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Farmers' Use of Plant Growth Regulators Registered by the Department of Agricultural Extension in Bangladesh

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Abstract

This study examined farmers' use of plant growth regulators (PGRs) registered by the Department of Agricultural Extension (DAE) in Bangladesh and contribution of the selected characteristics of the farmers to their PGR use. Data were collected from 150 farmers of Shibganj upazila under Bogura district by using a pre-tested interview schedules during the period from November 2020 to March 2021. Results revealed that the majority (70.7%) of the farmers were medium users of Plant Growth Regulators (PGRs) followed by 15.3% low users and 14.0% high users. Based on descending order of Standardized PGR Use Index, 'Nitrobenzenes' ranked first followed by '4-Chlorophenoxyacetic acid (4-CPA), 'Gibberellic acid (GA_3)', 'Micronutrient supplementary as PGR' and 'Amino acid. Knowledge on PGRs, attitude towards use of PGRs, farming experience and awareness on use of PGRs of the farmers had significant contribution to their use of PGRs. Based on the findings it may be concluded that attempts should be taken by the concerned authority like DAE to increase judicious use of PGRs for better and time demanded crop management by providing necessary and authentic information on PGRs to the farmers.

Keywords: Bangladesh, Crop Management, Department of Agricultural Extension, Farmer Awareness, Plant Growth Regulators

Introduction

Plant Growth Regulators (PGRs) are organic compounds, other than important nutrients, that influence plant physiological processes by performing as bio-stimulants or bio-inhibitors. They control plant metabolism through their interaction

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with particular enzymes and enzyme systems and are effective at very little concentrations (Nahar et al., 2015). The significance of PGRs was first recognized in the 1930s and since then, both natural and synthetic compounds have been developed to change plant growth, morphology and development. Right now, PGRs are widely used to regulate crop growth patterns at various stages from germination to post-harvest preservation (Kumar et al., 2014).

In topical agriculture, particularly in horticulture, PGRs play a significant role in improving crop productivity and value (Gued et al., 2011). They are used to enhance fruit setting under critical environmental conditions, especially when temperature limits natural fertilization. PGRs influence a wide range of physiological processes, including rooting, fruiting, flowering, abscission, senescence and plant resistance to environmental stresses such as drought and temperature extremes (Gelmesa et al., 2010). Their useful applications include preventing lodging in cereals, reducing pre-harvest fruit drop, synchronizing crop maturity, accelerating harvest cycles and minimizing manual labor requirements.

Previous studies on major crops such as maize, wheat, soybean, rice and vegetables have shown that PGRs can vary important agronomic traits, including plant height, seed number, maturity period and lodging resistance (Gupta et al., 2015; Yadav et al., 2017; Verma et al., 2017; Dias, 2019). On the other hand, such physiological modifications do not always translate into better yields. Compared to horticultural crops, field crops generally give lower economic returns; consequently, the adoption and commercial development of PGRs in field crops have been comparatively limited. In Bangladesh, PGRs represent a small share of agrochemical use and are mostly applied for specific purposes such as sucker control, fruit setting, lodging control and ripening (ACI, 2018). Despite their relatively low toxicity to humans the use of synthetic PGRs is increasing and becoming an important component of modern agricultural practices in Bangladesh (Rostami, 2019).

Plant hormones also play an important role in seed germination and early plant development. Gibberellins for instance, are responsible for breaking seed dormancy (Verma et al., 2017). However, in most of the field crops, dormancy is short-lived and does not significantly hinder germination under normal conditions. Environmental factors, particularly low soil temperature may decrease germination rates and studies have shown that seed treatment with gibberellic acid can increase germination under such conditions (Hasanuzzaman et al., 2013). Nevertheless, in field conditions, poor seedling emergence caused by soil crusting, moisture stress or low temperature is habitually more critical than germination itself. While some indication suggests that PGRs may improve seedling growth and their effectiveness in enhancing emergence under stress conditions residue limited (Harms and Oplinger, 1988).

