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Foliar Spray of Urea: A Sustainable Way to Minimize the Rate of Fertilizer Application for Mustard Production in Drought Prone Area of Bangladesh

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ABSTRACT

From the beginning of November 2021 to February 2022, an agricultural investigation was conducted at the Agronomy Field Laboratory of Rajshahi University, Bangladesh. Three sets of replications including a Randomized Complete Block Design (RCBD) were used by this design. In this study mustard variety BARI Sarisha-11 was used with five fertilizer levels viz. T_1 = control (no fertilizer), T_2 =60 % of recommended dose (RD) urea [50% of RD as soil application (SA) + 10% RD as foliar application (FA)], T_3=85% of recommended dose (RD) urea [70% of RD as soil application (SA) + 15% of RD as foliar application (FA)], T_4= 100% of recommended dose of urea (Traditional practice), T_5= 100% of recommended dose of urea +3% magic growth as foliar application. In case of T_2 and T_3 (except T_1 & T_4) magic growth was sprayed with urea i.e. liquid fertilizers, in case of T_5, only magic growth given by three times (25 DAS, 35 DAS and 45 DAS). The yield indicators under investigation were all significantly impacted by liquid fertilizer. The use of T_3 treatment yielded the best figure (2.45 t ha^{-1}) across yield as well as yield attributes. The following second positional values was displayed in the circumstances where T_4 (2.24 t ha^{-1}) or customary methods were used. The lowest values for all of traits were observed from T_1 (1.45 t ha^{-1}) treatment. So, it is concluded that, through the foliar application of liquid fertilizer (urea with magic growth), 15% urea can be saved compared to traditional practice.

Keywords: Mustard; Urea; Treatment; Traditional method; Spray; Drought; Foliar application; Liquid fertilizer; Recommended dose; Yield.

1. Introduction

Agrarian country like Bangladesh, mustard is the central parts of all oil crops having a paramount significance as a major source of livelihood for rural people. Beside this, its production not only ensures the sustainability of economy but also ensure the food security as well as the environmental viability. Each year, a large amount of land is dedicated to produce mustard throughout the country, illuminating its role in the nations. Among various oilseed crops that are grown throughout Bangladesh are in the course of the fiscal year 2021-2022, mustard stands foremost in terms of acreage and output, having 6.10 lakh hectors and 822 thousand metric tons of output, correspondingly (BBS, 2023). Edible oilseeds account for around 3% of the overall cultivated area, producing 830 kg of end product per acre annually, whereas mustard produces 459 kg of output per acre annually (AIS, 2017). Typically, mustard seeds make up between 28 and 32 percent oil, 28 to 36 percent proteins, 20 to 23 percent carbohydrate, and 12 percent saturated fats (Abul-Fadl *et al.*, 2011). As opposed to roughly 2400 kg ha^{-1} in comparable European countries, this nation's standard production for mustard stands merely 700 kg ha^{-1} (Alam *et al.*, 2015). This may result from uneven fertilization techniques or from improper application of fertilizers, lack of high yielding varieties, farmers apathy to using high quality seeds and not using improved technologies in mustard production. The first of the key macronutrients underlying the growth of mustard is nitrogen. Nitrogen fertilizer is being used much more in mustard crops over the past few decades since it serves as a necessary component of proteins, enzymes, and chlorophyll, all of which are vital for promoting advancement of crops in their vegetative phase (Kant et al., 2011). Moreover, it positively impacts yield and yield qualities as well as the number of productive branches per plant. It is estimated that 75% of urea fertilizer applied in traditional way is frequently lost through surface

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runoff, immobilization, leaching, denitrification, and volatilization, all of which accelerate environmental deterioration (Monira *et al.*, 2017). Conversely, overuse of N affects all stages of crop growth, including the growing up of seedlings, branching, canopy formation, and pod filling, and all of which can have a detrimental effect on crop output. A sophisticated collection of solutions will be needed to optimize crop productivity and nitrogen use efficiency in order to make improvements.

