.86	-	80.40	1.86
	-	-	89.20	1.84	-	70.67	1.88	-	79.93	1.86
C.D. at 5% A		6.34	9.04	0.126	2.36	3.07	0.408	5.39	7.60	0.341
B		NS	NS	NS	NS	2.98	NS	NS	NS	NS
AB		NS	11.93	NS	NS	NS	NS	NS	11.08	NS
CV %		13.67	10.04	4.39	8.95	6.42	16.84	11.81	8.68	12.30

rice except in one attribute, that is, rhizome length plant^{-1} of sweet flag. Numbers of tillers were in significantly increasing order with widening the row space between sweet flag and rice and registered 103.14 and 124.45% increase at 40 cm row spacing in IR-64 and Swarna, respectively. Similarly, rhizome length and rhizome diameter of sweet flag were also in increasing order and maximum at 40 cm spacing. The increment in tillers number due to increased spacing was related to the availability of more light and space through intercropping than sole crop. Whereas, number of tillers of rice in rice + sweet flag (mixed) were at par with sole crop of rice (Table 1, Figures 1 and 2). In contrast, rhizome length and rhizome diameter of sweet flag were reduced drastically in additive series (rice + sweet flag mixed) as well as closer spacing of replacement series (20 cm) (Figures 3 to 5). Above observations indicate that rice crop significantly affected the growth of sweet flag not leaving space for sweet flag to grow specially in closer spacing and intra row spacing. Sweet flag grown as sole crop had significantly higher in mean rhizome length (80.16 cm plant^{-1}) and diameter (1.86 cm plant^{-1}) compared to other treatments of intercropping. There was 62.59 and 17.38% reduction in rhizome length of sweet flag was noticed when planted with in intra row space and inter row space of 40 cm respectively compared to sole crop of sweet flag (Figure 5).

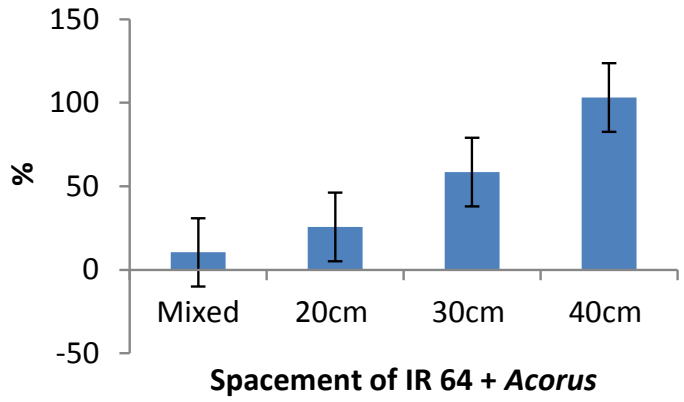

Figure 1. Percent increase in tiller number of IR 64 than monocrop.

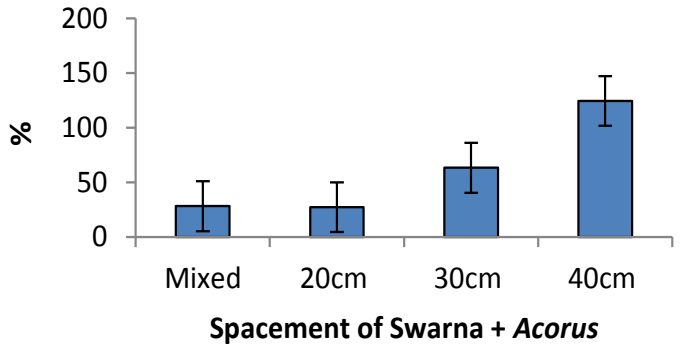

Figure 2. Percent increase in tiller number of Swarna than monocrop.

Similarly, sweet flag planted with rice in intra row space and inter row space of 40 cm had reduction of 56.30 and 18.18%, respectively in rhizome diameter (Figures 7 to 8).

The reason for reduction in rhizome length and diameter of sweet flag intercropped with rice might be due to faster vegetative growth of rice than sweet flag. Tiwari et al. (2011) reported that that cultivation of Sweet flag and Bramhi alone appeared to be more suitable than intercropped with rice. Intercropping with early and late cultivars of rice did not have significant effect on yield components of sweet flag.

Grain yield and rhizome yield q ha^{-1}

The results on the effect of different series of intercropping on yield and equivalent yield of sweet flag grown as intercrops with early (IR-64) and late "Swarna" (MTU- 7029) varieties of rice are presented in Tables 2 and 3 and Figures 9 to 11. Yield data of both years indicate that, sweet flag planted in intra row space (rice + sweet flag mixed) did not affect yield of rice whereas, rhizome yield of sweet flag was affected significantly.

