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RESEARCH ARTICLE

Prospect and Problem of Using Nitrobenzene in Vegetable Farming: A Case of Bangladesh

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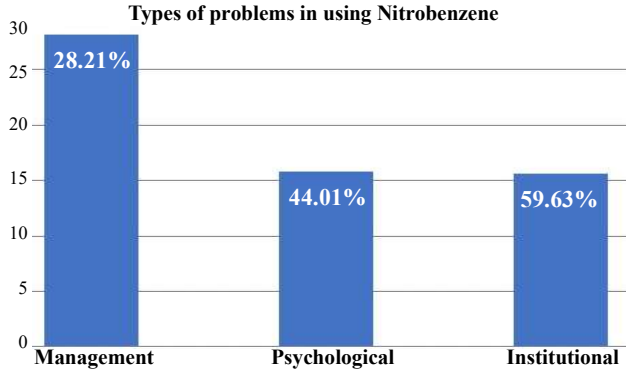
HIGHLIGHTS

- Nitrobenzene can play an important role to boost vegetable production in Bangladesh.
- Farmers face management, psychological and institutional problems in receiving and use Nitrobenzene.
- Both public and private sectors should disseminate Nitrobenzene among the farmers to increase sustainable production.

GRAPHICAL ABSTRACT



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ABSTRACT

Context: Nitrobenzene is a plant growth regulator (PGR) that applies to crops and vegetables to increase productivity.

Objectives: This paper aims to identify the prospects and problems of using Nitrobenzene in vegetable cultivation in Bangladesh.

Methodology: Both primary and secondary data were collected and used in the study. Primary data were collected from randomly selected 330 farmers of 3 vegetable-intensive growing districts of Bangladesh. The survey was conducted through a face-to-face interview based on a structured questionnaire. Secondary data were collected from relevant literature and related organizations. Data were interpreted by developing the Problem faced index (PFI) and factor analysis.

Results and Discussion: It was observed that there is a reasonable prospect of applying Nitrobenzene to boost vegetable production in Bangladesh. However, to receive and use this PGR, lack of awareness towards nitrobenzene application in vegetables ranked as the most severe barrier, followed by price to purchase Nitrobenzene, lack of knowledge regarding judicious use of Nitrobenzene, and lack of media and government, respectively. Farmers faced three types of barriers: management, psychological, and institutional, where management barriers were the most important in hindering the dissemination of Nitrobenzene among the farmers.

Recommendation: Besides private sectors, the Department of Agricultural Extension (DAE) should be involved in the dissemination process of this PGR to increase vegetable production as well as to achieve food security in Bangladesh

The agricultural sector exerts a considerable influence on macroeconomic aspects such as food security, nutritional fulfillment, poverty reduction, and employment generation. Moreover, the development of sustainable food systems aimed at enhancing yield per unit of land area, the agricultural sector can play a pivotal role in ensuring more dependable food and nutritional security (Noopur *et al*., 2023a), aligning with the objectives outlined in the Sustainable Development Goals (SDGs). Vegetable production has shown a gradual increase, albeit at a slow pace, rising from 2.93 MT in 2012-13 to 4.12 MT in 2016-17 in Bangladesh. The expansion in vegetable production extends beyond particular seasons, with winter vegetables experiencing a notable upswing (Sharmin et al., 2018). The surge in vegetable cultivation has not only enhanced food security and diminished malnutrition but has also established sustainable sources of food and income (Khan, 2023 and Kharumnuid *et al*., 2021).

Vegetable production, especially organic farming, aims to yield toxic-free food, often achieved through the application of various nutrient sources. Alongside nutrients, plant growth regulators (PGRs) play a crucial role in altering physiological processes within plants. Also referred to as bio-stimulants or bio-inhibitors, PGRs operate within plant cells, stimulating or inhibiting specific enzymes or enzyme systems to regulate plant metabolism (Vamshi, 2023). Among them nitrobenzene play a significant role in improving growth and yield of crops including vegetables. Functioning as a plant energizer, bloom stimulant, and yield enhancer, nitrobenzene combines nitrogen with plant growth regulators (Tania *et al*., 2022; Samad *et al*., 2020). Plants readily assimilate it, influencing biochemical processes and enhancing nutrient absorption from the soil. Moreover, it elevates nutrient utilization efficiency, thereby promoting vegetative growth. Its applicability extends to various crops, including vegetables.