The practice of foliar fertilization involves applying liquid fertilizer to a plant's leaves such that the stomata and epidermis allow the nutrients to enter the plant's tissues (Fernández *et al.*, 2013). Many ways have tried by the researchers for evaluating the fertilizer use by improving fertilizer nutrient use efficiency and minimizing environmental impacts (Monira *et al.*, 2023). Occasionally, farmers experience insufficient urea supply throughout the sowing season. Under such circumstances, applying plant nutrients topically to crops is both cost-effective and efficient (Kahn *et al.,* 1993). Foliar fertilization, as opposed to soil usage, could be the most effective method for addressing nutrient shortages, particularly a focus on nitrogen lacking in conditions of drought (Banerjee et al., 2019). In addition to magic growth, urea applied topically may help mustard function better. It may lessen the need for chemical fertilizers in the soil, particularly nitrogenous fertilizers. Because of these circumstances, urea-saving investigation using foliar administration of liquid fertilizer (i.e., urea and magic growth) was conducted recently in an effort to improve mustard productivity.

1.1. Objectives of the study

The investigation was undertaken with the contemplation of the subsequent aims: (1) To evaluate the effect of foliar fertilization on growth performance of mustard, (2) To determine the foliar urea efficiency, (3) To assess the effect of liquid fertilizer on the yield and yield attributes of mustard, (4) To determine the optimum doses of liquid fertilizer, (5) To investigate the optimum timing of liquid fertilizer application, and (6) To evaluate the yield of mustard under stress condition.

2. Materials and Methods

2.1. Location and experimental site

The study was carried out from November 2021 to February 2022 at Rajshahi University's Agronomy Field Laboratory's experimental field, located at Rajshahi-6205, Bangladesh. The land in question is part of AEZ-11's high Ganges River Flood Plain. The earth's surface had a pH of 8.5 as well as comprised sandy loam. Approximately an average elevation of 71 feet over sea level, the location of the experiment is situated geographically at 24°22'36'N Latitude and 88°38'92" E Longitude. The area had good drainage, remained level with the ground, and was over the risk of flooding. The earth's composition exhibited an enrichment of 1.44% in organic matter, 0.09% in total nitrogen, 17.61 ppm in available phosphorous, 0.21 ppm of available potassium, 9.36 ppm of available sulfur, and 0.33 ppm of available zinc.

2.2. Climate

A brief growth season is suitable for the cool-season crops mustard. The crop that was used was produced during the winter, while there was considerably less daylight along with occasional unanticipated rain towards the start of the experimental period as well as throughout harvest. Over the course of the research timeframe, the field of study location saw a mean temperature of 21.62^{0}C, 70% humidity, 19.82 mm of rainfall, and lots of sunlight hours.

2.3. Chemical materials for liquid fertilizer

Urea: Urea was applied as per treatment.

Magic Growth: The liquid fertilizer known as Magic Growth (MG) was developed by Md. Arif Hossain Khan, Joint Director (Fertilizer Management Division). Bangladesh Agricultural Development Corporation (BADC), Rajshahi division which is prepared to obtain official acknowledgement. It contains different type of essential nutrients for plant growth and development. In this experiment, magic growth was used (4 g/L water) with urea as foliar spray.

2.4. Variety

BARI Sarisha-11 (*Brassica juncea*) was used for the experiment. The Bangladesh Agriculture Research Institute (BARI), located in Gazipur, generated this particular cultivar in 2001. The variety having drought and salt tolerant capacity with the yield of 2-2.5 t ha^{-1}.

2.5. Treatments

(1) T_1 = control. (2) T_2=60% of Recommended dose (RD) urea [50% of RD as soil application (SA)+10% of RD as foliar application (RA)]. (3) T_3=85% of Recommended dose (RD) urea [70% of RD as soil application (SA)+15% of RD as foliar application (FA)]. (4) T_4=100% of Recommended dose of urea (Traditional practice). (5) T_5=100% of Recommended dose of urea + 3% Magic growth as foliar application.

