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Impact of water depth on growth of gorgon nut and associated weed under wetland ecosystem of North Bihar province in India

B. R. JANA

ICAR-RCER, Research Center for Makhana,
Basudeopur, Darbhanga,Bihar-846004

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ABSTRACT

A field experiment was conducted at ICAR –RCER, Research Centre Makhana, Darbhanga, Bihar during 2015-16 for standardization of water depth for gorgon nut or makhana cultivation and associated weed control. The makhana crop was grown at different depth of water bodies ranging from 10, 20, 30, 40, 50 cm and > 50 cm following randomized block design and observation taken on weed appearance and their control. It had been found that more the depth of water accounted for more vigorous vegetative growth of makhana plant. Makhana growing in field system, where growths of plant were significantly reduced which were the positive traits for horticultural practices due to reduction in water column. At field having 30 cm water produced the medium leaf diameter (104.84 cm) and pod having (82.50) bold seeds. The maximum test weight of the raw seed was 97.12 g found in 30 cm water containing plot. The maximum number of fruits (12.66) and yield of 23.83 Q ha^{-1} were found in field having 30 cm water. Weed population were increased in shallow depth of water. The common weeds at Darbhanga were Cyperus defformis, Cyperus rotundous, Hydrilla verticillata, Aeschynomene aspera and Sagittaria guayanesis. Weed management was excellent when field was well pulverized with rotavator followed by application of castor and neem cake in equal poportion [2T (50:50) ha^{-1}]. Butachlor spraying was ineffective for aquatic weed control as irrigation of 30-40 cm water was given after herbicide application. We concluded from the present study that Makhana performed well under field condition giving yield of 23.83Q ha^{-1} when 30 cm water column was maintained throughout its life span and when weeds were controlled by the application of organic cakes (2tha^{-1}).

***Keywords* :** Correlation, depth of water, makhana growth, seeds and weed population.

Makhana is one of the most important aquatic nuts produced in India as cash crop. It is belongs to the monogenic family Eruyaledaceae (Nymphaeceae). It is predominately a self pollinated crop. Fruit development occurred either under water or by flower opening on the surface of the water. The authors explained that makhana kernel with a moderate 9.7 per cent protein content and whose essential amino acid index (EAAI) is very high (Jha *et al.*,1991a and b). Makhana has unique glycosides' combinations which are effective against myocardial eschemic reperfusion injury (Das *et al*, 2006). In India, Bihar is the leading producer of makhana (90%). It has also been noticed that not only in India but also in the world the North Bihar ranked first. Wetlands of North Bihar accounted for the maximum makhana production due having lot of ponds, lakes and stagnant water bodies. Makhana thrives best when range of air temperature is (20-35^{O}C), relative humidity is 50-90 per cent and annual rainfall is about 100-250 cm (Mondal *et al.* 2010). Kumar *et al* (2011) reported that cultivation of makhana is possible in general agricultural field with clay soil for better water holding capacity. *Euryale ferox*(Salib), makhana, is the foremost aquatic plant grown as a cash crop followed by water chestnut. It has been found that 30-40 cm constant water requirement is the best for field based makhana crop (Singh *et al.*, 2014). Apart from Bihar, lower part of Assam (Verma *et al*., 2010) and the Loktak lake of Manipur are another natural habitat of genetic diversity of Makhana (Kumari *et al.*, 2014). Fishery activity could be possible for rearing fishes as well as for nursery ponds after crop harvest in October the period between the two successive Makhana crops under field condition (Verma *et al.*, 1996 and Ahmad and Singh , 1997). It has been found that Nymphaea is difficult to control since only petioles are detached from the plant during manual weeding (Jha, 2002 and Sunilkumar and Jhon , 2002) allowing to it aggravate further. Another author, Joy *et al*, (2008) cited that *Hydrilla verticillata*, spp. and *Sagittaria guayanesis* are the major aquatic weeds in India during rainy season. Herbicide like paraquat and glyphosate are effectively used in aquatic weeds control. Moreover, makhana cultivation is becoming limited due to dwindling and depleting water and soil resources (Jha, 2002). Keeping this in view, the present experiment have been conducted to evaluate exact depth of water for its ideal reproductive growth and associated weed management for clean commercial field cultivation. In this experiment we are giving interest on exact water requirement as ground water is depleting. The research interest is accompanied by natural resource minimization (soil and water and profit maximization through higher production followed by lower cost of cultivation.