Roots development in field crops is mostly influenced by environmental factors such as soil temperature, moisture and nutrient availability rather than hormonal deficiencies (Dharmasiri et al., 2013). For example, root growth in maize is highly correlated with soil temperature and moisture conditions (Gupta et al., 2015). Therefore, although PGRs can influence particular physiological processes, their role in field crop establishment is relatively very poor compared to environmental factors.

Bangladesh is mainly an agricultural country where a large proportion of the population depends on agriculture for their livelihood (Sultana and Hasan, 2010). The sector plays a very important role in ensuring food security, reducing poverty and supporting economic development contributing around 14.23% to the national GDP with 10.66% derived from the crop sub-sector (Bangladesh Economic Review, 2018). However, the adoption of modern agricultural technologies has also resulted in environmental challenges due to the unnecessary use of agrochemicals (Ghosh and Hasan, 2013). Pesticides and fertilizers are generally used to control pests and increase crop yields, but their indiscriminate use poses severe risks to human health and environmental sustainability (Damalas and Eleftherohorinos, 2011; Delcour et al., 2015).

In Bangladesh, agrochemical use has increased substantially since the 1970s, often accompanied by excessive chemical fertilizer application which contributes to soil degradation and declining productivity (Hasan et al., 2005; Hasan et al., 2015). These challenges are mores ever in developing countries where farmers habitually lack of adequate knowledge, training and safety measures (Cohen, 2006; Khan, 2011; Stadlingeret al., 2011). Therefore, promoting the judicious use of agricultural inputs including PGRs is very much essential for achieving sustainable crop production.

Even with the increasing importance of PGRs, farmers often use them without adequate knowledge regarding their composition, recommended doses, timing, and purposes. In many cases, PGRs are used as substitutes for chemical fertilizers, leading to suboptimal results and economic losses (Lim et al., 2015). Although the Department of Agricultural Extension (DAE) provides recommendations for the proper and judicious use of PGRs but these guidelines are not always followed at the farm level.

Moreover, existing research in Bangladesh has largely focused on chemical fertilizers and pesticides, while studies on farmers' use of PGRs remain limited. Therefore, there is a need for experimental investigation into farmers' use, and constraints regarding PGRs in crop production. The study was undertaken to address this gap with the following objectives:

i) To determine the extent of use of PGRs by the farmers in tomato and potato cultivation;

ii) To assess and describe some selected characteristics of the PGRs using farmers; and

iii) To explore the factors (selected characteristics of the PGRs using farmers) influencing the use of PGRs.

Materials and methods

Locale of the Study

The study was conducted in ShibganjUpazila under Bogura district of Bangladesh, a region recognized for its demanding cultivation of vegetables, particularly tomato and potato and for the widespread use of Plant Growth Regulators (PGRs). Three unions, namely Shibganj Sadar, Atmul and Kichak were purposively selected based on the high popularity of PGRs use. From each union, one village Uthaly, Betgari and Patair was selected randomly to make sure representativeness.

The geographical position of the study area lies within the north-western part of Bangladesh. A location map of the study area (Figure-1) was organized to show the spatial distribution of the selected villages within Shibganj Upazila.

