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Assessment of seasonal efficacy of different evaporation retardants in semi-arid tropics

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ABSTRACT

An experiment was conducted in 2007–08 at Arjia, Rajasthan to evaluate the efficacies of different evaporation retardants viz., Maize stover (6 kg m^{-2}), Burnt oil (2 mm thick film), Poly film (50 micron), Cetyle alcohol (2.2 kg ha^{-1}) and Control in reducing evaporation from surface of water bodies. Results revealed that there was significant relation between evaporation retardants and control treatments in pre-monsoon, monsoon and post-monsoon seasons. Due to application of different evaporation suppressants, on an average, maize stover resulted in lowest evaporation of 2.75 mm day^{-1}, followed by poly film (2.94 mm day^{-1}) and burnt oil (3.89 mm day^{-1}). As compared to control, cetyle alcohol as surfactant resulted in the lowest mean reduction (31.3%) in evaporation. On an average, the maize stover caused mean reductions in evaporation to the tunes of 59 and 58% over different seasons in comparison with open pan evaporation and control treatments, respectively. Thus it is concluded that application of maize stover is proved to be the most effective method for suppression of evaporation from free-water surfaces.

Key words: Seasonal efficacy, evaporation retardants, poly films, maize stover, correlation

In semi–arid tropics, most of the harvested rainwater is retained in farm ponds, lakes and traditional reservoirs, but storage of water in such a manner allows for the greatest loss through evaporation due to high evaporative demand of the environment during summer season. Evaporation losses may account for up to 50% of total storage losses in open shallow reservoirs and up to 20% in deep reservoirs (Walton, 1969). Daily variations in solar radiation also affects the evaporation from open water. The increasing demand for fresh water in the semi–arid tropics, emphasizes the urgent need to employ techniques for reducing evaporation aiming at the conservation of water. Monomolecular duplex films of certain surfactants can retard water evaporation (Barnes, 1986) and it is more viable technology for reducing the evaporative losses of water from rainwater harvesting structures *viz.*, farm pond, lake and reservoirs. For many years, important studies were carried out to identify the appropriate substances and optimal conditions for reducing water evaporation. Among the surfactants tested, biodegradable fatty alcohols of low toxicity exhibited the highest resistance to water evaporation, especially 1-hexadecanol and 1-octadecanol. The present investigation was planned for testing several evaporation retardants for reduction in the evaporation from small water bodies.

MATERIALS AND METHODS

The field experiment was conducted during 2007-08 at Dryland Farming Research Station, Arjia, Bhilwara, Rajasthan ($24^0$20' N; $74^0$20' E; 432 m above mean sea level). The experiment consisted of five treatments viz., (i) maize stover (6 kg m^{-2}); (ii) burnt oil (2 mm thick film); (iii) black poly film (50 micron); (iv) small crystal of cetyal alcohol (2.2 kg ha^{-1}); and (v) control. The experiment was conducted in plastic tubes of size 40 cm x 70 cm. Water used in the pan evaporimeter was added in these tubes at fixed level. The plastic tubes were covered with wire mesh. The evaporation was measured based on the standard procedure as followed in open pan evaporimeter. The evaporation retarding materials in different treatments were applied every month for an effective reduction of evaporation. The experiment was conducted for 365 days and statistical analysis was performed by considering days as replication (Gomez and Gomez, 1984). Performance of evaporation retardants were evaluated in different seasons viz., pre-monsoon, monsoon and post monsoon.

During the period under study, certain species of algae having slightly green colour was noticed on the water surface one month after commencement of the experiment. However, it was not observed in the burnt oil treatment. In order to check the possible contamination, the water in tubs was changed after one month and the treatments were again applied to reduce the evaporation.

RESULTS AND DISCUSSION

Response of evaporation retardants

The results (Table 1) indicated that maize stover gave the lowest, while the control gave the highest evaporation.