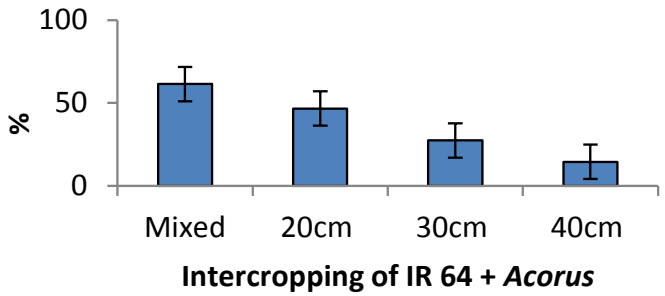

Figure 3. Percent decrease in rhizome length of *Acorus* compared with monocropped *Acorus*.

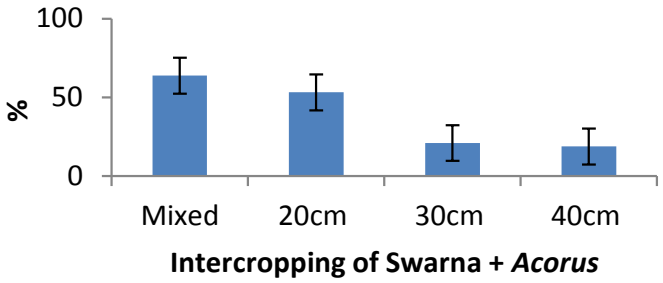

Figure 4. Percent decrease in rhizome length of *Acorus* compared with monocrop.

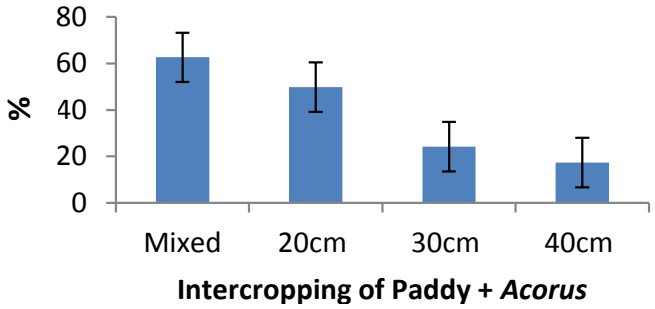

Figure 5. Percent decrease in mean rhizome length of both the paddy varieties compared to monocropped *Acorus*.

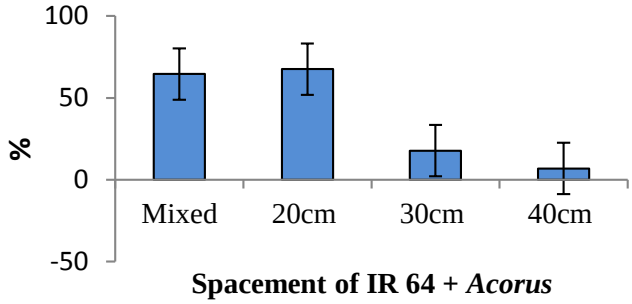

Figure 6. Percent decrease in rhizome diameter of *Acorus* grown with IR-64 + *Acorus*.

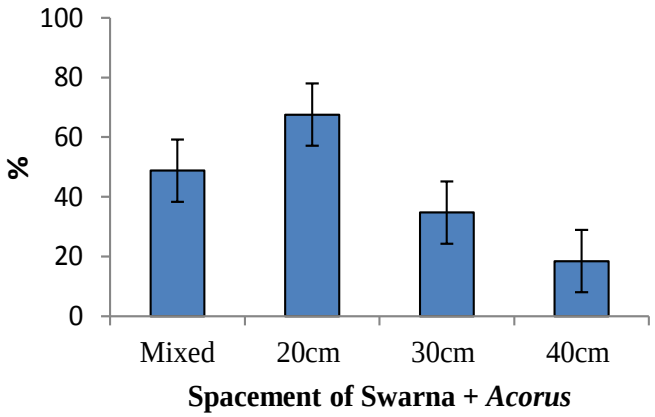

Figure 7. Percent decrease in rhizome diameter of *Acorus* grown with Swarna + *Acorus* than monocropped *Acorus.*

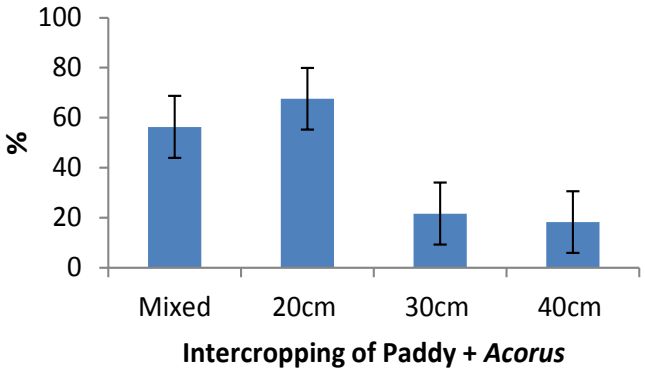

Figure 8. Percent reduction in mean rhizome diameter of both the paddy varieties compared to monocropped *Acorus.*

