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Effect of water management practices on Mat-sedges (*Cyperus tegetum* Roxb.) through rainwater harvesting and soil physico-chemical properties

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Abstract: From the literature, preliminary survey and contact with the farmers at Sabong and Pingla block of Paschim Medinipur, West Bengal, India, where mat-sedges is being widely cultivated mostly as mono-crop with poor management practices by the poor and marginal farmers, resulted poor returns. From their practice, it proven that this crop is raised as per their traditional practice without much care, needs further improvised agro-techniques. So, with the view on this fact, a field experiment was conducted to study the 'Effect of water management practices on mat-sedges (*Cyperus tegetum* Roxb.) through rainwater harvesting and soil physico-chemical properties' during 2006 - 07 to 2007 - 08 at farmer's field at Bural under Sabong block area of Paschim Medinipur, West Bengal, India on clay loam soil. Excess rainwater during rainy season was conserved in excavated harvesting pond in adjacent of experimental area for subsequent use as life-saving irrigation by the crop. From the experiment it reveals that during *kharif* season, there was no significant difference observed in respect to plant height, number of tillers m^{-2} and dry matter accumulation of mat-sedges in pooled data. However, during winter and summer season, W_6 treatment (W_3 + paddy straw mulching during winter and summer season, respectively) exhibited highest plant height (88.54 and 111.25 cm), maximum no. of tillers m^{-2} (216.8 and 269.6) and higher value of dry matter accumulation (277.4 and 387.5 g m^{-2}), respectively (pooled data). Soil carbon and nitrogen status of the soil after harvest of mulch treated plots were increases. Mat-sedges crop during *kharif* season resulted in taller plants and more no. of tillers m^{-2} as compared to regeneration crop during winter and summer season, respectively.

Key words: Mat-sedges, Water management practices, Rainwater harvesting, Life-saving irrigation, soil carbon status and seasonal effect

Introduction

Cultivation of mat-sedges and its valuable products and production of mat-reed can play an important economic role in this aspect. There are several species under the genus *Cyperus*, are mostly habitants in swampy, marshy land and dominated in tropics to sub-tropical environmental condition. Mandal (1986) reported that application of irrigation water according to physiological growth stages of the crop, particularly during the drier months of the year increased productivity of mat-sedges as water management practices is one of the most important aspect during winter and summer season. Mats are generally woven by the aged family members of either sex of a farmer's family and can earn a net income of Rs. 60 – 80/- per day from this job (Puste, 2004). In rural areas of Paschim Medinipur have gained wide popularity and even enjoyed president's Award for its quality and artistic work. The mats from this area are being exported to other countries. It is essential to know the proper time for irrigation to obtained maximum yield components. So, for the economic use of water, it is essential to apply irrigation at critical growth stages of mat-sedges crop. Mulches reduce evaporation loss of soil moisture, thus conserve soil moisture. The research-based information on the water management practices of mat-sedge in this region is very meager.

Hence, this experiment was conducted in order to find out: (1) to study the effect of water management practices on most important yield components of mat-sedges viz., plant height and no. of tillers m^{-2} and (2) to determine the critical growth stages, particularly during winter and summer season towards moisture sensitivity.

Materials and Methods

A field experiment was conducted to study the 'Effect of water management practices on mat-sedges (*Cyperus tegetum* Roxb.) through rainwater harvesting and soil physico-chemical properties' during 2006 - 07 to 2007 - 08 at farmer's field at Bural under Sabong block of Paschim Medinipur district, West Bengal, India on clay loam soil. The experiment was laid out in randomized complete block design (RCBD) with six different types of water management practices [W_1 – Farmer's Practice (Rainfed during *kharif* + one irrigation during winter + 2 irrigations during summer); W_2 – Rainfed during *kharif* + one life-saving irrigation during winter and summer, respectively; W_3 – Rainfed during *kharif* + 2 irrigations during winter + 3 irrigations during summer; W_4 – Rainfed during *kharif* + 3 irrigations during winter + 4 irrigations during summer; W_5 – W_2 + paddy straw mulching during winter and summer, respectively; W_6 – W_3 + paddy straw mulching during winter and summer season, respectively] were carried out randomly with four replications. The irrigation water is effective, particularly during the drier months of the year. So, a precise irrigation according to need based and physiological growth stages of the crop was provided for better growth and yield components. For this, excess rainwater was conserved in excavated two harvesting ponds (50m x 20m x 3m) in adjacent of experimental area for subsequent use by the crop for providing life-saving irrigation and need-based irrigations. Pooled analysis was made from two years data of three seasons, namely *kharif* (2006 and 2007), winter (2006-'07

and 2007-'08) and summer (2007 and 2008), respectively. Post harvest soil samples were collected and were analysed for pH [Beckman's pH meter method (Jackson, 1967)], organic carbon (OC) [Walkely-Black method, 1934 (Jackson, 1967)] and available N [Modified Kjeldahl's method (Jackson, 1967)], P [Olsen's method (Jackson, 1967)] and K status [Flame photo metric method (Muhr *et al*., 1965)]. The following practices are adopted during the experiment.