In case of T_2 and T_3 (except T_1 &T_4) magic growth was sprayed with urea i.e. liquid fertilizer. In case of T_5 only magic growth was sprayed. Liquid fertilizer was applied in each treatment as following- T_2 (For one spray) urea 5.00 kg ha^{-1} + magic growth 2.5 L ha^{-1} + water 500 L ha^{-1}, T_3 (For one Spray): urea 7.5 kg ha^{-1} + magic growth 2.5 L ha^{-1}+ water 500 L ha^{-1}, T_5 (For one spray): magic growth 1.5 L ha^{-1}+water 500 L ha^{-1}.

2.6. Fertilizer management

The following fertilizers were applied to the experimental plot: TSP (120 kg ha^{-1}), MOP (90 kg ha^{-1}), Gypsum (65 kg ha^{-1}), $ZnSO_4$ (45 kg ha^{-1}), and Boric acid (2 kg ha^{-1}). When finalizing land preparation, the entire TSP, MOP, $ZnSO_4$, and boric acid were applied. A treatment-based application of urea was made.

2.7. Application of liquid fertilizer

Liquid fertilizers were applied three times e.g. 1st at 25 DAS, 2nd at 35 DAS and 3rd at 45 DAS. Spray was done in afternoon to avoid leaf burning. Liquid fertilizer was sprayed as per experimental treatment.

2.8. Design and layout of the experiment

Three replications with a randomized complete block design were used to set up the trial. Every block was split up into randomly assigned units. Three times five, or fifteen, unit plots made up the complete hypothetical design, 8 m^2 was the basis for plot area. There was a 0.5 m plot to plot as well as a one m block to block spacing.

2.9. Land preparation

On November 1, 2021, an agricultural tractor was put to use to unveil the experimenting land. Three country ploughings were conducted, along with each was followed with a laddering operation to break up any clods and smooth the surface of the ground. The area had been cleared of weeds and stubble. On November 13, the field configuration was completed and the conclusion of getting the soil ready was finished.

2.10. Sowing of seeds

On November 14, 2021, the seeds were put down at a rate of 8 kilogram per hectare. Seeds were sown in a straight line with a 25×5 cm spacing between lines. Seeds had been encased with topsoil and gently pushed by hand following they had been sown.

2.11. Harvesting

In February 2022, at 102 DAS, the crops were taken out at 90% siliqua maturation. In order to gather information on yield parameters in general, five randomly chosen plants were taken from every single plot prior to the entire plot being harvested.

2.12. Data analysis technique

A wide range of variables were gathered prior to harvest, and following harvest, the data were tallied, processed, and arranged for statistical analysis. Analysis of Variance (ANOVA) was computed using the IBM SPSS software. By using Duncan's New Multiple Range Test (DMRT), the mean deviation was shown (Gomez and Gomez, 1984).

3. Results and Discussion

The goal of the current study was to determine how foliar application of liquid fertilizer affected mustard (BARI Sarisha-11) yield and yield contributing characteristics. The experiment's parameters were statistically examined, and the findings were reported. In this chapter, the experiment's results have been discussed in terms of parameters.

3.1. Plant height (cm)

Liquid fertilizer administration resulted in a notable variance in plant height at harvest (Table 1). In T_3 (144.40 cm), where 85% of the urea was put to the soil and 15% was applied topically to promote magic growth, the highest plant height was noted. When the recommended dosage of fertilizer was administered, this outcome was statistically comparable to T_4 (128.07 cm). In T_1 (110.15 cm), where fertilizer was not applied, the plant had a height that was record-lowest. The foliar treatment of several nutrients, either separately or in combination, was found to significantly improve the plant height of mustard (Laishram & Jaswal, 2023).