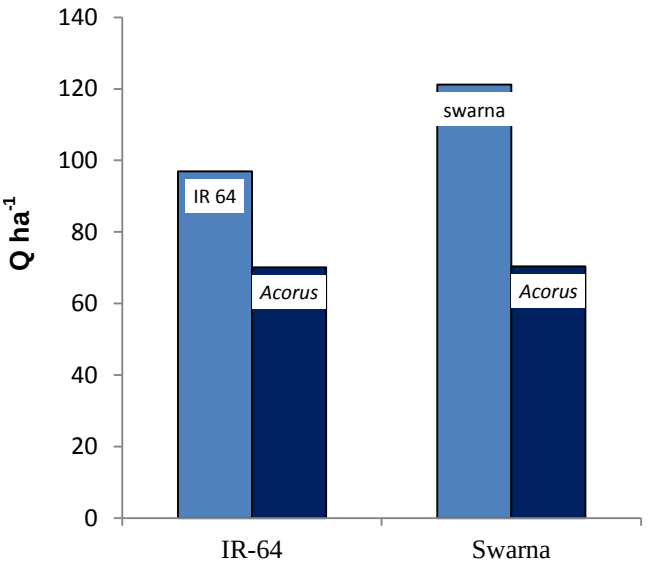

Figure 9. Actual yield (Q ha^{-1}) of IR-64, Swarna and Rhizome yield of *Acorus* grown as monocrops.

Sole crops of rice and sweet flag harvested significantly higher grain yield and rhizome yield respectively compare to different series of intercropping.

Sole cropping of IR-64 and Swarna yielded highest grain yield of 96.46 and 121.20 q ha^{-1}, respectively (Figure 9) but found to be at par with grain yield of rice grown in additive series of inter cropping (sweet flag + rice mixed). Whereas, both varieties of rice planted with sweet flag at spacing of 20, 30 and 40 cm had incremental decrease in grain yield (Figure 10). The maximum reduction of 246.46 and 237.51% in grain yield was recorded in varieties IR-64 and MTU- 7029, respectively under replacement series of intercropping with sweet flag at 40 cm spacing compare to sole crop of both varieties. The widening the gap between rows was resulted into declining in the paddy yield could be attributed to reducing plant density (Gabatshele et al., 2012).

Sole crop of sweet flag had highest rhizome yield (70.26 q ha^{-1}), whereas same planted in intra row space of rice varieties IR-64 and MTU-7029 gave lowest rhizome yield of 21.61 and 21.63 q ha^{-1}, respectively (Figures 9 to 11). There was incremental increase in rhizome yield of sweet flag planted with rice at 1:1 at 20 cm, 30 cm and 40 cm distance. Sweet flag planted at 40 cm distance had higher rhizome yield despite having less plant population compare to 20 and 30 cm distance of planting. The rhizome yield was improved significantly with the increase in spacing under both the paddy varieties. This indicate that the wider spacing provided enough space for sweet flag to have higher nutrient uptake, because their roots could reach far and deep without much competition (Lyocks et al., 2013). There was an increase in rhizome yield of sweet flag planted with IR 64 compare to MTU-7029. However, intercropping of sweet flag with early and late cultivars of rice did not give significant difference in rhizome yield of sweet flag.

It is clear from the above findings that rice yield was declined with increasing space between rice and sweet flag, while rhizome yield was in increasing trend with increasing spacing from 20 to 40 cm. This suggests that over shading of sweet flag by increasing growth of rice plants significantly affected rhizome yield at closer spacing. While, at wider spacing sweet flag plants had higher percentage of space, light and nutrient for better development of rhizome through efficient absorption of soil nutrients. This result is in agreement with earlier findings of Lyocks et al. (2013) who reported low yield of ginger in maize ginger intercrop occurred at closer spacing.

Equivalent yield to rice

Equivalent yield (EQY) to rice obtained from different

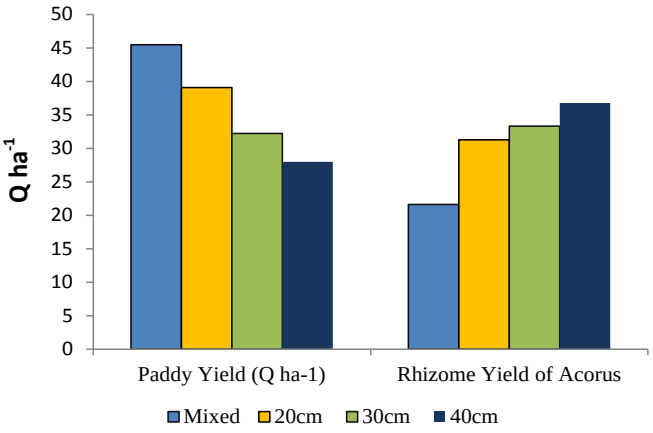

Figure 10. Actual yield of IR-64 and *Acorus* intercropped at different spacing.