In Bangladesh, the ongoing increase in population is placing pressure on available cultivable land, resulting in its decline. This poses a significant challenge to sustain the upward trajectory of vegetable production. However, the utilization of nitrobenzene presents a potential solution to address this challenge. As a plant growth regulator, nitrobenzene has demonstrated efficacy in enhancing both plant growth and yield in vegetable farming. Nevertheless, its use also entails negative consequences for crop, vegetable, and fruit production, as highlighted in various studies (Sadeghi *et al*., 2023; Bagale *et al*., 2022).

The use of nitrobenzene, a PGR, has shown promising results across various crops, contributing to improved crop development and yield. Studies by Ullah and Bano (2011) demonstrated that nitrobenzene application led to enhanced sunflower growth and yield compared to control. Similarly, Mithila *et al*. (2012) found that the application of nitrobenzene along with three-fourths of the recommended fertilizer significantly improved plant growth and yield in tomato cultivation, presenting a potential strategy to alleviate fertilizer usage pressure. While in case of potato, Rahim *et al*. (2017) reported remarkable results, with the highest yield recorded under nitrobenzine (Flora) spray. Potato sarpomira variety yielded 44 per cent more (9.15 tons/ha) with Flora spray compared to without (5.15 tons/ha). Furthermore, in bottle gourd cultivation, Samad et al. (2020) highlighted the superiority of Nitrobenzene treatment at a concentration of 2 ml/L, particularly with a frequency of application of two sprays, which significantly influenced growth and yield.

In a study on brinjal germplasm, Singh *et al*. (2022) noted significant differences in flowering time, flower production, and fruit yield when treated with a combination of GA3 and nitrobenzene compared to control groups. Additionally, Kohombang *et al*. (2019) emphasized the significant influence of nitrobenzene application on the growth, reproductive capacity, yield, and quality of sweet cucumbers, attributing enhanced fruit quality to increased yields facilitated by blossom proliferation.

The existing research primarily focuses on the effects of PGRs or nitrobenzene on crops, fruits, and vegetable production, the present study concentrates solely on vegetable production. Furthermore, it aims to explore the potential and challenges associated with the use of nitrobenzene in vegetable cultivation. Therefore, there is a pressing need for further investigation into the feasibility of using nitrobenzene to enhance vegetable production in Bangladesh and to ascertain the constraints being faced by farmers in its utilization. A comprehensive study is essential to address the research questions pertaining to the prospects and challenges of Nitrobenzene application in vegetable farming in Bangladesh:

- Can Nitrobenzene help to boost vegetable production in Bangladesh?
- What are the problems faced by the farmers in adopting Nitrobenzene for vegetable cultivation?
- What type of factor act as a most influential barrier to adopt Nitrobenzene?

The study's findings may help formulate policies to make effective diffusion strategies of Nitrobenzene among vegetable growers to boost vegetable production in Bangladesh.

METHODOLOGY

The study was conducted in three districts namely Bogura, Jessore and Narsingdi of Bangladesh. Bogura district is located in the Northern region; Jashore district is located in the southwestern region, whereas, Narsingdi district is located in the north-eastern region of Bangladesh (Fig 1). However, the economy of Bogura, Jashore, and Narsingdi is predominantly dependent on agriculture. Nearly 63.38 per cent, 55.57 per cent, and 51.22 per cent of the total households are agriculture farm holdings in Jashore Bogura and Narsingdi district, respectively (BBS, 2020). Data were collected from six selected villages from these three districts, including two villages from each district. There were 1320 vegetable producing farmers (tomato and brinjal) in the selected villages. These farmers were considered the study's population. Twenty-five

Fig. 1: A map of Bangladesh showing study area (Jessore, Narsingdi and Bogra district)

(25) per cent of the total population was considered the study's sample. Thus, the sample size was 330. The study focused on two crucial aspects: the prospect of using nitrobenzene in vegetable cultivation and the problem faced in using nitrobenzene. Both primary and secondary data were collected and used for the study.