Email: brjana.ars@gmail.com

MATERIALS AND METHODS

The research centre for makhana (Fox nut) is located in Darbhanga, Bihar, India with in latitude 260 10'N and Longitude 850 87'E. In Research farm 3 ponds and 3 field plots (250 M^2 each) were selected for studies during 2015. Randomized block design with 3 replications was adopted for data analysis. Thirty plants within each ponds and fields were selected and 3 replication rows and 10 plants were marked separately. Swarna Baidehi was the cultivar of choice for the whole experiment. Planting distance was 1.25 x 1.25 m. The makhana crop was grown at different depth of water bodies ranging from 10, 20, 30, 40, 50 cm > 50 cm at fields and ponds. Vegetative and reproductive data were taken by standard methods. The fields and ponds were thoroughly observed and obnoxious weeds were identified. In the next year *i.e*., 2016, weed management studies were done for clean cultivation. The treatments imposed were, T_1= non tillage, T_2= tillage, T_3= tillage and puddled, T_4= tillage, paddled and herbicide and T_5= tillage, puddled and organic cakes. Approximately 30 cm water was maintained in every plots. Herbicide of choice was Butachlor @ a.i.2 kg ha^{-1} as pre-emergence and organic cakes were castor (*Ricinus communis* L) and neem (*Azadiracta indica* L) cake [2T (50:50)ha^{-1}] which was applied after irrigation. Fields were left for 2-3 days for decomposition and then transplanting of makhana plants was performed. Weeding schedules were at 15 and 30 DAT. Data on weed biomass was taken from 1 m^2 area and expressed as kg m^{-2} on the basis of fresh weight. Weed infestation and their host specificity were also observed by visual methods

RESULTS AND DISCUSSION

Data on table 1 revealed that leaf diameter is positively correlated with the depth of water. The minimum leaf diameter was found in T_1 treatments (82.74 cm) whereas the maximum leaf diameter of 116.61 cm was found in T_6 being statistically comparable with T_5 (110.44cm). Kumari *et al* (2014) also found large leave of some makhna germplasm in their study. Similar type results were also observed in case of leave stalk length. From these type of results it was evident that makhana plant growth enhancement was depend on water column available in the field which entailed indirectly that spacing is the principle component for plant's vegetative growth. In T_6 treatment the maximum leave stalk length was observed (93.667 cm). In case of flower stalk length positively grow with water column up to 30 cm and flower bloomed at the upper surface of the leaf. But when the makhana plant was grown above 40 cm water depth (like in 50 cm and greater than 50 cm water depth) the maximum flowers underwent fruit development under the water because of its predominant habit of self pollination. The maximum fruits/plant (12.66) and yield (23.83 Q ha^{-1}) was observed in treatment T_3 *i.e.* when the plant was grown under 30 cm water. It might be due to better penetration of solar radiation and pressure of water column were ideal for growth and development of crops in T_3 treatment. As we cultivated best released cultivar 'Swarna Baidehi', its number of fruits was the highest (12.66), which was relatively higher than the findings of authors them (Kumari *et. al*., 2014). This results was inconformity of findings of Kumar *et al.* (2011) where yield was about to 2.6-3.0T/ha. As the number of seeds/fruit and test weight were also highest in T_3 treatment where all the flowers opened at upper surface of the leaves because of proper self pollination. T_4 treatment also got the same provisions but due to greater water depth it led to higher vegetative: reproductive growth and fruits are also not rounded. In T_3 treatment recorded the highest reproductive growth which was highly desirable for horticulture of this crop (Fig-1) This results also provided information that prickly water lily *allias* makhana plant requires less water for its physiological process (like growth and development) but required more water just to float on water keeping roots at soil. From the above results it may be concluded that at least 30 cm water depth at rainy season is required to get the maximum yield under field condition rotating its cultivation in another crop like wheat and fodder crops (Mahto and Jha, 1998) in winter. Singh *et.al*. (2014) also reported that Makhana as a rainy season crop, is cultivated in shallow plots for rotational cultivation with water chestnut or barseem in winter.