Table 1. Effect of liquid fertilizer on plant height (cm)

Treatment	Plant height (cm)			
	30 DAS	60 DAS	80 DAS	Harvest
T_1	12.000e	63.471d	104.09c	110.15c
T_2	31.828c	73.103bc	123.65b	127.30b

T_3	50.438a	82.762a	139.80a	144.40a
T_4	40.809b	79.398ab	124.23b	128.07b
T_5	23.055d	68.258cd	117.74b	121.95b
LS	0.01	0.01	0.01	0.01
CV (%)	11.42	6.03	3.72	3.56

Note: "In each column, treatment means followed by the same letter (e.g., a, b) are not significantly different from each other at the 5% level of significance according to Duncan's Multiple Range Test (DMRT). Means with different letters indicate significant differences. CV = Coefficient of Variation; DAS = Days After Sowing."

3.2. Number of primary branches plant^{-1}

Because foliar application was applied differently in each case, the total number of primary branches varied greatly (Table 2). T_3 (5.63) yielded the greatest primary branches plant^{-1}, which was statistically similar to T_4 (4.33). T_1 (2.27) yielded the lowest primary branches plant^{-1}. These findings are consistent with those of Khan *et al.* (1993), who observed that applying N, P, and S solutions topically increased the number of primary branches in mustard plants.

3.3. Number of secondary branches plant^{-1}

The total amount of auxiliary branches that the plant generated was significantly impacted by the application to the foliage of magic growth and urea (Table 2). T_4 (4.97) exhibited the fewest secondary branching each plant, whereas T_3 (7.50) exhibited the greatest number of secondary branches. The control treatment T_1 (3.73) in this instance produced the fewest secondary branches per plant. According to Khan *et al.* (1993), applying N. P. and S. solution topically increases the number of secondary branches in mustard plants.

3.4. Number of leaves plant^{-1}

The study found that liquid fertilizers had a substantial impact on the quantity of leaves. Table 2 indicates that among the treatments, T_3 had the greatest leaves plant^{-1} (17.53 and 23.18) for 30 and 60 DAS respectively, while the control treatment had the lowest (9.86 and 10.73) for the same duration. In T_4, there were the second-highest number of leaves 14.27 and 21.67 at 30 and 60 DAS respectively.

Table 2. Effect of liquid fertilizer on number of branches and leaves

Treatments	Branch number		Leaves number	
	30 DAS	60 DAS	30 DAS	60 DAS
T_1	9.857c	10.733c	2.267d	3.733b
T_2	13.333b	15.167b	3.183c	4.700b
T_3	17.533a	23.167a	5.633a	7.501a
T_4	14.267b	21.667a	4.333b	4.967b
T_5	10.133c	13.367bc	2.733cd	3.933b
LS	0.01	0.01	0.01	0.01
CV (%)	8.16	8.44	10.18	20.07

Note: "In each column, treatment means followed by the same letter (e.g., a, b) are not significantly different from each other at the 5% level of significance according to Duncan's Multiple Range Test (DMRT). Means with different letters indicate significant differences. CV = Coefficient of Variation; DAS = Days After Sowing."

3.5. Dry weight (g) plants^{-1}

The research investigation concluded that there is a strong correlation between plant dry matter accumulation and treatment. Taking into account the experimental data for various DAS, it was shown that, in comparison to other treatments, the T_3 had the most (1.30, 4.59, 6.55, 11.25 g at 30, 60, 80 and at harvest) building up of dry matter rate (Table 3). In comparison to the other treatments, T_1 displayed the lowest dry matter accumulation (0.79, 1.62, 3.82, 4.20 g at 30, 60, 80 and at harvest).