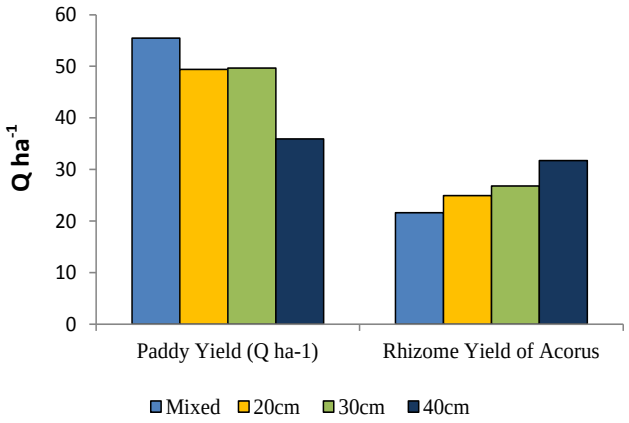

Figure 11. Actual yield of Swarna and *Acorus* intercropped at different spacing.

series of intercropping and sole cropping indicated that during both years, most of the treatments of intercropping had higher equivalent yield compare to sole crop of both varieties of rice grown for two successive crop seasons (Tables 2 and 3, Figure 13). However, EQY recorded from different treatments of intercropping with early and late cultivars of rice was at par with each other.

Sweet flag planted as sole crop fetched highest mean equivalent yield of 234.19 q ha^{-1} compared to other treatments. Sweet flag intercropped with early variety (IR 64) gave higher equivalent yield compare to late variety (Swarna). An increase in equivalent yield of 21.18 and 54.38% was recorded when sweet flag was intercropped with IR 64 in intra row space and at 40 cm inter row space respectively compared to early rice variety (Figure 12).

Similar results were also obtained when sweet flag was intercropped with MTU-7029 (Figure 13). The intercropping is biologically more efficient than the sole crops due to enhanced land equivalent ratios which would be required to produce the same amount of paddy in sole culture.

Higher EQY from different series of intercropping indicated the possibility of intercropping of sweet flag with rice preferably with early cultivars at wider spacing (30–40 cm) and allowed to grow for one season later on after rice harvest. Highest equivalent yield of sweet flag alone (sole crop) indicated that sweet flag (*A. calamus*) could be a better substitute to rice crop under submerged as well as under aerobic conditions. Continuous cultivation of rice on same field adversely affected the soil health therefore crop rotation with sweet flag would be a very effective alternative under rice ecosystem.

Economics and cost benefit ratio

Data presented in Table 4 indicated that gross return and net profit incurred more from all series of intercropping compared to rice as sole crop irrespective of both early and late maturing cultivars of rice. Whereas, sweet flag planted as sole crop incurred highest gross return (Rs 281028.00 ha^{-1}) and net profit (Rs 219528.00 ha^{-1}) among different treatments. However, cost–benefit ratio was highest under intercropping of rice + sweet flag planted at 40 cm spacing with IR 64 (1:4.83) and MTU-7029 (1:4.58) both cultivars followed by sweet flag alone (1:4.56). Sweet flag intercropped with rice in intra row space had lowest (1:2.2 – 1:2.39) cost–benefit ratio. Higher cost of cultivation under rice + sweet flag intercropping system was mainly due to higher input cost of planting material of sweet flag as well as cumulative cost of cultivation of both crops. Whereas, intercropping of sweet flag at wider spacing effectively reduced the cost of planting material of sweet flag. Moreover, sweet flag intercropped with either rice at wider spacing (40 cm) or planted as sole crop had given higher net return and cost- benefit ratio.

Experiment 2

Grain yield and rhizome yield q ha^{-1}

Results of second experiment conducted on effect of different series of intercropping with varying crop cycles are presented in Tables 4 and 5. Grain yield of rice and rhizome yield of sweet flag recorded from different treatments during both the years indicated that sweet flag intercropped with rice gave higher rhizome yield when it was grown as sole crop for a period of one year after rice harvest than 1.5 year of crop cycle.

Higher grain yield of rice sole crop grown for two (109.58 q ha^{-1}) and three (169.82 q ha^{-1}) successive crop seasons was recorded during both years of experimentation compared to rice grown with sweet flag either as additive series of intercropping (rice + sweet flag

Table 2. Grain yield of rice cultivars (IR-64 and MTU – 7029), rhizome yield of sweet flag and equivalent yield of rice as influenced by different series of inter cropping.