Table 1 : Water evaporated from tubs and percentage of evaporation reduction (ER) covered with different evaporation retardants in different seasons

Evaporation retardants	Evaporation (mm day^{-1})				ER (%) over control				ER (%) over pan evaporation			
	PMS	M	POMS	Mean	PMS	M	POMS	Mean	PMS	M	POMS	Mean
Maize stover (6 kg m^{-2})	3.39	3.01	1.86	2.75	56.5	56.9	63.7	59.0	55.4	55.8	62.7	57.9
Burnt oil (2 mm thick film)	4.64	4.57	2.45	3.89	40.4	34.6	52.2	42.4	38.9	32.8	50.9	40.9
Poly film (50 micron)	3.78	3.10	1.93	2.94	51.2	55.6	62.4	56.4	50.9	54.4	61.3	55.5
Cetyle alcohol (2.2 kg ha^{-1})	6.54	5.00	2.58	4.70	16.1	28.3	49.6	31.3	13.9	26.4	48.3	29.6
Control	7.79	6.98	5.13	6.63					2.6	2.6	2.8	2.7
SEm ±	0.19											
CD ($p < 0.05$)	0.61											
Pan evaporation	7.60	6.80	4.99	6.46	2.44	2.56	2.72	2.57				

PMS : Pre-monsoon M : Monsoon POMS : Post-monsoon

Table 2 : Relation between evaporation retardants and control in different seasons

Treatment	Pre-monsoon			Monsoon			Post-monsoon		
	Intercept	Slope	r-value	Intercept	Slope	r-value	Intercept	Slope	r-value
Maize stover	0.0515	0.44	0.92*	2.02	1.65*	0.96*	3.43	0.95*	0.96*
Burnt oil	0.0045	0.58	0.94*	0.95	1.32*	0.93*	2.18	1.20*	0.95*
Poly film	-1.6279	0.71	0.94*	1.88	1.64*	0.95*	3.36	0.92*	0.95*
Cetyle alcohol	0.0560	0.85*	0.94*	1.09	1.18	0.95*	2.92	0.86	0.94*
Open evaporation	-0.0126	1.03	0.97*	0.25	0.99	0.98*	0.18	0.99	0.97*

The evaporation ranged from 3.39 to 7.79 mm day^{-1} under pre-monsoon, 3.01 to 6.98 mm day^{-1} under monsoon, and 1.86 to 5.13 mm day^{-1} under post-monsoon seasons. The cetyle alcohol gave the lowest, while maize stover gave the highest evaporation reduction over control and also over pan evaporation. The evaporation reduction over control was found to range from 16.1 to 56.5% in pre-monsoon, 28.3 to 56.9% in monsoon and 49.6 to 63.7% in post-monsoon seasons. The evaporation reductions over pan evaporation ranged from 13.9 to 55.4%, 26.4 to 55.8% and 48.3 to 62.7% in pre–monsoon, monsoon and post–monsoon seasons, respectively.

The data (Table 1) further showed that after 24 hours of treatment application, the highest mean evaporation reduction of 59% was observed under maize stover, followed by poly film (56.4%) and burnt oil (42.4%) as compared to control. Abbe (1914) also reported that burnt oil is an effective retardant for reducing the evaporation. Similarly, 50 micron thick films, consisting of paraffin oil containing spreaders of high molecular weight reduced the evaporation of water by 15% of the original value (Heymann and Yoffee, 1942). The maize stover, poly film and burnt oil have resulted in mean reductions in evaporation by 58.0, 56.5 and 41.0% over open pan evaporation, respectively. On average, the control treatment registered 2.6% higher evaporation than open pan evaporation. This might be due to the variation in the sizes of tanks. The higher evaporation in the small sized tank as compared to a bigger tank was due to more energy needed for evaporation in the latter. The maize stover reduced the evaporation by condensation of evaporated water and small changes in the air circulation. The black poly film absorbed more radiation energy as compared to maize stover and resulted in more evaporation of water. The burnt oil and cetyle alcohol have brought about an appreciable change in the air circulation as compared to maize stover and poly film which changed the deposition and the poor homogeneity of the surfactant solution on the water surface. The results indicate that maize stover and poly film seem to have greater potential for reducing the evaporation from water surfaces.