Table 3. Effect of liquid fertilizer on dry weight plants^{-1} (g)

Treatment	Dry weight plants^{-1} (g)			
	30 DAS	60 DAS	80 DAS	Harvest
T_1	0.795b	1.619c	3.822	4.206c
T_2	1.533a	3.627b	4.554	7.743b
T_3	1.303ab	4.590a	6.550	11.254a
T_4	1.277ab	3.768ab	5.720	10.165a
T_5	1.057ab	3.059b	5.895	6.956b
LS	0.01	0.01	NS	0.01
CV (%)	29.06	13.92	28.48	14.85

Note: "In each column, treatment means followed by the same letter (e.g., a, b) are not significantly different from each other at the 5% level of significance according to Duncan's Multiple Range Test (DMRT). Means with different letters indicate significant differences. NS = Non-significant; CV = Coefficient of Variation; DAS = Days After Sowing."

3.6. Number of pods plant^{-1}

When total pods plant^{-1} were taken into consideration, a statistically significant difference was calculated between the plants (Table 4). Of the treatments, T_3 produced the highest outcome (105.23), whereas T_1 produced the lowest (85.93).

3.7. Number of filled pods plant^{-1}

The total quantity of packed pods plants in this investigation varied significantly (Table 4). T_1 (71.33), which received no fertilizer possessed the least amount of completed pod plants, while T_3 (96.37) possessed the greatest. Siddiqui *et al.* (2008) have demonstrated the foliar application of the nitrogen, phosphorus, and sulfur solution enhances the number of completed pod plants in mustard, which is consistent with what we have found.

3.8. Pod length (cm)

Findings showed that applying doses of different foliar solutions produced a notable variance in pod length (Table 4). Under the treatment T_3, the optimal pod length was attained (6.96 cm). The second-longest pod (6.45 cm) belonged to T_4. In this study, T_1 had the shortest pod length (3.23 cm). The optimum amounts of pod length for rainfed mustard were obtained by foliar urea application combined with multiplex spray, as reported by Hu *et al*. (2010).

Table 4. Effect of liquid fertilizer on pods plant^{-1}, effective pods plant^{-1} and pod length (cm)

Treatment	Pods plant^{-1}	Effective pods plants^{-1}	Pod length (cm)
T_1	85.93d	71.333c	3.233c
T_2	96.27b	77.833b	4.812b
T_3	105.23a	96.367a	6.961a
T_4	100.47b	90.767a	6.450a
T_5	91.10c	81.800b	3.733c
LS	0.01	0.01	0.01
CV (%)	2.50	3.61	7.53

Note: "In each column, treatment means followed by the same letter (e.g., a, b) are not significantly different from each other at the 5% level of significance according to Duncan's Multiple Range Test (DMRT). Means with different letters indicate significant differences. CV = Coefficient of Variation."

3.9. Number of seeds siliqua^{-1}

The siliqua seed count of the study varied significantly (Tables 5). T_1 (11.46), the sample with the lowest result, did not use any fertilizer. When 15% of the recommended amount of urea was sprayed as a spray on the leaves in addition to magic growth, T_3 (17.82) yielded the most siliqua seeds. Ali & Kazemi (2010) offered evidence in favor of the comparable outcomes.

3.10. Number effective seeds silique^{-1}

Considering the foliar treatments, there was a substantial variation in the amount of effective seeds silique^{-1}. T_3 showed the highest (Table 5) figure (16.07), despite T_1 showed a reverse outcome (8.53) which was statistically considerable to T_5 (8.87).

Table 5. Effect of liquid fertilizer on no. of seeds siliqua^{-1}, no. effective seeds silique^{-1}

Treatment	Number of seeds siliqua^{-1}	Effective seeds pod^{-1}
T_1	11.457c	8.533c
T_2	13.490bc	11.667b
T_3	17.817a	16.067a
T_4	16.013ab	13.000b
T_5	11.517c	8.867c
LS	0.01	0.01
CV (%)	12.50	10.39

Note: "In each column, treatment means followed by the same letter (e.g., a, b) are not significantly different from each other at the 5% level of significance according to Duncan's Multiple Range Test (DMRT). Means with different letters indicate significant differences. CV = Coefficient of Variation."