Intercropping (A)	Varieties (B)	2004-05			2005-06		
		Actual yield (Q ha^{-1})		Equivalent yield rice (q ha^{-1})	Actual yield (Q ha^{-1})		Equivalent yield rice (Q ha^{-1})
		Paddy	Sweet flag		Paddy	Sweet flag	
Rice alone	IR 64	100.03	-	100.03	93.83	-	93.83
	Swarna	123.76	-	123.76	118.64	-	118.64
Sweet flag + Rice (mixed)	IR 64	44.03	17.87	103.40	46.89	25.35	131.89
	Swarna	56.41	17.21	113.70	54.49	26.06	141.38
Sweet flag + Rice at 20 cm	IR 64	36.11	30.06	136.32	42.01	32.49	150.32
	Swarna	50.55	24.86	133.42	48.21	24.99	131.35
Sweet flag + Rice at 30 cm	IR 64	31.79	34.53	146.89	32.63	32.13	139.75
	Swarna	44.73	26.34	132.53	54.63	27.25	145.47
Sweet flag + Rice at 40 cm	IR 64	22.51	34.66	134.32	33.44	38.44	161.58
	Swarna	31.32	33.76	143.88	40.51	29.75	139.78
Sweet flag alone	IR 64	-	79.54	265.14	-	60.70	202.36
	Swarna	-	77.10	257.00	-	63.70	212.25
CD at 5% A				20.64			20.70
B				NS			NS
AB				12.49			8.60

mixed) or as replacement series (1:1). Besides, there was three to five folds reduction in grain yield of rice intercropped with different series of intercropping. Rhizome yield of sweet flag recorded from different treatments indicated that sole crop of sweet flag gave higher rhizome yield either with crop cycle of one year (67.30 q ha^{-1}) or 1.5 years (104.35 q ha^{-1}) compared to intercropping for one year (32.48 q ha^{-1}) or 1.5 years (65.90 q ha^{-1}). Moreover, crop cycle of 1.5 years found to be most suitable for optimizing the rhizome yield of sweet flag (Table 5). Planting of sweet flag in intra row space (rice + sweet flag mixed) of rice gave higher rhizome yield (37.10 q ha^{-1}) compared to planting of sweet flag (27.87 q ha^{-1}) in inter row space (rice + sweet flag 1:1).

Equivalent yield to rice

Equivalent yield was calculated based on rhizome yield of sweet flag grown as sole crop as well as intercrop with rice for a period of 1 and 1.5 years and presented in Table 5. Results indicated that equivalent yield of sweet flag alone taken either a period of one year (223.97 q ha^{-1}) and 1.5 years (347.83 q ha^{-1}) gave significantly higher equivalent over other treatments. Sweet flag intercropped with rice either in additive series (rice + sweet flag mixed) or in replacement series (rice + sweet flag 1:1) had produced significantly higher EQY than rice sole crop which was grown for two (109.58 q ha^{-1}) and three (169.82 q ha^{-1}) successive

Table 3. Grain yield of Rice cultivars (IR-64 and MTU – 7029), rhizome yield of sweet flag and equivalent yield of rice as influenced by different series of inter cropping (pooled mean two years).

Intercropping series Treatments (A)	Treatment (B) Varieties					
	IR-64			MTU – 7029		
	Rice (Q ha^{-1})	Sweet flag (Q ha^{-1})	Equivalent yield of rice (Q ha^{-1})	Rice (Q ha^{-1})	Sweet flag (Q ha^{-1})	Equivalent yield of rice (Q ha^{-1})
Rice alone	96.93	-	96.93	121.20	-	121.20
Sweet flag + Rice (mixed)	45.46	21.61	117.40	55.49	21.63	127.58
Sweet flag + Rice at 20 cm	39.06	31.27	143.32	49.38	24.93	132.47
Sweet flag + Rice at 30 cm	32.21	33.31	143.32	49.68	26.79	139.00
Sweet flag + Rice at 40 cm	27.97	36.75	149.65	35.91	31.75	141.83
Sweet flag alone	-	70.12	233.75	-	70.40	234.63
CD at 5%, B, AB	A - 23.70 B – NS AB - 10.75					

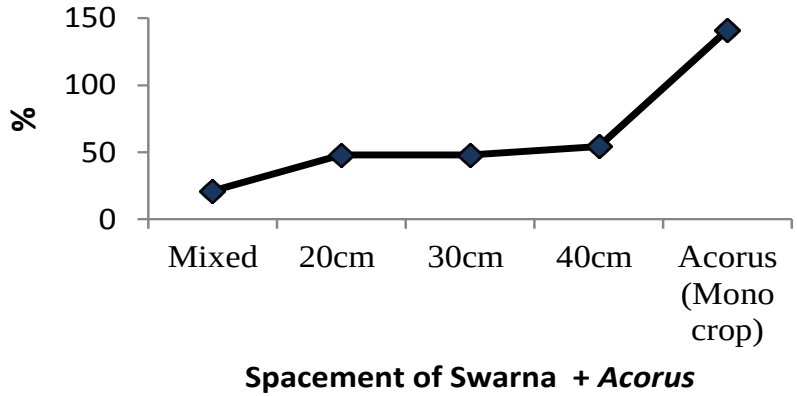

Figure 12. Percent increase in EQY of IR 64 + *Acorus* intercropped at different spacing compared to EQY of sole IR-64.

cropping seasons. However, EQY of sweet flag intercropped with rice in additive series (rice + sweet flag mixed) with a crop cycle of one year (165.76 q ha^{-1}) and 1.5 years (268.06 q ha^{-1}) was at par with EQY of sweet flag intercropped with rice in replacement series (132.43 and 253.23 q ha^{-1}). Moreover, intercropping of sweet flag and rice with a crop cycle of 1.5 years produced significantly higher equivalent yield (Figure 14) than crop cycle of one year.

