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Interventions to reduce drudgery of workers in the traditional method of harvesting Makhana (*Euryale ferox* salisb.) seeds from ponds

Abhijit Khadatkar[1,]*, L. P. Gite[1] and V. K. Gupta[2]

[1]Central Institute of Agricultural Engineering, Bhopal 462 038, India
[2]Regional Centre for Makhana, Darbhanga 846 005, India

Makhana (*Euryale ferox* salisb.) is a seed produced from an aquatic crop, which normally grows in water bodies like ponds. In the traditional way of harvesting, a worker goes deep into the pond, lies down, holds his breath and drags the mud with both hands towards a bamboo pole called 'kaara', which is later sieved using a bamboo screen called 'ganjaa'. During this operation mud enters into the ears, eyes, nose and mouth of the worker. Also, the workers are affected by skin-related diseases due to unhygienic working environment. Therefore, an intervention was made and an improved system was developed which consists of a floating platform providing support to a 10 l cylinder having compressed air, 10 m hose pipe with regulator and a mini diving kit having suit with cap, mask and content guage. A comparative study was conducted

*For correspondence. (e-mail: abhijitnu2@gmail.com)

using both traditional system (T1) as well as improved system (T2) of harvesting Makhana seeds from ponds. The results indicate that the average output is only 3.8 kg/h with T1 system, whereas it is 11.3 kg/h with T2 system. The overall discomfort rate is 8.3 in case of T1 system, whereas it is 4.2 in case of T2 system. Also, the body parts discomfort score is higher (78.8) with T1 system compared to T2 system (48.2). The harvesting of Makhana seeds using the improved system involves less drudgery in comparison to traditional system with significantly higher work output.

Keywords: Drudgery, harvesting, Makhana seeds, traditional system.

MAKHANA (*Euryale ferox* salisb.), also known as gorgon nut or fox nut, is a seed produced from an aquatic crop which belongs to the family Nymphaeaceae. It normally grows in stagnant water bodies like ponds, low depressions, lakes, etc. (Figure 1 *a*). About, 80% of total Makhana in India comes from Darbhanga, Madhubani, Purnia and Katihar districts of Bihar[1]. It is mostly cultivated in lowland ponds of Bihar, Odisha, Assam and West Bengal. It is well suited to tropical and sub-tropical climate with 20–35°C temperature, 50–90% humidity and about 100–250 cm rainfall[2]. It has been reported that about 13,000 ha area is under Makhana cultivation in the country[3]. A single Makhana plant produces about 8–9 leaves and flowers arranged alternately, intermingled together (Figure 1 *b*). The leaves are large and round (about 1–2 m in diameter) and float on water, with a leaf stalk attached at the centre of the lower surface. The upper surface of leaf is green, while the underside is purple in colour. The surfaces are covered with sharp prickles/thorns. The roots are long, fleshy and fibrous in nature and generally in 2–3 clusters with a number of air pockets; the seeds are round and lumpy, and about 0.5–1.5 cm in diameter. The flowers are bright purple in colour (Figure 1 *c*). Raw Makhana is a good source of carbohydrates, proteins and minerals containing 76.9% carbohydrate, 12.8% moisture, 9.7% protein, 0.9% phosphorus, 0.5% minerals, 0.1% fat, 0.02% calcium and 0.0014% iron[1,4]. It also has medicinal value and is recommended for treating respiratory, circulatory, digestive, excretory and reproductive disorders[4].

In ponds, 10% of the Makhana plants germinate from the leftover seed of the previous crop. About 80 kg of seeds is normally required for 1 ha of pond area. The depth of the pond varies from 1.2 to 2.4 m, with average depth about 1.8 m. Sprouting takes place during December and January and the Makhana plant comes to the upper surface of the pond during March. Normally, 1 × 1 m spacing (row-to-row and plant-to-plant) is maintained by thinning-off extra plants. Also, during March and April, young and healthy plants are collected from nearby ponds and transplanted at an interval of 1 × 1 m spacing for filling the gaps. The entire pond water surface gets covered with big, expansive and prickly leaves during April and May. After 2–3 months of transplanting, bright purple flowers begin to appear on the pond surface. The flowers change to fruits (Figure 1 *d*) and the fruits then burst inside the water after 30–45 days of flowering. The fresh seeds float on the water surface for 2–3 days before settling down at the bottom, where the red arils of fresh seeds become seasoned or decomposed and turn black in colour at the time of harvesting. Each flower after fruiting produces 8–13 seeds and a single plant produces about 100 seeds. In a pond system, there are about 10,000 plants/ha and seed yield in the traditional system is around 1.8–2.0 t/ha (ref. 1).

