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Awareness on INM in makhana (*Euryale ferox Salisb.*) under field conditions

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Abstract
A field study was conducted for three consecutive years from 2019–20 to 2021–22 at Sultanpur district in U.P., India to find out the effect of integrated nutrient management (INM) on production performance of makhana (*Euryale ferox* Salisb.) under field condition. The experiment consisted of six INM treatments and executed in ran- domized block design with four replications. Results revealed that application of 25% RDN through vermicompost + 75% RDN through chemical fertilizers + recommended dose of P_2O_5-K_2O proved to be the best treatment and recorded significantly higher leaf diameter, total chlorophyll content in leaves, number of fruits per plant, number of seeds per fruit, seed weight, seed yield and profitability as compared to other treatments. The combined applica- tion of synthetic and organic fertilizers has been found to be the best solution to improve the production potential of the crop and keep the natural resources sustainable for longer time.

Keywords: Fox nut, gorgon nut, makhana, net returns, seed yield, yield attributes

Introduction

Fox nut or gorgon nut (*Euryale ferox* Salisb.) commonly known as Makhana is an aquatic crop, belongs to the fam- ily Nymphaeaceae, although it is occasionally regarded as a distinct family *Euryalaceae*. Traditionally it is grown in stagnant perennial water bodies like ponds, land depres- sions, oxbow lakes, swamps and ditches. Kumar *et al.* (2011) [8] showed that the cultivation of makhana could be done in general agricultural fields having clayey soils which are being used for rice cultivation. It is a crop of tropical and subtropical climate. For its proper growth and development, the conducive range of air temperature is 20- 35°C, relative humidity 50-90% and annual rainfall 100- 250 cm (Mandal *et al.,* 2010) [10]. As per the recent estimate of Directorate of Horticulture, Government of Bihar, total area under makhana cultivation in the state of Bihar is estimated to be 35,000 hectares that accounts 85% of the total area to be utilized for makhana cultivation in India. The major makhana growing states in India area Bihar,
West Bengal, Manipur and Assam.

Traditionally, no external fertilization is given to makhana growing under pond conditions as the pond sys- tem is self-sustaining in nutrient supply due to accumulated decomposed plant residues. But now-a-days scenario has changed tremendously when it is being cultivated in field conditions. Like other upland cereal crops the farmers are also applying synthetic fertilizers injudiciously to this crop too. This practice has started getting strong criticism from many agriculturist and environmentalists at various plat- forms. Under this situation, to halt this traditional practice a well proven scientific methods of application of nutrient sources that is integrated nutrient management practice would certainly be the best practice for maintaining the fertility and productivity of the soil as well as sustainability of the system (Babar and Dongale, 2013) [2]. Singh *et al.* (2014) [15] reported that makhana cropping itself adds a hand- some quantity of organic matter to the soil. Soil organic matter has profound effect on improving soil physical properties, retaining water for longer time and increasing available nutrients which ultimately resulted in greater biomass and crop yield (Onemli, 2004 and Bullock *et al*., 2002) [12]. Soil organic carbon has particularly been reported to be a major determinant of makhana productivity (Dutta *et al*., 1986) [5]

However, scanty information is available till date on integrated nutrient management in makhana crop and the appropriate dose of nutrients are yet to be determined for optimum crop productivity under field cultivation. There- fore, to develop an appropriate integrated nutrient manage- ment technique for cultivation of makhana under field conditions, the present study was planned to find out the impact of INM on performance of makhana under field condition.

Materials and Methods

A field experiment was conducted for three consecutive years from 2019–20 to 2021–22 at Sultanpur. Soils of experimental plot was sandy loam in texture (40% sand, 40% silt and 20% clay) and slightly acidic in reaction (pH 6.52) with EC of 0.32 dSm^{-1}. The soil was low in organic carbon (0.38%) and available nitrogen (171 kg N/ha), medium in available phosphorus (22.38 kg P/ha) and potassium (220.63 kg K/ ha). The DTPA extractable Fe, Mn, Zn and Cu in experi- mental soil was 21.01, 2.30, 1.60 and 1.80 mg/kg of soil, respectively. The experiment comprised of six treatments of integrated nutrient management, *viz*. control (T_0), 100% recommended dose of fertilizers (T_1), 25% recommended dose of nitrogen through vermicompost + 75% recom- mended dose of nitrogen through chemical fertilizers + recommended dose of PK (T_2), 25% recommended dose of nitrogen through neem cake + 75% recommended dose of nitrogen through chemical fertilizers + recommended dose of PK (T), Azolla @ 100 g/m^2 + recommended dose of PK (T_4), 25% recommended dose of nitrogen through vermicompost + 25% recommended dose of nitrogen through neem cake + 25% recommended dose of Nitrogen through chemical fertilizers (T_5). The experiment was laid out in randomized block design with four replications.