Economics and cost benefit ratio

Data presented in Table 6 and Figure 15 indicated the significant effect of intercropping and crop cycle period on cost of cultivation, gross return,

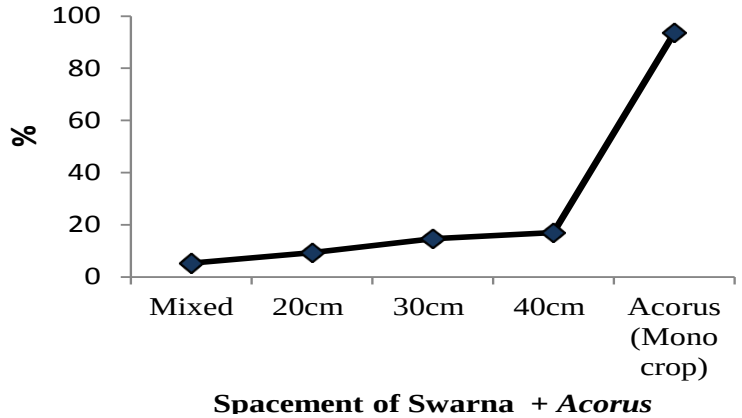

Figure 13. Percent increase in EQY of Swarna + *Acorus* intercropped at different spacing compared to EQY of sole Swarna.

Table 4. Economics of different series of intercropping of sweet flag with rice (mean of two years).

Intercropping	Varieties	Equivalent yield to rice (q ha^{-1})	Cost of cultivation (Rs ha^{-1})	Gross return (Rs ha^{-1})	Net return (Rs ha^{-1})	Cost–Benefit ratio
Rice alone	IR 64	96.93	48000.00	116316.00	68316.00	1:2.42
	Swarna	121.20	48000.00	145440.00	97440.00	1:3.03
Sweet flag + Rice (mixed)	IR 64	117.40	64000.00	140880.00	76880.00	1:2.20
	Swarna	127.58	64000.00	153096.00	89096.00	1:2.39
Sweet flag + Rice at 20 cm	IR 64	143.32	52750.00	171984.00	119234.00	1:3.26
	Swarna	132.47	52750.00	158964.00	106214.00	1:3.01
Sweet flag + Rice at 30 cm	IR 64	143.32	42300.00	171984.00	129684.00	1:4.06
	Swarna	139.00	42300.00	166800.00	124500.00	1:3.94
Sweet flag + Rice at 40 cm	IR 64	149.65	37125.00	179580.00	142455.00	1:4.83
	Swarna	141.83	37125.00	170196.00	133071.00	1:4.58
Sweet flag alone		234.19	61500.00	281028.00	219528.00	1:4.56

Prevailing market rates: Paddy – Rs 1200 q^{-1}, Sweet flag – Rs 4000 q^{-1}.
Input cost:
Planting material: Sweet flag: Rs 40000.00/ha.
Rice: Rs 2500.00/ha.
Cultivation cost for sweet flag and rice: Rs 21500.00/ha.

Table 5. Comparative evaluation of actual and equivalent yield of paddy and Sweet flag as influenced by intercropping for one year and one and half year of crop cycles.

Treatments (A)	2006-07		2007-08		Pooled mean
	Actual Yield (q ha^{-1}) Sweet flag Rice	EQY of rice (q ha^{-1})	Actual yield (q ha^{-1}) Sweet flag Rice	EQY of rice (q ha^{-1})	EQY of rice (q ha^{-1})
Rice for two crop seasons (1 year)	- 104.57	104.57	- 114.59	114.59	109.58
Rice for three crop seasons (1.5 year)	- 162.37	162.37	- 177.27	177.27	169.82
Rice + Sweet flag 1:1 (1 year)	30.16 38.88	139.42	25.58 40.31	125.57	132.43
Rice + Sweet flag 1:1 (1.5 year)	65.65 35.88	254.62	63.75 39.20	251.70	253.23
Rice + Sweet flag mixed (1 year)	41.00 41.84	178.50	33.20 42.31	152.97	165.76
Rice + Sweet flag Mixed (1.5 year)	69.58 44.69	276.64	64.63 44.02	259.45	268.06
Sweet flag sole for two crop seasons (1 year)	67.28 -	224.26	67.32 -	223.69	223.97
Acorus sole for three crop seasons (1.5 year)	100.83 -	336.10	107.87 -	359.56	347.83
C.D. at 5%		37.33		47.03	47.91
CV%		11.33		9.74	10.94

Market Price: Sweet flag @ Rs 4000/q, Paddy @ Rs 1200 /q.

Table 6. Economics of different series of intercropping of sweet flag with rice (mean of two years).