Makhana cultivation has several constraints, some of them being no ownership of the pond, drudgery in operation, lack of credit facility, lack of scientific knowledge of cultivation, lack of improved varieties, short lease period and labour-intensive process.

In this communication, we study the environmental concern and drudgery of the workers involved in the traditional way of harvesting Makhana from the ponds in Darbhanga district, Bihar. Makhana harvesting is the only source of income for the Mallah community in the district. Thus the harvesting practice of Makhana has to be improved to reduce their drudgery and improve their livelihoods.

Harvesting refers to collection of scattered Makhana seeds from the bottom surface of the pond. The collection of seeds in the pond system is done during August–October in the morning around 6.00–11.00 am (Figure 1 *l*).

First all the parts of the plant are cut and allowed to decompose in the pond, only then do the workers get inside the pond. The pond environment is unhygienic due to mud, thornes/prickles, insects, etc. A worker has to go deep into the pond and hold his breath for a long time. In the traditional system, a bamboo pole locally called 'kaara' is fixed in the pond and the worker goes to the bottom, lies down and drags the mud near the pole with both palms. He covers a radius of his height around the periphery of the pole. A heap of mud is formed near the base of the bamboo pole which is later sieved with locally made bamboo screen called 'ganjaa' (Figure 1 *f*). The black coloured seeds are taken through the water on top and put in earthen pots (Figure 1 *g*). During this operation, mud enters into the ears, eyes, nose and mouth of the worker. Many a times the workers suffer from skin problems like rashes, itching, etc. and injuries due to the presence of sharp thornes/prickles, leech bite, etc. (Figure 1 *h* and *i*).

About 50–60% of the cost of cultivation goes in paying the labour charges for harvesting. Table 1 provides the economics of Makhana cultivation in the traditional system. Normally in ponds, harvesting is done in 2–3 phases. Initially, the charges paid begin with Rs 15–20/kg for the first harvest, Rs 30–40/kg for the second harvest and Rs 50–60/kg for the third harvest and so on if the harvesting phase continues. The increase in the amount paid for

Figure 1. ***a***, Makhana crop in pond. ***b***, Makhana plant. ***c***, Makhana flower. ***d***, Makhana flower changing to fruit. ***e***, Harvesting of Makhana in pond. ***f***, Traditional tool for harvesting Makhana. ***g***, Makhana seeds. ***h***, Palm of Makhana harvester affected by thornes. ***i***, Skin disease in Makhana harvester. ***j***, Improved system for Makhana harvesting. ***k***, Makhana harvesting using improved system.

harvesting is because the collection of seed decreases with increase in harvesting phase.

According to the workers, limit to breathing time inside the pond is the main problem followed by mud entering their eyes, ears, nose and mouth. To eradicate these problems, an improved system has been developed by the Central Institute of Agricultural Engineering, Bhopal and Regional Centre for Makhana, Darbhanga.

The improved system consists of a floating platform having 10 l cylinder of compressed air with a regulator strapped on it, 10 m hose pipe with a regulator and a mini diving kit having suit with cap and mask for use by the workers (Figure 1 *j* and *k*). In this system, the worker is supplemented with filtered air through a 10 m long hose. As the worker is safe and comfortable, the output is higher compared to the traditional system. Also, there are no injuries and skin-related problems as he is protected by the diving kit.

Ten healthy subjects in the age group of 25–62 years with no previous history of occupational injury were randomly selected for the study from the villages near Darbhanga district. The age, height and weight of the selected subjects were recorded. The subjects were familiarized with the protocol before the data were collected.

The subjects were given sufficient rest before conducting the experiment. After calibration, they were made to do harvesting operation using both the methods, i.e. by traditional system (T1) and improved system (T2). At the beginning and end of each experiment, the subjects were given 30 min rest so that all the physiological parameters regained their normal levels. Each operation was carried out for 1 h duration.

