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Impact of Different Treatments and Temperatures on Algae in Makhana Production

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ABSTRACT: Among different states of India, Bihar is the largest producer of Makhana, not only in India but in the world. It alone produces for more than 85 % of world production of Makhana. Generally, makhana is grown in stagnant water ponds or swampy wastelands. One common difficulty in cultivation of makhana in these water ponds or inland water-area is threatening by the invasion of noxious aquatic weeds. In recent years a minor aquatic weed, especially algae, started creating problem in makhana cultivation, makhana fish aquaculture and all other makhana based cropping system. Day by day, algae is becoming a serious problem in makhana-based cropping systems, resulting in loss of yield and deterioration of water quality. During day time, in presence of sunlight, algae gets involved in photosynthesis resulting into more oxygen production, which is good for aquatic life. But at night the process becomes reverse. Algae starts using oxygen resulting into decrease in the supply of oxygen to the entire aqua based makhana production system. However, in a very small span of time during night the densely populated algae in a pond can create oxygen deficient environment, which is very harmful for all the aquatic ecosystem including makhana crops or even harmful for makhana-fish intercropping and other makhana based cropping system. Besides depleting oxygen in makhana field, when large populations of algae grow in the Makhana fields, the temperature of the water also increases, which further depletes oxygen dissolved in the water & impacting the health of the whole aqua ecosystem. It was therefore, felt necessary to take an experiment for managing algal menace in makhana cultivation. Rice straw has been found promising in controlling the growth of algal bloom in makhana growing plots, and its application also resulted in maintaining the temperature towards normal, hence maintaining the aquatic environmental health.

Keywords: Algae, Aquaculture, Dissolved Oxygen, Makhana-cropping system, Temperature, Water Quality.

INTRODUCTION

In India the Makhana crop is mainly cultivated in majorly low-lying areas, ditches, ponds *etc.* The waterlogged wasteland is being utilized for the seed production of Makhana. Among different states of India, it is estimated that Bihar alone produces about 90% of the total Makhana produced in the country. Apart from Bihar, the natural habitat of genetic diversity of Makhana were found in the lower part of Assam (Mishra *et al.,* 2003) and the Loktak lake of Manipur (Kumari *et al*., 2014; Laishram *et al*., 2021).

Makhana is a cash crop exclusively cultivated in the pond/field system that is shallow and stagnant, providing economic and nutritional security to farmers having smaller land hold throughout the Bihar and throughout the different villages of north and eastern region of India (National Research Centre, 2020). Bihar is a flood prone state, majority of its wasteland under stagnant water ponds or swampy wastelands remains underutilized. But nowadays, these wastelands are being utilized for the cultivation of Makhana and other Makhana based cropping systems. In Bihar state, 35,000 hectare land area is under makhana cultivation, which includes the following districts such as Sitamarhi, Madhubani, Saharsa, Supaul, Muzaffarpur, Darbhanga, Champaran, Madhepura, Araria, Purnea, Kishanganj and Katihar. Due to the larger extent of water bodies, there is an immense potential for Makhana cultivation to be done in these districts. But lack of high yielding varieties, improved packages and practices are the major constraints for high production and productivity of wetlands.

Makhana belongs to the family of Lotus *i.e. Nymphaeceae*. The origin of Makhana plant is reflected to a native of China and South- East Asia. The Scientific name of Makhana is *Euryale ferox* (Salib). A full grown makhana crop bears large floating green leaf full of spines.It is predominately a self-pollinated crop. Fruit development occurs either under water or by flowers opening on the water surface. The seed of gorgon nut is round in shape, black in colour characterized by its hard blackseed coat (shell), and black seed. The optimum range of temperature required for proper growth and development of makhana is 20°C to 35°C along with a relative humidity of 50%-90% and an annual rainfall of 100-250 cm is necessary for potential cultivation of Makhana crop. Other conditions that are ideal for a crop to flourish are those in which the rainfall should reach water bodies in an organic manner and have a water transparency of <50%.

In general the agricultural field with clay soil for better water holding capacity is good for cultivation of makhana reported by Kumar *et al.* (2011). Makhana, is the most prominent aquatic cash crop grown in major lowland areas of Bihar, the second aquatic cash crop grown in line of makhana is water chestnut. The field system of makhana cultivation reported good yield if the makhana field maintains a constant water height of 30-40 cm (Singh *et al*., 2003).