Weed management studies were performed during 2016 in details. The close perusal of the table 2 revealed that the weed *Marsilea spp.* only found in shallow depth of water. In T_1 treatment, it was found in profuse growth. But when water depth was increased in the field from 10 to 20 cm it's population was decimated. And almost absent in field having water depth >20cm. *Cyperus defformis* was the most obnoxious weed for makhana cultivation but it's presence was observed in the water depth up to 30 cm. But *Cyperus rotundus* instead of *Cyperus defformis* was present at water depth of 40-50 cm *i.e.* shallow depth of water in Rice field (Mahto and Jha, 1998). They also confirmed that *Cyperus rotundus* was the major weed in rice field. Occurrence of *Hydrilla* and *Algal bloom* were most common features in the field having more than 40 cm water depth (Jha, 2002). Thirty (30) cm water depth which affected makhana cultivation positively by using optimum water for the crop stand. *Cyperus defformis* and *Aeschynomene aspera* were remarkably controlled by the application of organic cakes like neem (*Azadiracta indica* L.) and arandi (*Ricinus communis* L) in equal proportion and @2-3 ton ha^{-1} after pulverized the soil with rotavator (Fig.2). Chaffy and immature seeds of *Sagittaria guayanesis* and other weeds are also controlled by the application of organic cakes but bold and mature seed are mostly germinated while less number of seeds was destroyed by soil pulverization (Jana, 2016). Makhana and *Sagittaria guayanesis* are closely related genus and aquatic crops in nature , therefore absolute removal of *Sagittaria guayanesis* from the plot is impossible. When we applied organic cakes for growth of Makhana crop the maximum weed seeds were get affected. Although some weeds get germinated their growth was suppressed by the rapid growth of makhna crop, which covered whole field within the one month. It was reported that *Nymphaea*

Table 1: Plant growth characters of makhana as affected by water depth during 2015.

Treatments (Water depth) (cm)	Leaf diameter (cm)	Leave stalk length (cm)	Flower stalk length (cm)	No fruits. plant^{-1}	No. of seed. fruit^{-1}	Test weight (g)	Yield (q ha^{-1})
T_1=10	82.74^{d}	66.63^{d}	15.88^{e}	6.89^{d}	60.59^{d}	83.45^{b}	16.15^{d}
T_2=20	85.59^{d}	67.73^{d}	22.60^{d}	7.62^{d}	66.21^{c}	84.12^{b}	18.33^{c}
T_3=30	104.84^{c}	75.66^{c}	30.75^{c}	12.66^{a}	82.50^{a}	97.12^{a}	23.83^{a}
T_4=40	107.66^{bc}	80.66^{b}	40.18^{b}	11.42^{ab}	74.36^{b}	85.33^{b}	21.01^{b}
T_5=50	110.44^{b}	91.65^{a}	45.11^{a}	10.33^{bc}	61.66^{d}	72.22^{c}	17.67^{cd}
T_6>50	116.61^{a}	93.66^{a}	46.25^{a}	9.48^{c}	60.45^{d}	70.14^{c}	16.98^{cd}
LSD(0.05)	**2.92**	**2.07**	**2.34**	**1.32**	**1.84**	**2.83**	**2.038**

Table 2: Appearance of different kinds of weeds as affected by water depth at the field during 2015.

Treatments (Water depth) (cm)	Mostly found (1)	Moderately found (2)	Sparsely found (3)
T_1 = 10	*Cyperus defformis* L.	*Sagittaria guayanesis*	*Marsilea quardrifolia.L.*
T_2 = 20	*Cyperus defformis* L.	*Sagittaria guayanesis*	*Marsilea quardrifolia L.*
T_3 = 30	*Aeschynomene aspera* L.	*Cyperus defformis* L.	*Sagittaria guayanesis*
T_4 = 40	*Aeschynomene aspera* L.	*Cyperus rotundus L.*	*Sagittaria guayanesis*
T_5 = 50	*Hydrilla vertistillata* Royle.	*Cyperus odoratus L.*	*Sagittaria guayanesis*
T_6 > 50	*Hydrilla vertistillata* Royle.	Algal bloom	———

Table 3: Major insect pest of Makhna-2015 from the existing weeds which causes negative influences to Makhana production.

Insect pest	Scientific name	References	Alternative host observed
Makhana aphid	*Rhopalosiphum nymphaeae*	Mishra *et al.* (1992) Swaraswati *et al.* (1990).	1. *Cyperus defformis, Cyperus rotundus* during rainy season. 2. *Chenopodium album* during *Ravi* season (Dahlin and Vladimir (2013).
Makhana leaf roller	*Nymphula* spp .	Banerjee (1972) Mishra *et al*. (1992).	Grassy weeds and wild rice (Ramkumar and Singh, 2013).
Rhizome borers	*Donacia delesserti*	Mishra *et al*. (1992).	Stables of *Sagittaria guayanesis*
Leaf gall (fungus)	*Doassansiopsis euryaleae*	Verma and Jha (1999).	Different *Cyperus spp.*
Makhana blight	*Alternaria alternata*	Hyder and Nath (1987), Dwivedi *et al.* (1995).	*Cyperus alopeuroids, Cyperus rotundus, Cyperus odoratus and Nelumbo spp,* (El-Sayel *et al*, 2006).

Plate 1 : *Sagittaria guayanesis* L.

Plate 2 : *Hydrilla vertistillata* Royle

Plate 3 : *Aeschynomene aspera* L.