3.11. 1000 -grains weight (g)

The 1000-grains weight varied significantly depending on the treatments used (Table 6). In terms of statistics, T_3's highest weight of 1000 grains (4.34 g) was comparable to T_4's (4.21 g). The control treatment, T_1 (2.36 g), had the lowest possible value for grain weight (1000). These results concur with those of Siddiqui *et al*. (2008), who discovered a considerable increase in grain weight (1000 grains) using foliar nutrition spray.

3.12. Grain yield (t ha^{-1})

The experiment's data demonstrated that foliar application of liquid fertilizer had a considerable impact on grain output (Table 6). Plot T_3 (2.34 t ha^{-1}) produced the highest seed production when crops were sprayed with 15% N as a recommended dose and 70% N as a basal dose. T_4 had the second-highest grain output (2.14 t ha^{-1}) when the required amount of urea was added to the soil. From a statistical perspective, both are equal. The least amount of grain produced by the T_1 control treatment (1.38 t ha^{-1}), which did not apply any fertilizer. The quantity of cultivars with main along with subsidiary branches, the number of full pod plants, and the 1000-grain weight of the corresponding treatment combinations were the main factors contributing to the enhanced grain output resulting from different treatment combinations. As a result of urea and other nutrients being applied topically, these results were comparable to those of Kumar, (2013).

3.13. Straw yield (t ha^{-1})

It came to light that the effects of various urea and magic growth applications on the straw yield of mustard were statistically significant (Tables 6). It was observed that treatment T_3 (4.07 t ha^{-1}) produced the highest straw yield, whereas the T_1 produced the lowest (1.91 t ha^{-1}) one. Kahn *et al. (*1993) reported a noteworthy increase in the straw yield of mustard sprayed with micronutrients and urea, which supported the same conclusion.

Table 6. Effect of liquid fertilizer on 1000 seed weight (g), grain and straw yield (t ha^{-1})

Treatment	1000 Seed weight (g)	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})
T_1	2.362c	1.383b	1.910b
T_2	2.987b	2.097a	3.567a
T_3	4.343a	2.343a	4.070a
T_4	4.210a	2.147a	4.013a
T_5	2.874b	1.647b	2.600b
LS	0.01	0.01	0.01
CV (%)	6.25	9.44	11.50

Note: "In each column, treatment means followed by the same letter (e.g., a, b) are not significantly different from each other at the 5% level of significance according to Duncan's Multiple Range Test (DMRT). Means with different letters indicate significant differences. CV = Coefficient of Variation."

3.14. Biological yield (t ha^{-1})

Various treatments showed significant effects regarding biological yield (Table 7). T_3 (6.35 t ha^{-1}) reported the largest biological output, which is statistically comparable to T_4 (6.22 t ha^{-1}). Furthermore, T_1 (3.29 t ha^{-1}) had the lowest biological yield, next to T_5 (4.25 t ha^{-1}). The identical results were discovered when N was sprayed on leaves by Ali & Kazemi (2010).

3.15. Harvest index (%)

There was no discernible variation in the harvest index during the trial (Table 7). T_4 had the least harvest index (34.50 %), in contrast to T_1 got the greatest index of harvest (41.95 %). T_2 shows the next-lowest outcome (37.15

%), while T_5 provided the second-best harvest index (38.88). Ali & Kazemi (2010) reported that foliar nitrogen sources had an extensive effect on the harvest index.

Table 7. Effect of liquid fertilizer on biological yield (t ha^{-1}) & harvest index (%)

Treatment	Biological yield (t ha^{-1})	Harvest index (%)
T_1	3.293d	41.953
T_2	5.663b	37.147
T_3	6.353a	37.239
T_4	6.220ab	34.498
T_5	4.247c	38.879
LS	0.01	NS
CV (%)	6.63	10.74

Note: "In each column, treatment means followed by the same letter (e.g., a, b) are not significantly different from each other at the 5% level of significance according to Duncan's Multiple Range Test (DMRT). Means with different letters indicate significant differences. NS = Non-significant; CV = Coefficient of Variation."