The prospect of utilizing nitrobenzene in vegetable cultivation was assessed through the review of related literature, relying on secondary data. Various studies were reviewed, summarized, and highlighted in introduction part to understand nitrobenzene's performance in vegetable cultivation. In contrast, primary data regarding the challenges encountered by vegetable farmers when using nitrobenzene were gathered through structured interviews. A questionnaire comprising 10 problem-related queries concerning nitrobenzene usage in vegetable cultivation was administered to farmers. Farmers were asked to indicate the severity of problems they faced while utilizing nitrobenzene for vegetable cultivation.

Selected items of problems were arranged in the scale to have actual feelings on problems faced by the farmers in vegetable cultivation. Each of these items was asked the respondent farmers to indicate the severity of problems with four alternative responses as 'severe problem,' 'moderate problem,' 'low problem, and 'no problem', and the scores were assigned as 3, 2, 1, 0 respectively to the alternative response. A score of problems faced in using nitrobenzene by a respondent was determined by adding up all the scores for all the responses of that respondent's items (Rahman *et al*., 2023; Islam *et al*., 2024). Thus, the possible range of score of problems faced in using nitrobenzene was 0-30, while '0' indicates no problems and '30' indicates severe problems the farmers faced in using nitrobenzene for vegetable cultivation. Problems faced Index (PFI) for each of 10 items was computed by using the following formulae:

$$PFI = fn \times 0 + fl \times 1 + fm \times 2 + fs \times 3$$

Where
PFI=Problem faced Index
fn = Number of farmers faced no problem
fl = Number of farmers faced low problem
fm = Number of farmers faced moderate problem
fs = Number of farmers faced severe problem

Thus, the range of PFI of the problem could be 0-990, where '0' indicates no problem and '990' means the highest problem (Talukder *et al.,* 2021). A rank

order of the problems based on score was also made to compare the barriers (Barman *et. al.*, 2024; Baruah *et. al.*, 2024; Priyanka *et al.*, 2024). After the data were collected, they were processed and analyzed according to the objectives of the study. PFI was calculated to rank the problems faced by the farmers when using Nitrobenzene. In addition, factor analysis was run to determine the grouping of problems responsible for using Nitrobenzene. The analysis was done using the software SPSS version 22.

RESULTS

To evaluate the potential of nitrobenzene utilization in vegetable production in Bangladesh, the information was compiled on the effects of nitrobenzene in vegetable cultivation from countries sharing similarities with Bangladesh in terms of socio-economic, geographic, and environmental factors.

The identification of problems faced by farmers in using nitrobenzene, individual as well as group-wise approaches was adopted. Individual severity of each problem was highlighted using the Problem Frequency Index (PFI) score, while group-wise analysis relied on factor analysis. For individual assessment, ranking 10 selected problems faced by farmers in adopting nitrobenzene based on their PFI scores. The total scores of all respondents against each problem were aggregated to derive the farmers' nitrobenzene adoption index for that particular issue (Table 1). Notably, "Lack of awareness towards nitrobenzene application in vegetables" emerged as the most severe problem, while "Lack of availability in the local market" was identified as the least severe issue. "Confusion about profitability to use nitrobenzene" and "Lack of knowledge regarding judicious use of nitrobenzene" was ranked as the second and third most severe problems, respectively. In the group-wise analysis, problems such as "Lack of media support to disseminate information regarding nitrobenzene," "Absence of government support for the procurement and use of nitrobenzene, and Lack of demonstrations were categorized as moderate-level challenges faced nitrobenzene usage by farmers.