The weed infestation, growth of noxious aquatic weeds is a serious problem in those water ponds or inland water area where makhana based cropping system is being practised, which reduces the yield of Makhana crop. The traditional way of manual weeding is very tedious, time-consuming and expensive. Due to less availability and shortage of skilled labour makhana growers faces a lot of challenges, as makhana requires highly skilled nature of operations.Few major weeds like *Marcilea quadrifolia, Eichhornia* etc is also a serious problem in makhana based cropping system, resulting in loss of yield and deterioration of water quality.

Apart from all these major aquatic weeds, one minor weed algae, started posing serious threats to water quality, productivity of crops, fishing and navigation in recent years in makhana. When it proliferates, its profuse growth leads to green soupy colouration of makhana field reportedly resulting in yield loss of makhana. It was therefore, felt necessary to take an experiment for managing algal menace in makhana cultivation, the integrated approach using rice straw and aqueous neem extract helped in managing algae in the Kosi region of Bihar

Makhana cultivation requires minimum expenditure when cultivated under the traditional pond method of cultivation. Under the wild conditions the waste low-lying area once taken under the cultivation of Makhana crop, it will remain under makhana aquaculture, as the onset of favourable climatic condition will lead to germination of Makhana seedling from the older seed of previous crop. Hence, ponds presently under cultivation of Makhana, do not require fresh new seeds for taking Makhana crops in the current season as saplings are produced from the previous year' seeds which remain unharvested in the makhana field. In that case, only thinning out of the excess or surplus plants is required and transplanting them back these plants into the areas, having sparse or poor growth of makhana crop is noticed.

MATERIALS AND METHODS

Research Design are of several types like quasi-experimental study, ex post facto Research Design and experiment research design (Lal & Samadder 2020; Srivastava & Lal 2021; Kumar *et al.*, 2022; Shukla *et al.,* 2022; Lal *et al.,* 2023; Srivastava *et al.,* 2023; Buruah *et al.*, 2023). During the year 2018 to 2021, a field experiment was carried out at the Makhana Research Unit in Research Farm of Bhola Paswan Shastri Agricultural College, Purnea (Bihar Agricultural University) Sabour, Bihar. The experiment was conducted in a RBD, with seven treatments, namely T_1 - Control (Conventional Practice); T_2 - Aqueous Neem Extract @500ppm; T_3 - Aqueous Neem Extract @1000ppm; T_4 - Aqueous Neem Extract @1500ppm; T_5 - Rice -Straw @ 250kg/ha; T_6 - $CuSO_4.5H_2O$@ 0.5ppm; T_7 - $CuSO_4.5H_2O$ + Citric Acid (2:1); T_8 - Real time nutrient Management and T_9 - Limestone @ 2t/ha plot. All the treatments were replicated thrice. Under this experiment, the makhana crop was taken under field system of cultivation, the field was either ploughed twice or thrice. It was kept submerged for a few days for acclimatization purpose and was later puddled 4-5 days before the transplanting of Makhana. The first step required for an algae-free Makhana pond is to test the water. As the water quality is highly dependent on physical, chemical and microbiological conditions (Trivedy and Goel 1984), most important values can be determined using a hand held HANNA meter. For the growth environment of weed in makhana field in particular for algae, the temperature is important, because it gives us information about the O_2/CO_2 content of the water. Analysis of physico-chemical parameters – Water temperature (°C) readings including total dissolved solids (TDS), pH, Dissolved Oxygen and EC (Electrical Conductivity) were measured *in situ* using a portable HANNA pH/EC/ DO/TDS/temperature meter (model no H198194).

Fig. 1. Surface-floating leaf of *Euryale ferox* & Flowering, respectively.

RESULTS AND DISCUSSION

During early stages after transplanting, weeds need to be checked under field system of makhana cultivation since aquatic weeds such as water hyacinth, water fern, *etc.,* compete with main crops for nutrient, light and space growth of makhana leaves. During the different stages of crop and months, among the different physico-chemical parameters – Water temperature (°C) was estimated in terms of finding the most suitable temperature range for the optimum growth and development of the makhana.

Table 1: Two ways (Temperature) for the optimum growth and development of the makhana.