Plate 4 : *Cyperus defformis* L..

Plate 5 : *Marsilea quadrifolia* L

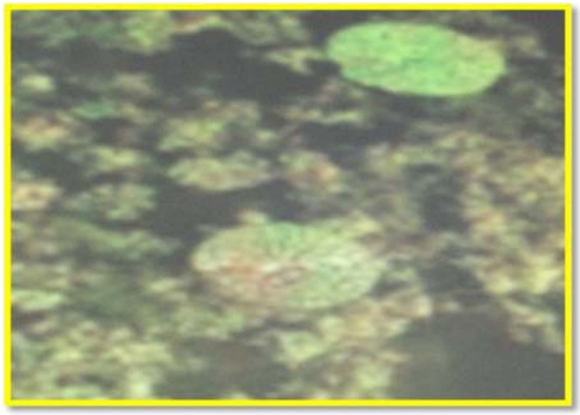

Plate 6 : Algal bloom

Plates (1-6) of weeds of makhana crop grown under different water depth

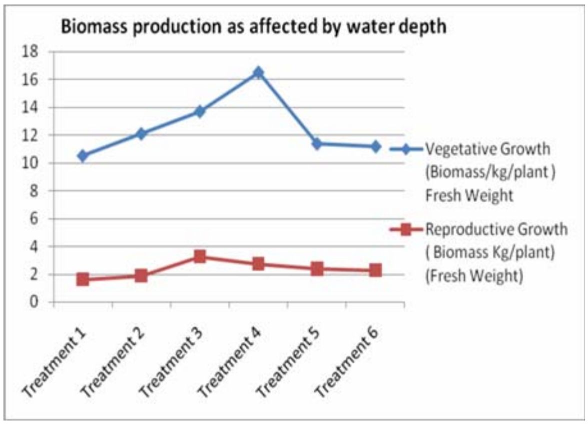

Fig:-1: Different biomass productions as affected by water depth

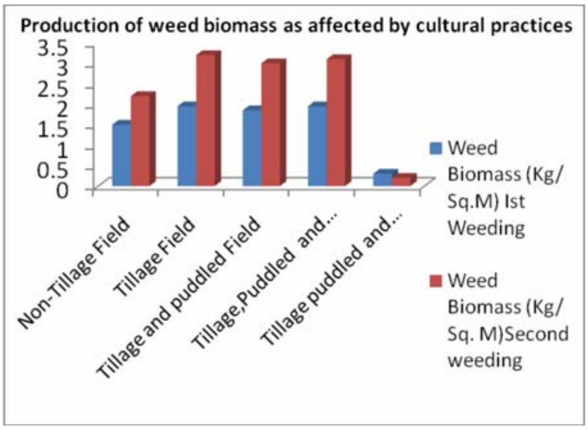

Fig -2: Weed Biomass production with different practices [Fresh weight (kg m^{-2})].

was difficult to control (Jha, 2002). From our study we found that not only *Nymphaea* but also *Sagittaria guayanesis* had the same property (Sunilkumar and Jhon, 2002) since only petioles are detached from the plant and root remained in the soil in most of the cases during manual weeding. Other authors (Joy *et al.*, 2008) cited that *Hydrilla verticillata, Sagittaria guayanesis* and *Nymphaea spp.* are the major aquatic weed in India during rainy season.

Only tillage field accounted for the maximum weed production in terms of weed biomass (Fresh weight = kg. m^{-2}) both in first and second weeding. It might be due to exposure of buried weed seeds and rhizomes of different aquatic weeds got germinated in presence of irrigation. Herbicide application did not significantly reduce the aquatic weeds because most of the weeds develop after 15 days of transplanting with 30-40 cm depth of water. Herbicide treatment and immediate water pouring in the field did not affect the aquatic weed seeds. On account of decomposition of organic cake led to huge heat generation in soil, which destroyed the most of the sage and dicotyledonous grasses when soil was well pulverized by rotavator. Weed management in makhana field was essential. Weeds not only compete for nutrients with makhana but also act as alternative hosts for a number of pest and diseases (Jha *et al.*,2002) (Table-3). The weed spp. like; *Cyperus alopeuroids*, *Cyperus rotundus*, , *etc*. behaved as alternative host for makhana blight diseases. The findings was corroborated by the study of El-Soyel *et al.* (2006) . Ramkumar and Singh (2013) also reported that the host plant of leaf roller were *Cyperus defformis* and other sage spp./grassy spp. From the recent studies it may be concluded that weeds harbor the numbers of pest and diseases of makhana under wet land ecosystem (Table-3). Hence, identification of weed, their management and removal were urgently performed for clean cultivation of makhana.

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