The maize stover recorded the highest mean reduction in evaporation amounting to 59 and 58% over control and open pan evaporation, respectively. The correlation coefficients (Table 2) as registered between evaporation retardants and control with open pan evaporation were highly significant during all the three seasons. In pre-monsoon season, cetyle alcohol had a maximum correlation coefficient of 0.94, while maize stover had a minimum correlation coefficient of 0.92. In monsoon season, maize stover had a maximum correlation coefficient of 0.96, while burnt oil had a minimum correlation coefficient of 0.93. In post-monsoon season, maize stover had a maximum correlation coefficient of 0.96, while cetyle alcohol had exhibited minimum correlation coefficient of 0.94. The results of regression analysis (Table 2) indicated higher rate of change in evaporation as evidenced by the slope value of 0.85 occurred under cetyle alcohol treatment, while a minimum slope value of 0.44 was observed under maize stover treatment (0.44) under pre-monsoon situation. In monsoon season, minimum slope of 1.18 was recorded under cetyle alcohol treatment, while the highest slope of 1.65 was observed under maize stover treatment. In post-monsoon season, minimum slope of 0.86 was observed under the treatments of cetyle alcohol, while a maximum slope of 1.20 was observed under burnt oil. In case of open pan evaporation treatment, slopes of 1.03, 0.99 and 0.99 were observed in pre-monsoon, monsoon and post-monsoon seasons respectively. Thus, the results revealed that the evaporation from control and open pan evaporimeter were almost of same magnitudes though the sizes of tubes were of different dimensions which confirm the earlier findings of Guobin *et al*., (2004).

Seasonal effect of evaporation retardants

As compared to control, the highest evaporation reduction (64%) was observed under maize stover treatment in the post–monsoon season, followed by poly film (62%) (Table 1). As compared to other seasons, the burnt oil and cetyle alcohol were also found to be highly effective in the post monsoon season due to lesser air circulation and no rainfall. Thus, the films of burnt oil and cetyle alcholol were not destroyed during the post–monsoon season. All the evaporation retardants tested were found to be more effective during the post–monsoon season than in other seasons due to low intensity air circulation. On the contrary, the efficiency of retardants diminished during the pre-monsoon season due to more air circulation, rainfall, more solar radiation and higher evaporative demand (Davanport, 1967). In all the seasons, the evaporation was higher in control than in open pan evaporation, due to differences in the sizes of tubs. The control registered a higher value of evaporation (2.57%) than the open pan evaporation.

Effect of evaporation retardants on water quality

The quality of water is of paramount importance for drinking and irrigation purposes. The presence of certain species of algae on the water surface was noticed under cetyle, maize stover, alcohol, poly film and control except in the burnt oil treatment. Cetyle alcohol does not adversely affect the water quality including the taste, odour and colour as demonstrated by Timblin *et al.*, (1957) and is not toxic to human or fish as reported by Berger Benard (1958). The maize stover gave some odour as leaves fell down in water which was changed in to brown and yellow colour. Similarly, the burnt oil also gave its odour to water. However, the poly film did not change colour and taste.

The results of determination of electrical conductivity, pH and sodium adsorption ratio before and after use of evaporation retardants revealed that the irrigation water quality was not adversely affected through evaporation retardants. The electrical conductivity was found to be 0.52 d/sm, pH was 7.4, and SAR was 4.5% before and after use of evaporation retardants. The study indicated that the maize stover @ 6 kg m^{-2} was highly effective in reducing the evaporation by 59% from water surface bodies. The cetyle alcohol was found to be the least effective in reducing the evaporation due to air circulation and rainfall.

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