Besides rank order of the problem, factor analysis to identify the group of barriers and their relative importance was done. To assess the suitability of the data and gauge the homogeneity of the variables input into the model, the Kaiser-Meyer-Olkin (KMO) measures of sampling adequacy and Bartlett's Test of Sphericity (BTS) were utilized (Kabir and Rainis, 2015). The data met the requirements for factor analysis, as indicated by the KMO value of 0.655 and the BTS value of 771.339 (P<.01). As an extraction technique, principle component analysis was employed. The analysis's findings are shown in Tables 2 and 3, respectively. From both Tables, it was observed that farmers' problem can be grouped into management barriers, psychological barriers, and institutional barriers. Management barriers were found to be the most important accounted 28.21 per cent of

Table 1. Rank order of problem faced by the farmers in adopting Nitrobenzene

Nature of problems	Score	Rank order
Lack of awareness towards nitrobenzene application in vegetables	737	1
Confusion about profitability of using nitrobenzene	665	2
Lack of knowledge regarding judicious use of nitrobenzene	655	3
Lack of media support to disseminate information regarding nitrobenzene	651	4
Absence of government support for taking and use of nitrobenzene	646	5
Lack of demonstration	640	6
Residual effects of nitrobenzene	631	7
Lack of motivation for using nitrobenzene	621	8
Spraying problem	571	9
Lack of availability in local market	496	10

Table 2. Items loaded in the factor using principal component analysis

Factors/Variables	Factor loading
Management	
Spraying problem	.806
Lack of market availability	.755
Lack of demonstration	.673
Lack of motivation	.553
Residual effect of Nitrobenzene	.489
Psychological	
Confusion about profitability of Nitrobenzene	.787
Lack of awareness towards Nitrobenzene	.728
Lack of Knowledge on the judicious use of Nitrobenzene	.463
Institutional	
Lack of government initiative	.913
Lack of media support	.843

Table 3. Eigen values, Variance percentage and Cumulative variance percentage of extracted determinants

Factors	Eigen value	% of variance	Cumulative %
Management	2.821	28.21	28.21
Psychological	1.580	15.80	44.01
Institutional	1.562	15.62	59.63

total variance followed by psychological (15.80%) and institutional (15.62%) barriers.

DISCUSSION

Vegetables are known as protective foods due to their abundant supply of essential nutrients, antioxidants (Noopur *et al*., 2023b), and beneficial nutraceuticals (Panwar *et al*., 2024). Moreover, the utilization of nitrobenzene has demonstrated a significant capacity to enhance the growth and yield of vegetables. Nitrobenzene has been observed to stimulate vegetable production by promoting vegetative growth, flowering, and yield. Its application has proven effective in increasing the production of various vegetables, including brinjal, sweet cucumber, bottle gourd, chilli, potato, tomato, and sunflower. It was observed that application of nitrobenzene is a proven technique to boost vegetable production in Bangladesh and at global level. The finding is consistent with the study of Sadeghi *et al.,* (2023) and Bagale *et al.,* (2022) who commented PGR or nitrobenzene play important role to increase crop and vegetable production.

It is evident that nitrobenzene application holds significant promise in augmenting sustainable vegetable production in Bangladesh. This application of plant growth regulators (PGRs) presents a favourable outlook for enhancing vegetable production and improving the livelihoods of smallholder vegetable growers. While technological advancements can undoubtedly bolster crop production, their efficacy relies heavily on user awareness and adoption. Hence, initiatives like the successful application of nitrobenzene in enhancing vegetable production should be more widely promoted by various organizations. Both public and private sectors should intensify their efforts to disseminate information about nitrobenzene among vegetable growers in Bangladesh, thereby empowering them to leverage this technology for improved agricultural outcomes.