1) One irrigation: After cutting (previous crop) at tiller initiation stage (12 – 15 DAC) during winter and summer,
2) Two irrigations: 1st and 2nd at tiller initiation and maximum tillering stage (70 DAC),
3) Three irrigations: 1st, 2nd and 3rd at tiller initiation, tillering (40 DAC) and at maximum tillering stage, respectively and
4) Four irrigations: 1st, 2nd, 3rd and 4th at tiller initiation, tillering, maximum tillering and at inflorescence initiation stage (90 DAC), respectively.

Results and Discussion

As the mat-sedges is perennial in nature, grown round the year once it's established in the field with proper agro-techniques. After full establishment of the crop in the field, it may possible to take 3 cuttings for their economic return. Here, respectively three-season's mat-sedges crop are highlighted, viz. *kharif* season (June to end of September of 2006 and 2007, respectively), subsequent winter season (October to end of January of 2006 - 07 and 2007 - 08, respectively) and summer season (February to end of May of 2007 and 2008, respectively). The plant height and no. of tiller m^{-2} are most important, as it produces the ultimate economic part of the plant. In addition, plant height is more important, which determine the original width of a hand-made mat, as the market price of the hand-made mat varies according to its width.

Plant height: In general, plant height of mat-sedges increased successively with the advancement of crop age. It reveals from the experimental results, no significant difference in respect to plant height at 120 DAP (days after planting) was observed during 2006, when crop grown under rainfed situation. At 120 DAC (days after cutting) (at harvest), the maximum plant height (150.07 and 136.88 cm during 2007 and in pooled data, respectively) was recorded from the treatment W_6. As because, good growth and development of rhizomes along with production of sucker were obtained from combined use of paddy straw mulching and irrigations during winter (October to end of January of 2006 - 07) and summer season (February to end of May of 2007), which produced the taller plants of mat-sedges in W_6 treatment (Table 1). Improvement in root proliferation and development of lateral suckers in moist clay and clay loam soil was observed by Sarkar and Samanta (1987). Lowest plant height was obtained with the treatment W_2 during *kharif* 2007, which received only one life-saving irrigation during winter and summer season, respectively. However, in case of pooled data, plant height of mat-sedges was not significantly differed at the time of harvesting among the treatments during *kharif* season. During winter and summer season, the highest plant height of mat-sedges were recorded from the treatment W_6 (W_3 + paddy straw mulching during winter and summer season, respectively). It was statistically at par with treatment W_4 (3 and 4 irrigations during winter and summer, respectively) at harvest. The treatment W_2 (one life saving irrigation at tiller initiation stage) recorded the lowest plant height during summer and it was significantly lower than other treatments (Table 1). Thus, it was clear from the results that plant height of mat-sedges increased with the increase in irrigation frequency along with paddy straw mulching, had beneficial influence on the growth of plants.

Table- 1: Effect of water management practices on plant height (cm) of mat-sedges at harvest

Treatments	Kharif season			Winter season			Summer season		
	2006	2007	Pooled	2006-07	2007-08	Pooled	2007	2008	Pooled
W_1	121.50	124.62	123.06	59.50	60.50	60.00	73.41	74.56	73.98
W_2	122.62	123.62	123.12	58.23	59.85	59.04	58.57	60.22	59.39
W_3	123.42	133.25	128.33	71.35	73.97	72.66	83.98	84.63	84.30
W_4	123.62	142.50	133.06	85.50	87.32	86.28	98.73	100.23	99.48
W_5	122.72	130.46	126.59	72.97	74.56	73.76	73.56	75.14	74.35
W_6	123.70	150.07	136.88	87.67	89.42	88.54	109.8	112.7	111.25
S.Em. (±)	7.14	6.18	4.72	3.82	3.43	2.57	4.46	4.69	3.23
CD (0.05)	NS	18.63	NS	11.53	10.35	7.73	13.43	14.12	9.73