	March	April	May	June	July	Mean A
T_1	19.94	34.89	34.21	33.53	31.42	30.80
T_2	20.60	31.02	34.76	25.27	29.69	28.27
T_3	20.09	31.48	28.03	31.47	26.81	27.58
T_4	20.28	31.72	28.52	35.83	35.52	30.38
T_5	19.57	30.93	22.43	26.63	30.67	26.05
T_6	20.69	30.77	25.81	33.33	25.55	27.23
T_7	17.65	28.34	23.08	31.83	32.52	26.69
T_8	18.86	30.31	24.31	28.77	34.92	27.43
T_9	21.42	31.06	25.34	27.13	27.22	26.44
Mean B	19.90	31.17	27.39	30.42	30.48	

Factors	C.D.	SE(d)	SE(m)
Factor(A)	3.189	1.602	1.133
Factor(B)	2.377	1.194	0.844
Factor(A × B)	N/A	3.582	2.533

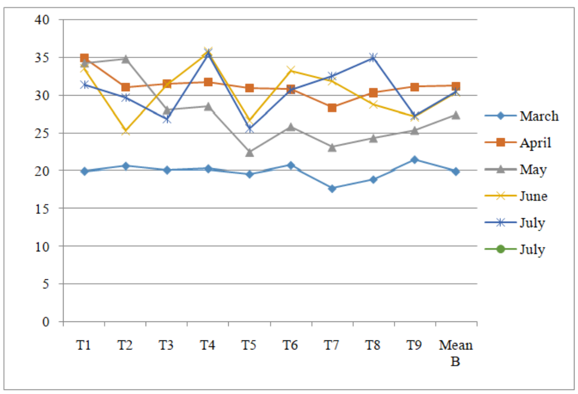

Fig. 2. Effect of temperature and treatments on algae growth.

The perusal of data as well as graph shows that the highest water temperature was recorded during the month of June in the treatment T_4, whereas the lowest water temperature was recorded in the month of March in the treatment T_9. Among the different treatments, the treatment T_1 *i.e.*, conventional Practice of growing makhana recorded highest temperature due to the higher infestation of algae in makhana irrespective of the months whereas treatment T_5 *i.e.,* practice of inclusion of rice straw as algistat in plots growing makhana recorded lowest temperature. The perusal of a two-way table also shows that there is no significant correlation between the treatments and different growing months of makhana.

Table 2: Two ways (pH) for the optimum growth and development of the makhana.

	March	April	May	June	July	Mean A
T_1	6.77	8.96	8.86	8.48	7.32	8.08
T_2	6.82	8.64	8.57	7.93	7.29	7.85
T_3	6.69	8.31	8.23	7.79	7.47	7.70
T_4	6.68	7.91	7.44	7.61	7.25	7.38
T_5	6.78	7.08	7.04	7.06	6.98	6.99
T_6	6.66	7.75	7.49	7.46	7.26	7.33
T_7	6.34	7.32	7.32	7.77	7.19	7.19
T_8	6.69	7.39	7.29	7.41	7.38	7.23
T_9	7.16	7.79	7.65	7.53	7.34	7.50
Mean B	6.73	7.90	7.77	7.67	7.28	
Factors	**C.D.**	**SE(d)**	**SE(m)**			
Factor(A)	0.196	0.098	0.07			
Factor(B)	0.146	0.073	0.052			
Factor(A × B)	0.438	0.22	0.156			

Perusal of data revealed that Treatment T_5 - Rice -Straw@ 250 kg/ha has been found promising in controlling the growth of algal bloom in makhana growing plots as its application resulted in maintaining the mean pH towards normal. The water quality was estimated in terms maintaining pH towards normal that is most suitable for the optimum growth and development of the makhana and was registered maximum in treatment, T_1 - Control (8.48) in the month of June which was significantly highest over all other treatments in all other months under observation. The increase in pH shows the abundant growth of algal bloom. Amongst different treatments, Treatment T5-Rice -Straw @ 250 kg/ha had best results.

CONCLUSIONS

Practice of using rice straw, which is a biologically degradable, relatively abundant and highly economical material, is capable in controlling infestation of algae in makhana. Apart from this it also helps in maintaining the conductive range of water temperature (20°C to 35°C) for about all the five growing months of makhana throughout the year which further leads to proper growth and development of makhana. It has also proved its superiority in term of maintaining the balance of pH in water of experimental plot throughout the cropping season of makhana crop.

FUTURE SCOPE

The future scope of this research includes exploring advanced algal control methods using eco-friendly materials and biocontrol agents. Optimizing treatment protocols for maximum effectiveness and minimal environmental impact is essential. Studying climate change impacts on algae and Makhana crops will help develop adaptive management strategies. Conducting economic analyses will assess the cost-effectiveness of treatments. Informing policy and extension services can support Makhana farmers with guidelines and training. Evaluating the broader environmental impacts ensures sustainable algae management practices. Collaboration with agricultural extension services will disseminate the latest research and innovations to farmers.

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Conflict of Interest. None.

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