Makhana cv. Sabour Makhana-1 was taken for experi- ment. Seed of the crop was sown in nursery during the month of December and 55-60 days old seedlings were transplanted at 1.25 m x 1.25 m distance during 3rd week of February in 10 m x 10 m size plots. Agricultural grade lime @ 40 kg/ha were applied in all the plots. Recommended dose of fertilizers (75 kg N, 45 kg P2O5 and 30 kg K2O/ha) were applied through urea, Diammonium phosphate (DAP) and muriate of potash (MOP) in the respective plots as per the treatment. As per treatment half dose of nitrogen and full dose of phosphorus and potassium was applied as basal dose at the time of field preparation and remaining half dose of nitrogen was as top dressing at 45 DAT.

Vermicompost and neem cake were applied in the respec- tive plots at 10-15 days before transplanting of crop, whereas, azolla was applied in the respective plots just before transplanting of crop. Vermicompost contains 2.1% N, 1.4% P and 2.3% K, whereas, neem cake contains 5.1% N, 1.1% P and 1.3% K. The standard agronomical practices were adopted for cultivation of crop.

Five plants were selected randomly from each plot, tagged permanently and used for measurement of growth parameters and yield attributes. Leaf diameter was mea- sured by selecting 5 leaves from tagged plant using meter tap and average was taken. The chlorophyll content of makhana leaves was estimated at 50–60 days after trans- planting (DAT) by the method advocated by Arnon (1949) [1]. The number of fruits formed on five tagged plants were counted and averaged for calculating number of fruits per plant. Five fruits from tagged plants were randomly se- lected for calculation of number of seeds per fruit. A ran- dom sample of seed was taken from the produce of the net plot to measure the 1,000-seed weight. Makhana crop was harvested treatment wise after complete degradation of leaves. After collection of all seeds from the experimental plots, the unwanted materials were removed and thor- oughly rubbed by feet to remove the membranous cover from the seed. The seeds were washed with fresh water and dried in air for 8-10 hours and weighed for measuring seed yield. The economics of different treatments were worked out by considering the cost of input and income obtained from output based on the prevailing market price. Statisti- cal analysis of the data was carried out using standard analysis of variance (Gomez and Gomez, 1984) [6].

Results and Discussion

Growth attributes

Application of 25% RDN through vermicompost + 75% RDN through chemical fertilizers + recommended dose of P2O5-K2O produced broadest leaf with 140.2 cm diameter as compared to control, 100% RDF and *Azolla* @ 100 g/m^2 + RD of P2O5-K2O (Table 1). However, total chlorophyll content in leaves of makhana was significantly higher (9.65 mg/g) under application of 25% RDN through vermicompost + 75% RDN through chemical fertilizers + recommended dose of P2O5-K2O over control treatment only. All the INM treatments appreciably improved the total chlorophyll content in leaves of makhana. Integration of organic manures with inorganic fertilization helps in in- creased availability of essential nutrient coupled with favourable physical and microbial activities enables the plants to assimilate more photosynthates and growth of the plant (Kumar *et al.,* 2017, Neti *et al.,* 2022 and Saharan *et al.,* 2023) [9, 11, 13].

Table 1: Effect of integrated nutrient management on leaf size and total chlorophyll content in leaves of makhana (pooled mean data of 3 years)

Treatment	Leaf diameter (cm)	Total chlorophyll content (mg/g)
T_0, Control	102.8	7.29
T1, 100% RDF (75:45:30 N-P2O5-K2O)	121.9	9.61
T2, 25% RDN through VC + 75% RDN through CF + RD of P2O5-K2O	140.2	9.65
T3, 25% RDN through NC + 75% RDN through CF + RD of P2O5-K2O	131.2	9.54
T_4, *Azolla* @ 100 g/m + RD of P O -K O 2252	127.2	9.34
T5, 25% RDN through VC + 25% RDN through NC + 25% RDN through MC	133.5	9.52
CD (P=0.05)	10.28	0.75

Note: RDF, recommended dose of fertilizers; RDN, recommended dose of Nitrogen; VC, vermicompost; CF, chemical fertilizers; NC, neem cake; MC, mustard cake