The overall discomfort rate (ODR) and body parts discomfort score (BPDS) were measured after the experiment. After 1 h of experiment, each subject was asked to sit on a chair and quantify his ODR for the work he had just finished. For this purpose, a ten-point visual analogue discomfort scale (VADS) was used (0 – no discomfort and 10 – extreme discomfort)[5]. The subject was asked to indicate the point on the scale which represented his current level of overall discomfort by sliding a pointer on it. ODR given by each subject was averaged to get the mean value. BPDS was measured by the score-based technique[6]. For this, the whole body was divided into 12 parts and a similar body mapping was done by thermocol for rating the perceived exertion of the subject. Each subject was asked about the discomfort felt in his body parts. The total body parts score for a subject is the sum of all individual scores of his body parts. The body discomfort score of all the subjects were added and averaged to get mean score.

A comparative study was conducted for the traditional system as well as improved system for harvesting Makhana seeds from ponds in Dharamsar pokhar and Sursura pokhar of Darbhanga; and Nanoura and Rajokhar pokhar of village-Keoti, Darbhanga. The data obtained were analysed using two-tailed *t*-test to find out whether the mean values of the two groups differed significantly.

The harvesting of Makhana from ponds is a highly drudgery-prone operation. The unit activities involved in harvesting include going down to the bottom of the pond, lying down and sweeping the mud with both palms, collecting seed with ganjaa, washing them inside the water, bringing the ganjaa along with seeds to the top of the pond, and putting the seeds in an earthen pot floating on water. This action is repeated till the pot gets filled.

In the traditional system, a worker has to come to the surface of the pond about 2–8 times in a minute. But, using the improved system the worker can stay inside water up to 1 h and needs to come to the surface only 3–4 times for empting the seeds into the pot.

The mean age, height and weight of the selected subjects were 40.8 years, 1652 mm and 52.5 kg respectively. The harvesting trials were of 1 h duration for both T1 and T2 systems and ten subjects participated in the trial. Table 2 provides mean output of the harvesting trial conducted.

The results show that in 1 h a worker can harvest about 11.3 kg of Makhana seeds with ease using the developed system, whereas in the traditional method he can harvest about 3.8 kg of Makhana seeds. The *t*-test of the two systems shows that it is significant at 1% level. The results show that there is higher output in case of T2 system over T1 system due to the fact that using air cylinder with diving suit made the workers safe and comfortable. The workers can do harvesting with ease for 1 h without any extra effort. Whereas in case of T1 system, a worker needs to take 8–10 dips in 1 min, where a single dip lasts 6–8 sec only. Also, the body is exposed to sharp thornes/prickles, rashes, leech bite, etc.

Table 3 gives the ODR of the harvesting trial conducted.

The *t*-test shows that it is significant at 1% level. ODR was measured on a 0–10 point scale with VADS for assessing overall body discomfort (0–10 scale) (Figure 2). The average ODR (0–10) of subjects after harvesting

Table 1. Economics of Makhana cultivation using traditional system[1]

Item	Cost (Rs/ha)
Cost of cultivation (*A*)	
Rent of pond/year	15,000
Seed required (80 kg/ha @ Rs 70/kg)	5600
Interculture like thinning (12 labourers)	1440
Harvesting	27,000
Transportation charges	1000
Total cost	50,040
Output: (average seed yield – 1.8 t/ha and rate Rs 55/kg) (*B*)	99,000
Net return/ha (*A* – *B*)	48,960

Table 2. *t*-Test of output data of harvesting with T1 and T2 systems

Harvesting system	Mean	Standard deviation	Standard error	*t* Value
T1	3.87	0.68	0.22	10.74***
T2	11.35	2.52	0.80	

Table 3. *t*-Test of overall discomfort rate data of harvesting with T1 and T2 systems

Harvesting system	Mean	Standard deviation	Standard error	*t* Value
T1	8.3	0.82	0.26	10.82***
T2	4.2	1.03	0.33	

Table 4. *t*-Test of body parts discomfort score data of harvesting with T1 and T2 systems

Harvesting system	Mean	Standard deviation	Standard error	*t* Value
T1	78.8	4.47	1.41	21.49***
T2	48.2	4.92	1.55	