Table- 2: Effect of water management practices on number of tillers m^{-2} of mat-sedges at harvest

Treatments	Kharif season			Winter season			Summer season		
	2006	2007	Pooled	2006-07	2007-08	Pooled	2007	2008	Pooled
W_1	301.5	309.6	305.5	116.9	117.5	117.2	178.1	181.2	179.6
W_2	303.7	305.8	304.7	114.5	115.5	115.0	146.3	147.4	146.8
W_3	304.0	321.5	312.7	156.2	157.0	156.6	226.4	228.2	227.4
W_4	304.5	330.8	317.6	211.4	213.2	212.3	237.5	239.8	238.6
W_5	304.0	315.4	309.7	156.5	158.75	157.4	194.6	195.3	194.9
W_6	303.2	333.8	318.5	215.5	218.2	216.8	268.5	270.7	269.6
S.Em. (±)	8.03	5.17	4.78	12.85	12.40	8.93	9.80	10.04	7.03
CD (0.05)	NS	15.59	NS	38.71	37.37	26.88	29.52	30.13	21.09

Table- 3: Effect of water management practices on dry matter accumulation (g m^{-2}) of mat-sedges at harvest

Treatments	Kharif season			Winter season			Summer season		
	2006	2007	Pooled	2006-'07	2007-'08	Pooled	2007	2008	Pooled
W_1	435.2	453.0	444.1	153.2	160.7	156.9	260.6	267.6	264.1
W_2	434.6	451.3	442.9	152.8	156.3	154.5	199.5	207.2	203.3
W_3	434.2	490.5	462.3	227.3	235.8	231.5	326.8	333.5	330.1
W_4	435.7	498.3	467.0	263.8	273.5	268.6	347.2	349.8	348.5
W_5	434.4	476.2	455.3	229.6	238.2	233.9	275.2	281.5	278.3
W_6	433.6	511.4	472.5	272.4	282.4	277.4	384.6	390.4	387.5
S.Em. (±)	8.64	15.26	10.10	8.31	10.34	6.63	16.16	13.75	10.61
CD (0.05)	NS	45.97	NS	25.05	31.16	19.97	48.69	41.43	31.96

Table-4: Chemical properties of post harvest soil after completion of experiment

Treatments	Soil chemical properties				
At harvest	pH	Organic C (%)	Total N (%)	Available P_2O_5 (kg ha^{-1})	Available K_2O (kg ha^{-1})
W_1	6.4	0.47	0.046	13.45	184.5
W_2	6.4	0.47	0.047	13.56	184.6
W_3	6.4	0.48	0.046	13.36	182.3
W_4	6.4	0.48	0.047	13.25	181.6
W_5	6.3	0.51	0.051	15.82	183.7
W_6	6.3	0.51	0.051	15.87	182.7
Initial	6.4	0.49	0.048	14.90	198

This might be attributed to rapid cell division and elongation in presence of adequate moisture as compared to relatively stressed plants (Jana and Puste, 2012).

Number of tillers m^{-2}: At the time of harvesting the highest no. of tillers m^{-2} (333.8 and 318.5 no. of tillers m^{-2} during 2007 and in pooled data, respectively) were recorded from W_6 treatment (W_3 + Paddy straw mulching during winter and summer season, respectively) during *kharif* season (Table 2). It was statistically at par with the treatment W_4 (Rainfed during *kharif* + 3 irrigations during winter + 4 irrigations during summer). The lowest no. of tillers m^{-2} were obtained with W_2 treatment (Rainfed during *kharif* + one life-saving irrigation during winter and summer season, respectively) and it was statistically at par with W_1 treatment during *kharif* season 2007.

Thus, number of tillers m^{-2} were highest in W_6 treatment, where paddy straw mulching along with 2 irrigations and 3 irrigations during winter and summer season, respectively were imposed on the previous mat-sedges crop. Most growth of rhizomes and sucker occurred from a period of optimal moisture condition was observed by J. Lapham (1985). As more no. of tillers were produced from well developed rhizomes and suckers of this crop. The good effect of paddy straw mulching along with higher frequency of irrigation were reflected at *kharif* season 2007 in respective plot when mat-sedges crop grown under rainfed situation.

The maximum no. of tillers m^{-2} were recorded from W_6 (W_3 + paddy straw mulching during winter and summer season, respectively). It was statistically at par with treatment W_4 during winter and followed by treatment W_4 during summer season, where 3 and 4 irrigations during winter and summer season, respectively were applied according to physiological growth stages of the crop.