Yield attributes and yield

Application of 25% RDN through vermicompost + 75% RDN through chemical fertilizers + recommended dose of P2O5-K2O recorded significantly higher number of fruits per plant (11.8) over other treatments (Table 2). In terms of development of number of seeds per fruit, application of 25% RDN through vermicompost + 75% RDN through chemical fertilizers + recommended dose of P2O5-K2O re- mained statistically at par with 100% RDF and application of 25% RDN through vermicompost + 25% through neem cake + 25% RDN through mustard cake and proved signifi- cantly superior over other treatments. However, the signifi- cantly highest 1000 seed weight of 845.2 g was recorded under application of 25% RDN through vermicompost + 75% RDN through chemical fertilizers + recommended dose of P2O5-K2O over all other treatments applied to makhana crop. As already discussed, that integration of chemical fertilizers and organic manures maintains better availability of nutrients and helps in enhanced photosyn- thetic activities and translocation of photosynthates to-75% RDN through chemical fertilizers + recommended dose of P2O5-K2O recorded significantly higher seed yield of makhana (3.31 t/ha) over other treatments of nutrient management applied to makhana crop. The cumulative beneficial effect of growth and yield attributing characters was finally reflected on seed yield of makhana (Jana, 2017; Singh *et al*., 2020 and Sushma *et al*., 2024) [7, 16, 17].

Economics

Application of 25% RDN through vermicompost + 75% RDN through chemical fertilizers + recommended dose of P2O5-K2O fetched significantly higher net returns of ₹2,21,422/ha with 3.02 B:C ratio compared to other INM treatments (Table 3). This treatment enhanced the net returns by ₹97,062, 90,822, 71,483, 54,651 and 31,562 over 25% RDN through vermicompost + 25% RDN through neem cake + 25% RDN through mustard cake, control, 25% RDN through neem cake + 75% RDN through chemi- cal fertilizers + recommended dose of P2O5-K2O, Azolla @ 100 g/m2 + recommended dose of P O -K O and 100% 252 wards sink and finally resulted significant improvement in yield attributes of the crop (Neti *et al*., 2022 and Das *et al*., 2024) [4, 11]. Application of 25% RDN through vermicompost + RDF, respectively. The higher seed yield as compared to the additional cost of production under the respective INM treatment might be responsible for the significant enhance-

Table 2: Effect of integrated nutrient management on yield attributes and yield of makhana (pooled mean data of 3 years)

Treatment	Number of fruits/plants	Number of seeds/fruits	1,000- seed weight (g)	Seed yield (t/ha)
T_0, Control	7.52	71.6	731.4	2.24
T1, 100% RDF (75: 45: 30 N-P2O5-K2O)	11.05	86.6	826.5	2.88
T2, 25% RDN through VC + 75% RDN through CF + RD of P2O5-K2O	11.80	91.0	845.2	3.31
T3, 25% RDN through NC + 75% RDN through CF + RD of P2O5-K2O	10.95	80.7	801.8	2.86
T_4, *Azolla* 100 g/m + RD of P O -K O2252	9.75	81.2	764.5	2.70
T_5, 25% RDN through VC + 25% RDN through NC + 25% RDN through MC	9.26	84.8	789.3	2.84
CD (P=0.05)	0.50	6.73	7.22	0.23

RDF, recommended dose of fertilizers; RDN, recommended dose of Nitrogen; VC, vermicompost; CF, chemical fertilizers; NC, neem cake; MC, mustard cake

Table 3: Effect of integrated nutrient management on economics of makhana (Pooled mean data of 3 years)

Treatment	Cost of cultivation (₹/ha)	Net returns (₹/ha)	Benefit: cost ratio
T_0, Control	93,400	1,30,600	2.40
T1, 100% RDF (75:45:30 N-P2O5-K2O)	98,607	1,89,860	2.93
T2, 25% RDN through VC + 75% RDN through CF + RD of P2O5-K2O	1,09,611	2,21,422	3.02
T3, 25% RDN through NC + 75% RDN through CF + RD of P2O5-K2O	1,35,861	1,49,939	2.10
T_4, *Azolla* @ 100 g/m + RD of P O -K O2252	1,03,129	1,66,771	2.62
T5, 25% RDN through VC + 25% RDN through NC + 25% RDN through MC	1,59,340	1,24,360	1.78
CD (P=0.05)		22,890	0.21

RDF, Recommended dose of fertilizers; RDN, recommended dose of nitrogen; VC, vermicompost; CF, chemical fertilizers; NC, neem cake; MC, mustard cake

ment in the net returns and benefit to cost ratio of the crop (Singh *et al.,* 2020; Das *et al.,* 2024 and Sasmal *et al.,* 2024) [4, 14, 16].