Table 5. Techno-economics involved in harvesting of Makhana with improved system (T2)

Item	Improved system (T2)
Cost of equipment (Rs) (mini diving kit – two units, breathing air cylinder – one and floating platform and accessories)	5,00,000.00
Life (years)	10
Annual use/year (h)	450
Fixed cost	
Depreciation (Rs)	45,000.00
Interest @ 12% (Rs/year)	33,000.00
Taxes, insurance and shelter @ 2% (Rs/year)	10,000.00
Total fixed cost (Rs/year)	88,000.00
Variable cost	
Labour cost (Rs/h)	100.00
Repair and maintenance @ 5% (Rs/h)	55.56
Electricity cost (Rs/h)	6.00
Total variable cost (Rs/h)	161.56
Custom hiring charges per unit (Rs/h)	400.00
Break-even point (h)	369
Payback period (years)	4.8
Benefit–cost ratio	2.48

Makhana by T1 and T2 systems was found to be 8.3 and 4.2 respectively. ODR is more in T1 system compared to T2 system because of frequent diving in and out of water and the worker's body being exposed to cold water, sharp thornes/prickles, mud, insects, etc.

The BPDS of subjects after harvesting Makhana by T1 and T2 systems was found to be 78.8 and 48.2 respectively (Table 4). The *t*-test of the two system shows that it is significant at 1% level.

The total cost of the improved system (T2) was about Rs 5 lakhs. The major cost of the system was for the air compressor which is required for filling filtered air into the cylinder. The equipment can be procured by the self-help groups/non-government organizations/Krishi Vigyan Kendra/pond owners of the area and can be made available to the divers/workers involved in harvesting Makhana seeds as and when required. Table 5 shows the costs involved in the improved system (T2). It can be observed that the break-even point is about 369 h and payback period is 4.8 years with benefit–cost ratio of 2.48.

In conclusion, an improved system has been developed for Makhana collection. With this improved system, the workers can remain under water for 1 h with ease and perform their work efficiently without any drudgery and occupational health problems. The results of 1 h harvesting

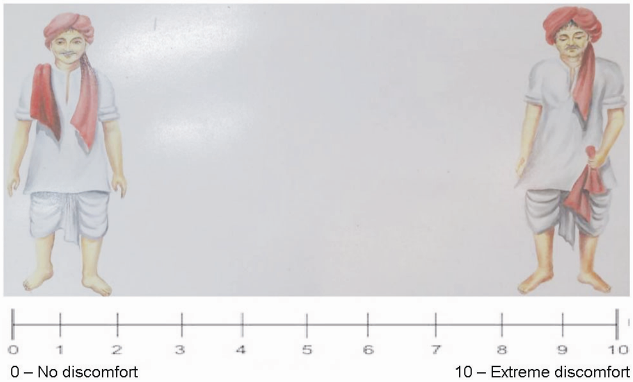
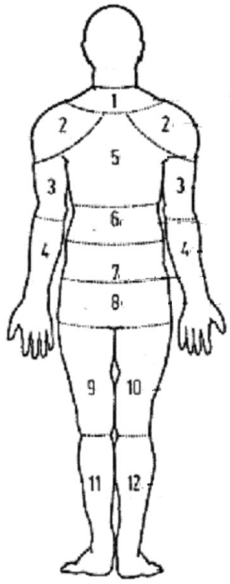


Figure 2. Visual analogue discomfort scale for assessing overall body discomfort (0–10 scale).



Sl. no.	Body part
1	Neck
2.	Shoulders
3.	Upper arms
4.	Lower arms
5.	Upper back
6.	Mid back
7.	Lower back
8.	Buttocks
9.	Left thigh
10.	Right thigh
11.	Left leg
12.	Right leg

Figure 3. Body part postural discomfort score[6].

trial conducted at four ponds with 10 subject show positive sign of using the improved system. The data indicate that the mean output is 11.3 kg/h with the T2 system and it was only 3.8 kg/h with the T1 system. The ODR on 0–10 scale is 4.2 in case of T2 system and it is 8.3 in case of T1 system. Also, the BPDS is lower with T2 (48.2) system compared to T1 (78.8) system. The techno-economics of the improved system was calculated; the break-even point comes out to be 369 h and payback period is 4.8 years with benefit–cost ratio of about 2.48.