The treatment W_2 and W_1 recorded the lowest number of tiller m^{-2} during winter season and it was significantly lower than other treatments of water management practices. During summer season the lowest no of tillers m^{-2} (146.3, 147.4 and 146.8 at harvest during 2007, 2008 and in pooled data, respectively) were obtained with the treatment W_2 and was significantly lower than other treatments of water management practices (Table 2). The no. of tillers m^{-2} obtained from W_1 (2 irrigations during summer) was statistically at par with W_5 (W_2 + paddy straw mulching), where one life saving irrigation along with paddy straw mulching was imposed on the crop. However, the treatment W_3 (3 irrigations during summer) showed an intermediate value.

Combination of straw mulch along with irrigations improved infiltration of water into the soil profile, soil moisture status, increase the availability of soil NPK, suppress weed growth in the field which in turn, produce more suckers as well as resulting good growth and development of rhizomes and ultimately produced more no. of tillers m^{-2} from rhizomes and suckers. Sarkar and Samanta (1987) also confirmed to the findings, where they reported that moist clay and clay loam soil is conducive for development of lateral suckers and ultimately accelerate the number and proper growth of culms of mat-sedges.

Dry matter accumulation: At the time of harvesting, the highest value of dry matter accumulation of mat-sedges (472.5, 277.4 and 387.5 g m^{-2} in pooled data during *kharif*, winter and summer, respectively) was recorded from W_6 (W_3 + paddy straw mulching). The lowest value of dry matter accumulation was obtained with W_2 (one life saving irrigation at tiller initiation stage) and it was significantly lower than other treatments of water management practices (Table 3). Dry matter accumulated in W_3 treatment (3 irrigations during summer) was statistically at par with the treatment W_4 (4 irrigations during summer). However, W_3 showed an intermediate value

significantly higher than W_1, W_2 and W_5 and significantly lower than W_6 treatment. Similar trend was also observed during winter season. Increase in dry matter accumulation with increase in irrigation frequency along with paddy straw mulching had favourable influence and stimulating effect on crop growth resulting in higher rates of photosynthesis, an increase in accumulation and distribution of assimilates in plant parts from seedling to maturity stages of the crop (Jana and Puste, 2012). As a result of which, deposited greater amount of photosynthate in plant parts. While, lack of soil moisture status might depressed photosynthesis and ultimately resulted in poor crop growth.

Soil physico-chemical properties: The paddy straw mulching (organic mulching) had a great influence on soil chemical properties (Table 4). There was a slight decrease in the pH value, when the soil was mulched with organic once and it was observed in case of paddy straw mulch condition. The decrease in pH value might be due to the results of some organic acids released during decomposition of paddy straw (organic material). Regarding soil organic carbon status, increasing trend of organic carbon content (0.51) of the soil was noted, when soil was mulched with paddy straw (organic residue). In relation to total soil nitrogen, there was an increasing trend with paddy straw mulching. This might be due to decomposition of paddy straw as an organic once. The available P_2O_5 was higher under paddy straw mulching due to the organic matter decomposition. There was a decrease in available P_2O_5 under no mulch situation than the initial value. Regarding available potassium (K_2O) in all the treatments showed a decreasing trend than the initial value and there was a slight variation in the available K_2O in different treatments. Thus, the mulching had less or no influence on available K_2O. The above results clearly indicated that straw mulching had a significant effect on soil chemical properties and nutrient utilization. This similar type of results was also reported by Mohan Kumar *et al.*, (1973) in *Amorphophalus*. The increase of soil carbon and nitrogen status of the soil after harvest of mulch treated plots was confirmed by Mandal and Ghosh, 1984 and Solaiappan *et al.,*1999.

The treatment W_6 (W_3 + paddy straw mulching during winter and summer season, respectively), where crop was irrigated with 2 irrigations + paddy straw mulching during winter and with 3 irrigations + paddy straw mulching during summer, produced highest plant height, maximum no. tillers m^{-2} and total dry matter production of mat-sedges as compared to other treatments of water management practices. Considering the economy of water use, single irrigation should be applied at tiller initiation stage of the crop, particularly when the water is scare.

Thus, application of paddy straw mulching along with higher frequency of irrigation (2 irrigations during winter and 3 irrigations during summer, respectively) not only enhanced the plant height, no. of tillers m^{-2} and total dry matter production of mat-sedges to a greater tune, but also found to be improved physico-chemical properties of soil.

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