4. Conclusion

Bangladesh has very low N levels in most places due to extensive crop farming and poor handling of artificial fertilizers. Farmers that use inappropriate quantities of fertilizers on their farms usually ruin the natural environment as well as the wellness of the agricultural land. In addition to this, farmers in Bangladesh frequently experience a shortage of necessary fertilizers during the cropping seasons. Every year huge amount of urea is needed for crop production. Nonetheless, numerous studies revealed that crop response to N was the greatest of all nutrients in this country. In the present instance, foliar application of magic growth, a nitrogenous liquid fertilizer, combined with urea may improve crop quality. Actually, applying nitrogen topically to leaves improves the number of plants with pods, functional pods, and fully developed grains per plant; these factors raise grain weight therefore promise farmers an excellent return on their investment.

It was concluded based on the results of the exploration that, T_3 demonstrated the most pods per plant (105.23), number of effective pods (96.367), and number of seeds (16.07) among the treatments, all of which contributed to the highest grain output (2.34 t ha^{-1}). In comparison to traditional varieties, the research findings suggest that 15% of urea can be conserved through foliar application of liquid fertilizer (urea with magic growth), which increases seed production in the case of T_3 (N 70% of RD as SA + N 15% of RD as FA). If this approach can be made available to farmers, they will be able to deal with issues like drought, water logging, and urea shortages during the crop-growing season. Together with these, more research is necessary to determine the right amounts of liquid fertilizers for various agroecological zones and recently developed mustard cultivars, taking into account the harmful effects of liquid fertilizers on the environment and agroecosystem. In order to maximize environmental resilience and minimize input costs, this technique should integrate a number of sustainable crop production practices, such as crop rotation, zero tillage application, soil moisture conservation measures, etc. The determination of economic profitability has to be grounded in extensive research utilizing traditional approaches for applying fertilizer. To improve the efficacy and efficiency of nutrient management, assessment and ongoing monitoring should be carried out using contemporary technologies such as remote sensing. In order to begin offering this technology to farmers, extensive field trials demonstrating its cost-effectiveness and climate resilience would be necessary. If these are implemented wisely, producers will benefit from reduced cultivation costs and improved economic development for themselves despite ecological damage.

Declarations

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Competing Interests Statement

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Authors' contributions

All the authors show the heartiest responsibility to fulfil the manuscript.

Consent for publication

The authors declare that they consented to the publication of this study.

Availability of data and materials

Data will be provided by the corresponding author upon a reasonable request.

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References

Abul-Fadl, M.M., El-Badry, N., & Ammar, M.S. (2011). Nutritional and chemical evaluation for two different varieties of mustard seeds. World Applied Sciences Journal, 15(9): 1225–1233. https://www.idosi.org/wasj/wasj15(9)11/5.pdf.

AIS (Agricultural Information Service) (2017). Krishi Dairy 2017. Khamarbari, New Airport Road, Farmgate, Dhaka, Pages 17–179. https://ais.portal.gov.bd/site/page/9f25bfe1-a500-4fec-b160-b16d77e52b49/.

Alam, M.J., Ahmed, K.S., Mollah, M.R.A., Tareq, M.Z., & Alam, J. (2015). Effect of planting dates on the yield of mustard seed. International Journal of Applied Sciences and Biotechnology, 3(4): 651–654. https://doi.org/10.3126/ijasbt.v3i4.13974.

Ali, M.B., & Kazemi, H.P. (2010). Influence of nitrogen and Sulphur on yield and seed quality of three canola (*Brassica napus*) cultivars. J. Plant Nutri., 12(1): 20–30. https://doi.org/10.1080/01904161003728644.