Despite the positive effects of nitrobenzene, there are several challenges hindering its adoption and utilization by farmers. Many vegetable producers lack awareness about the application of nitrobenzene to enhance production, and thus, are unaware of its impact on vegetable yields. Additionally, the prevalence of pests and diseases in vegetables demands farmers' attention towards pesticide application, leaving them with less focus on acquiring and applying nitrobenzene. Moreover, the limited involvement of organizations responsible for disseminating information about nitrobenzene among farmers further complicates its utilization as a plant growth regulator (PGR). The profitability aspect also contributes to the hesitancy in nitrobenzene usage, as farmers may have confusion regarding its economic viability. This finding aligns with previous studies by Alam *et al*. (2018) and Rakib *et al.* (2019), which underscore the significance of crop prices and profitability in influencing agricultural practices. To address these barriers and promote the effective use of Nitrobenzene for boosting vegetable production, it is imperative for the respective government sector to actively engage in nitrobenzene extension programs among farmers.

Several demonstrations need to be arranged by the public and private sectors to encourage and motivate farmers for using this yield boosting approach. The farmers lack knowledge about judicious use of nitrobenzene which may affect either less or higher use of this PGR than the recommended dose. A hand on training may help them to learn the application of recommended dose of nitrobenzene in vegetables. The finding is in line with the study of Kabir and Rainis (2015a) and other inputs (Chauhan *et al.,* 2022) where they mentioned that lack of knowledge act as a barrier to use food safety practice. Lack of government and media support is also barriers to adoption nitrobenzene. At the moment, only some agro-based private sectors are working to disseminate this PGR. The public sector, especially the Department of Agricultural Extension (DAE), should involve with the nitrobenzene dissemination program.

The factor analysis also showed that farmers face 3 types of barriers such as management barrier, psychological barriers and institutional barrier in adopting the use of nitrobenzene.

Management problem: Based on correlation among the problems and factor loading value, 5 problems

out of 10 was made a cluster or group which named as management barrier as these practices are involved with farm management. This group was found most severe group of barrier for the farmers. The finding is similar with the finding of Kabir and Rainis (2015b). The extension agent should help the farmers to minimize these barriers.

Psychological problem: This group includes three problems such as confusion about profitability to apply nitrobenzene, lack of awareness and lack of knowledge about judicious use of nitrobenzene. Psychological factors significantly influence farmers to adopt new technology (Haque *et al*., 2016). Therefore, initiative to reduce these barriers may help the farmers to take positive decision regarding use of Nitrobenzene.

Institutional problem: Institutional play an important role to adopt technology by the farmers (Kabir *et al*., 2017). This study found lack of media and government support under institutional problem to disseminate nitrobenzene among the farmers. Government and media should play important role to disseminate nitrobenzene among the farmers.

CONCLUSION

Nitrobenzene is one type of PGR used in many countries, including Bangladesh, to increase crop and vegetable productivity. The study found that the application of nitrobenzene has a positive impact on various vegetables such as eggplant, tomato, chili, cucumber, bottled gourd, etc. Bangladesh's vegetable production has been increasing over the last few years. To keep the trend, applying nitrobenzene can play an important role. There is a good prospect of applying nitrobenzene to boost vegetable production in Bangladesh. So, the authority should convey such information among the farmers so that they motivate and show interest to use nitrobenzene. On the other hand, there are some barriers to receiving and using nitrobenzene by vegetable growers, among which some of the most important are lack of awareness towards nitrobenzene application in vegetables, confusion about profitability to use nitrobenzene, lack of knowledge regarding judicious use of nitrobenzene and lack of media and government support. Managerial barriers were the most severe group, followed by socio-economic and institutional groups, respectively, to hinder the dissemination of nitrobenzene among the farmers. The public and private sectors should take the initiative to reduce these problems and make nitrobenzene available to the farmers. At the moment, only private sectors are disseminating nitrobenzene among the farmers. This research suggests that the largest technology extension public organization name Department of Agricultural Extension (DAE) should be involved with the dissemination process of this PGR to increase vegetable production of Bangladesh. In addition, the respective authority should arrange training, discussion and demonstration program to increase farmers' knowledge and awareness towards use of nitrobenzene in vegetable production.

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Authors' contribution : The first author collected and analysed data and wrote the first draft. The second author conceptualised, designed, and edited the manuscript. The third, fourth and fifth author supervised the entire study process. All authors read and approved the manuscript.

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