Intercropping	Equivalent yield to rice (q ha^{-1})	Cost of Cultivation (Rs ha^{-1})	Gross return (Rs ha^{-1})	Net return (Rs ha^{-1})	Cost-Benefit ratio
Rice for two crop seasons (1 year)	109.58	48000.00	131496.00	83496.00	1:2.73
Rice for three crop seasons (1.5 year)	169.82	72000.00	203784.00	131784.00	1:2.83
Rice + Sweet flag 1:1 (1 year)	132.43	52750.00	158916.00	104166.00	1:2.90
Rice + Sweet flag 1:1 (1.5 year)	253.23	57750.00	303876.00	246126.00	1:5.26
Rice + Sweet flag mixed (1 year)	165.76	64000.00	198912.00	134912.00	1:3.10
Rice + Sweet flag Mixed (1.5 year)	268.06	69000.00	321672.00	252672.00	1:4.66
Sweet flag sole for two crop seasons (1 year)	223.97	61500.00	268764.00	204264.00	1:4.37
Acorus sole for three crop seasons (1.5 year)	347.83	66500.00	417396.00	350896.00	1: 6.27

Prevailing market rates: Paddy – Rs 1200 q^{-1}, Sweet flag – Rs 4000 q^{-1}.
In put cost:
Planting material: Sweet flag: Rs 40000.00/ha.
Rice: Rs 2500.00/ha.
Cultivation cost for sweet flag and rice: Rs 21500.00/ha.

net profit and cost benefit ratio. Maximum gross return of Rs 417396.00 ha^{-1} and net profit of Rs 350896.00 ha^{-1} incurred from sweet flag taken as sole crop for a period of 1.5 years. All series of intercropping with crop cycle of 1.5 years were superior to crop cycle of 1 year in terms of getting higher net profit. Cost of cultivation was found to be highest in rice sole crop taken for three consecutive seasons (Rs 72000.00) due to three times addition of cultivation cost. Sweet flag intercropped with rice as either intercrop (rice + sweet flag @ 1:1) or planted in intra row space for

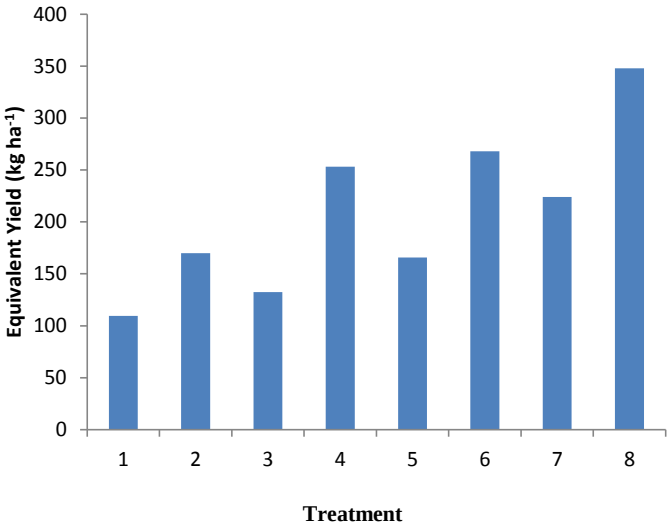

Figure 14. EQY (kg ha^{-1}) of rice intercropped with *Acorus* in 1 and 1.5 years crop cycles. Treatments :- 1 - Rice 1 Year; 2 - Rice 1.5 years; 3 - Rice+ *Acorus* (1:1) 1 year; 4 - Rice +*Acorus* (1:1) 1.5 years; 5 - Rice+*Acorus* (Mixed) 1 year; 6 - Rice+*Acorus* (Mixed 1.5 years; 7 - *Acorus* sole 1 year; 8 - *Acorus* sole 1.5 years.

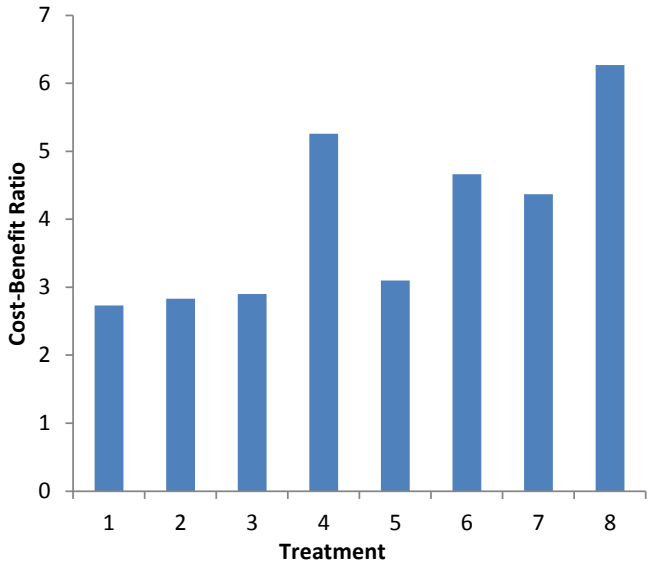

Figure 15. Cost-Benefit ratio of different series of intercropping of sweet flag with rice in 1 and 1.5 years of crop cycles. Treatments: 1 - Rice 1 Year, 2 - Rice 1.5 years, 3 - Rice+ *Acorus* (1:1) 1 year, 4 - Rice +*Acorus* (1:1) 1.5 years, 5 - Rice+*Acorus* (Mixed) 1 year, 6 - Rice+*Acorus* (Mixed 1.5 years, 7 - *Acorus* sole 1 year, 8 - *Acorus* sole 1.5 years.

a period of 1.5 years had given similar amount of net profit despite that gross return and net profit incurred more from all series of intercropping compared to rice as sole crop.