Banerjee, P., Kumari, V.V., Nath, R., & Bandyopadhyay, P. (2019). Seed priming and foliar nutrition studies on relay grass pea after winter rice in lower Gangetic plain. J. Crop and Weed, 15(3): 72–78. https://dx.doi.org/10.22271/09746315.2019.v15.i3.1240.

BBS (Bangladesh Bureau of Statistics) (2023). Statistical Yearbook of Bangladesh 2022. Bangladesh Bureau of Statistics, Stat. Div., Minis. Plan., Govt. People's Repub. Bangladesh, Dhaka. https://bbs.portal.gov.bd/sites/default/files/files/bbs.portal.gov.bd/page/b2db8758_8497_412c_a9ec_6bb299f8b3ab/2023-06-26-09-19-2edf60824b00a7114d8a51ef5d8ddbce.pdf.

Fernández, V., & Brown, P.H. (2013). From plant surface to plant metabolism: the uncertain fate of foliar-applied nutrients. Frontiers in Plant Sci., 4: 1–5. https://doi.org/10.3389/fpls.2013.00289.

Gomez, K.A., & Gomez, A.A. (1984). Statistical Procedures for Agricultural Research (2 Eds.). John Wiley and Sons, New York, Chuckester, Brisbane, Toronto.

Hu, Y., Burucs, Z., & Schmidhalter, U. (2008). Effect of foliar fertilization application on the growth and mineral nutrient content of maize seedlings under drought and salinity. Soil Science and Plant Nutrition, 54(1): 133–141. https://doi.org/10.1111/j.1747-0765.2007.00224.x.

Kahn, N.A., Samiuilah, & Aziz, O. (1993). Response of mustard to seed treatment with pyridioxine and basal and foliar application of nitrogen and phosphorus. J. Plant Nutri., 16(9): 1651–1659. https://doi.org/10.1080/01904169309364640.

Kant, S., Bi, Y.M., & Rothstein, S.J. (2011). Understanding plant response to nitrogen limitation for the improvement of crop nitrogen use efficiency. J. Experimental Botany, 62(4): 1499–1509. https://doi.org/10.1093/jxb/erq297.

Kumar, S., Sairam, R.K., & Prabhu, K.V. (2013). Physiological traits for high temperature stress tolerance in Brassica juncea. Indian J. of Plant Physio., 18: 89–93. https://doi.org/10.1007/s40502-013-0015-1.

Laishram, D., & Jaswal, A. (2023). Interactive Effect of Foliar Application of Zinc, Iron, and Nitrogen on Growth and Productivity of Mustard (*Brassica juncea* L.). J. Food Chem. Nanotechnol., 9(S1): S100–S107. https://doi.org/10.17756/jfcn.2023-s1-014.

Monira, S., Hoque A., Sultana Z., Khan A.H., & Alam S. (2017). Urea reducing protocol for BRRI dhan28 production through foliar feeding for better yield in Barind Tract. Physiol. Ecol. & Environ. Sci., 8(1&2): 49–55.

Monira, S., Mohamud, M.A., Shifa, M.F., Biswas, B., & Hoque, M.A. (2023). Performance of Different Percentage of Urea as Foliar Fertilizer on Growth and Development of Rice (Rabi dhan1). Cognizance Journal of Multidisciplinary Studies, 3(8): 324–336. https://doi.org/10.47760/cognizance. 2023.v03i08.009.

Siddiqui, M.H., Mohammad, F., Khan, M.N., & Khan, M.M.A. (2008). Cumulative effect of soil and foliar application of nitrogen, phosphorus, and sulfur on growth, physico-biochemical parameters, yield attributes, and fatty acid composition in oil of erucic acid-free rapeseed-mustard genotypes. J. Plant Nutri., 31(7): 1284–1298. https://doi.org/10.1080/01904160802135068.