Thus, it can be concluded that the application of 25% RDN through vermicompost + 75% RDN through chemi- cal fertilizers + recommended dose of P2O5-K2O has been found to be significantly superior for improving the growth, yield and economics of makhana. Consequently, the respective INM treatment combinations can be recom- mended to the farmers of makhana for getting higher productivity and profitability of the crop.

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कृषि विज्ञान केंद्र, हरदोई-II द्वारा कृषि विज्ञान केंद्र, सीतापुर-II के सहयोग से मखाना विकास पर जागरूकता कार्यशाला का सफल आयोजन किया गया।

Awareness on makhana production in saline sodic soils at KVK Hardoi-II

References

1. Arnon DI. Copper enzymes in isolated chloroplast I polyphe- nol oxidase in *Beta vulgaris*. Plant Physiology,1949:24:1–5.
2. Babar S, Dongale JH. Effect of organic and inorganic fertilizers on soil fertility and crop productivity under mus- tard-cowpea-rice cropping sequence on Lateritic soils of Konkan. Journal of Indian Society of Soil Science,2013:61(1):7– 14.
3. Bulluck LR, Brosius M, Evanylo GK, Ristaino JB. Organic and synthetic fertility amendments on organic con- ventional farms. Applied Soil Ecology,2002:19(2):147–160.
4. Das S, Pal S, Banerjee H, Kumar A, Shankar T. Optimizing rice (*Oryza sativa*) growth, productivity, profitabil- ity and nutrient uptake with coated urea and organic manure in the new alluvial zone of West Bengal. Indian Journal of Agronomy,2024:69(3):241–246. https://doi.org/10.59797/ ija.v69i3.5516
5. Dutta RN, Jha UN, Jha SN. The relationship of biomass yield of makhana (E. ferox) with soil properties and water quality. Plant and Soil,1986:95(3):345–350.
6. Gomez KA, Gomez AA. Statistical Procedures for Agricultural Research. Second Edition, John Wiley and Sons, New York., 1984, 680.
7. Jana B. Organic cultivation of makhana in low land during rainy season for enhancing farm profitability. International Journal of Ecosystems and Ecology Sciences,2017:7(3):419–424.
8. Kumar L, Gupta VK, Khan MA, Singh SS, Jee J, Kumar A. Field based makhana cultivation for improving cropping intensity of rice fields. Bihar Journal of Horticul- ture,2011:1:71–72.
9. Kumar V, Kumar T, Singh G, Singh RA. Effect of integrated nutrient management on yield of rice and its residual effect on wheat in rice-wheat system under lowland. Annals of Plant and Soil Research,2017:19(4):360–365.
10. Mandal RN, Saha GS, Sarangi N. Harvest and processing of Makhana (*Euryale ferox* Salisb.)-an unique assem- blage of traditional knowledge. Indian Journal of Tradi- tional Knowledge,2010:9(4):684–688.
11. Neti S, Sidar RS, Singh VK, Yadav D. Effect of integrated nutrient management on rice (*Oryza sativa* L.) yield under Surguja district. The Pharma Innovation Journal,2022:11(7):3,473–3,476.
12. Onemli F. The effects of soil organic matter on seedling emer- gence in sunflower (*Helianthus annuus* L.). Plant Soil Envi- ronment,2004:50:494–499.
13. Saharan B, Yadav RS, Kantwa SR, Kumar R. Integrated nutrient management in pearl millet (*Pennisetum glaucum*)–wheat (*Triticum aestivum*) cropping system. In- dian Journal of Agronomy,2023:68(1):30–36. https://doi.org/ 10.59797/ija.v68i1.199
14. Sasmal SS, Nanda SS, Dash S, Subhadarshi S. Nutrient management through organic and inorganic sources of nutrition in summer greengram (*Vigna radiata*). Indian Journal of Agronomy,2024:69(4):484–486. https://doi.org/ 10.59797/ija.v69i4.5556
15. Singh IS, Kumar L, Singh AK, Bhatt BP, *et al*. Impact of makhana (*Euryale ferox* salisb.) based cropping systems on nutrient dynamics of Inceptisols of north Bihar. International Journal of Agricultural and Statistical Sciences,2014:10(S–1):125–129.
16. Singh IS, Kumar M, Raut SM, Thakur AK, *et al*. Integrated nutrient management package for field cultivation of makhana in North Bihar. Journal of AgriSearch,2020:7(3):138–141.
17. Sushma M, Singh JP, Rajpoot SK, Bhushan C, Verma SK, Singh NK, *et al*. Sarson (*Brassica rapa* var. yellow sarson) under guava (*Psidium guajava*) based agri-horti system. Indian Journal of Agronomy,2024:69(3):352–355. https://doi.org/ 10.59797/ija.v69i3.5535