Conclusion

The intercropping of *Acorus* with both paddy varieties propounded higher yield and EQY compared to mono cropping of paddy varieties under test. The spacing between intercrops was the main factor affects all parameters of plant and yield of the both intercrops and in present study 40 cm spacing was found best in terms of yield and equivalent yield of paddy and *Acorus*. The monocropping of *Acorus* either one year or 1.5 years cropping system rendered the higher yield and equivalent yield among their categories. Thus as compared to sole cropping of paddy, intercropping of *Acorus* can be more profitable to farmers due to higher equivalent yield and income.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

REFERENCES

Balakumbahan R, Rajamani K, Kumanan K (2010). "*Acorus* calamus: An overview". J. Med.l Plants Res. 4(25):2740-2745.
Chaure NK, Pandey D, Thakur BS (2007). Effect of climatic parameters on evapotranspiration during rainfed paddy ecosystem. Environ. Ecol. 25(3):670-672.
Dykyjova D (1980). Production ecology of *Acorus* calamus. Folia Geobotanica and Phytotaxonomica 15:29-57.
Foley JA, DeFries R, Asner GP, Barford C, Bonan G, Carpenter SR, Chapin FS, Coe MT, Daily GC, Gibbs HK, Helkowski JH, Holloway T, Howard EA, Kucharik CJ, Monfreda C, Patz JA, Prentice C, Ramankutty N, Sny PK (2005). Global Consequences of Land Use. Science 309:570-574.
Gabatshele M, Legwaila Teko K, Marokane, Witness Mojeremane (2012). Effects of intercropping on the performance of Maize and Cowpeas in Botswana. Int. J. Agric. For. 2(6):307-310.
Gualtiero S (1990). Stanley Schuler, ed. Simon & Schuster's Guide to Herbs and Spices. Simon & Schuster, Inc. ISBN 0-671-73489-X.
Hejny S, Husak S (1978). Higher plant communities. In Dykyjova, D. & J. Kvet (ed.), Pond Littoral Ecosystems – Structure and Functioning. Springer-Verlag, Berlin, Heidelberg, New York pp. 23-64.
Li L, Sun JH, Zhang FS, Li XL, Yang SC, Rengel Z (2006). Wheat/maize or wheat/ soybean strip intercropping. Yield advantage and inter-specific interactions on nutrients. Field Crop Res. 71:123-137.
Lyocks SWJ, Tanimu J, Dauji LZ, Ogunleys DA (2013). Evaluation of the effects of intra row spacing on the growth and yield of maize (*Zea mays*). in maize ginger intercrop in samara, northern guinea savanna of Nigeria. Agric. Biol. J. North Am. 4(3):175-180.
McAlpine T, Warrier L (19960. Future World Trends in the Supply, Utilization, and Marketing of Endangered plant Species. London, McAlpine Thorpe & Warrier Limited: 176.
Mukherjee PK, Kumar V, Mal M, Houghton PJ (2007). "*Acorus* calamus: Scientific validation of ayurvedic tradition from natural resource. Pharmaceutical Biol. 45:651-666.
Takim FO (2012). Advantages of Maize- Cowpea intercropping over sole cropping through competition indics. J. Agric. Biod. Res. 1(4):53-59.
Tiwari RKS, Shambhakar VB, Das K, Sharma P (2011). Economic yield of medicinal herbs Sweet flag (*Acorus calamus)* and Bramhi (*Bacopa monnieri*) under different planting patterns in irrigated rice-ecosystem. J. Med. Aromatic Plant Sci. 33(4):418-422.
Tiwari RKS, Das K, Pandey D, Tiwari RB, Dubey J (2012). Rhizome

Yield of Sweet Flag (*Acorus calamus* L.) as Influenced by Planting Season, Harvest time and spacing. Int. J. Agron. pp. 1-8

Vojtiskova L, Munzarova E, Votrubova O (2001). Performance of some wetland plants under nitrogen nutrition - influence on C: N balance. Book of Abstracts. Plant Physiology Days of Young Scientist, Praha, P 45.

Vojtiskova L, Munzarova E, Votrubova O, Rihova A, Juriocova B (2004). Growth and biomass allocation of sweet flag (*Acorus calamus* L.) under different nutrient conditions. Hydrobiologia 518:9-22.

Weber M, Brandle R (1996). Some aspects of the extreme anoxia tolerance of the sweet flag, *Acorus* calamus L. Folia Geobotanica and Phytotaxonomica 31:37-46.