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Salbardi–Belkher inland basin: a new site of Lameta sedimentation at the border of districts Amravati, Maharashtra and Betul, Madhya Pradesh, Central India

Rupesh S. Mankar and Ashok K. Srivastava*

P. G. Department Geology, SGB Amravati University, Amravati 444 602, India

The Late Cretaceous infratrappean Lameta sediments in central and western India are known from five inland basins, viz. (i) Nand–Dongargaon, (ii) Jabalpur, (iii) Balasinor–Jhabua, (iv) Ambikapur–Amarkantak and (v) Sagar. Among these, the successions in the first three basins are well studied. The dinosaurian remains from the formations of these inland basins serve as a significant tool for regional reconstructions of palaeogeographic and palaeoenvironmental conditions during Lameta sedimentation. Here, a new inland basin with good outcrops of Lameta sediments having dinosaurian skeletal remains egg nests and eggs is documented. Considering the lithofacies and dinosaurian remains from this new inland basin, it is evident that Lameta sedimentation during the Late Cretaceous was not restricted to only five inland basins documented earlier, but was taking place contemporaneously in an additional inland basin in between Balasinor–Jhabua in the west and Nand–Dongargaon basin in the east. We propose the name of this new site as Salbardi–Belkher inland basin. This newly identified basin lying at the border of Maharashtra and Madhya Pradesh also redefines the existing palaeogeographic limits of Lameta sedimentation, including dinosaur inhabitation.

Keywords: Dinosaurian remains, fluvio-lacustrine succession, infratrappean sediments, inland basins.

THE infratrappean Lameta Formation, disconformably overlying the Gondwana or Precambrian rocks, is mainly exposed in Jablapur district, Madhya Pradesh (MP); Nagpur and Chandrapur districts, Maharashtra and Anjar and Kheda districts, Gujarat, besides the scattered occurrences in Saugor (Sagar) and Amarkantak districts, MP (Figure 1). The Lameta beds are mostly considered to be fluvial-lacustrine in nature. However, there is a debate about the type area succession at Jabalpur regarding its marine[1–4] versus non-marine[5–8] nature. In general, major lithologies of the Formation are represented by variously coloured argillaceous sedimentary rocks, medium to fine-grained sandstones and silicified, brecciated and nodular limestones, which may show variations in stratigraphic position, in the lithocolumns exposed at various localities depending upon the nature of depositional environment than on time of deposition[3,9]. Despite remarkable similarity in lithological sequence, the successions in various areas also show a common characteristic in having dinosaurian remains in the form of bones, egg nests and eggs. Based on lithological succession and fossil remains, Mohabey[9] identified five inland sub-basins in which Lameta sedimentation took place, viz. (i) Nand–Dongargaon, (ii) Jabalpur, (iii) Balasinor–Jhabua, (iv) Ambikapur–Amarkantak and (v) Sagar (Figure 1).

The present study documents a new region in which Lameta sediments are exposed. Good sections exposing Lameta beds in this region occur near Bairam (lat. 21°22′25″N; long. 77°37′23″E), Belkher (lat. 21°21′48″N; long. 77°31′23″E), Pandhri (lat. 21°22′02″N; long. 77°32′54″E) and Salbardi (lat. 21°25′15″N; long. 78°00′00″E), besides 3–4 small, isolated exposures in nearby locations. These exposures are spread over an aerial distance of 10–40 km. In two localities, dinosaur bones and eggs are preserved. Comparing the depositional environment set-up and dinosaurian remains of the studied areas with those of the other five inland basins[9], we propose a new inland basin for Lameta sedimentation called Salbardi–Belkher inland basin, exposed in an area which is presently covered partially by districts Amravati in Maharashtra and Betul in MP.

Small sedimentary inliers consisting of Lameta Formation, overlying the Upper Gondwana sedimentary rocks are exposed in the Deccan Trap region (inset Figure 1). Quartzo-feldspathic gneiss of Archaean age forms the basement for Gondwana sedimentary rocks, which rest on it nonconformably. Broadly, the Lameta Formation is represented by sandstone, clay-marl and limestone litho-units,

*For correspondence. (e-mail: ashokamt2000@hotmail.com)