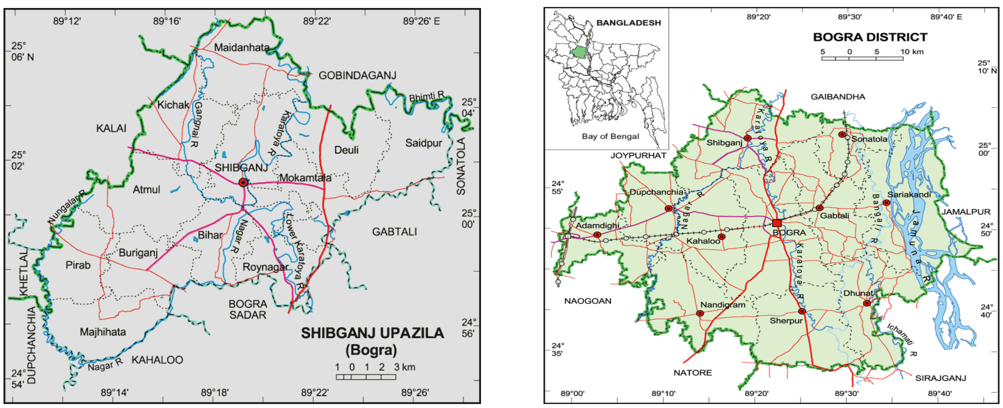

Fig. 1. Location map (Shibganj Upazila under Bogura District) of the study areas

Population and Sampling Procedure:

The population of the study comprised all farmers using PGRs in the selected villages. With the help of the Department of Agricultural Extension, a total of 598 PGR-using farmers were identified. A multistage sampling method was employed and 25% of the population (150 farmers) was selected proportionately using simple random sampling. An additional list of 15 farmers was maintained as reserve respondents to compensate for any non-response.

Methods of Data Collection

Data were collected during the period from November 2020 to March 2021 through an arrangement of quantitative and qualitative approaches. A structured interview schedule was used as the key instrument for data collection. The schedule included both open and closed ended questions to confine comprehensive information on farmers' characteristics and their use of Plant Growth Regulators (PGRs).

The interview schedule was pre-tested with 24 farmers of the study area excluded from the sample but included in the population to ensure simplicity, relevance and appropriateness of the questions. Essential modifications were made based on the pre-test results. Data were collected through face-to-face interviews conducted by the investigator with the assistance of Sub-Assistant Agriculture Officers (SAAOs).

To complement the survey data, 20 key informant interviews (KIIs) were conducted with agricultural officers; extension workers, input dealers and experienced farmers to identify commonly used Plant Growth Regulators (PGRs) and major issues related to their use.

Measurement of Dependent (Use of Plant Growth Regulators) Variable

Farmers' extent of use of Plant Growth Regulators (PGRs) registered by the Department of Agricultural Extension (DAE) was the dependent variable for the study. For measuring the extent of use of PGRs in tomato and potato cultivation items were selected after conducting Key Informants' Interview (KII). Twenty (20) key Informants were interviewed for this purpose which includes Upazila Agriculture Officer, Agriculture Extension Officer, Sub-Assistant Agriculture Officers, PGRs/pesticides/fertilizers dealers and progressive farmers of the study area. Key Informants were asked to indicate purpose wise chemical and trade name of available PGRs of the study area which were registered by the Department of Agricultural Extension (DAE). Thus, 13 types of PGRs were selected. Based on these 13 types of PGRs, all (13) items were selected after thorough consultation with the relevant experts and supervisory committee members. Necessary corrections and modifications were done based on pre-test results. Each of the 13 items were asked to the respondent PGRs using farmers to mention their extent of use of PGRs with 4 (four) alternative responses as never use (0/season), seldom use (1 time/season), occasionally use (2 times/season) and frequently use (3 times/ season) with assigning weights as 0, 1, 2, and 3 respectively. Score of PGR use of a farmer was computed by adding the weights against all the 13 items. Thus, the possible range of PGRs use score of the respondent farmers could be 0-39, where, '0' indicates no use and '39' indicating highest use of PGRs.

The PGRs Use Index for each of 13 items was computed by using the following formulae (Ali, 2009).

$$PUI = f_n \times 0 + f_s \times 1 + f_0 \times 2 + f_f \times 3$$

Where,

PUI = PGR use index

f_n= No. of farmers who never use PGR

f_x = No. of farmers who seldom use PGR

f_0 = No. farmers who occasionally use PGR

f_f = No. farmers who frequently use PGR

Thus, the range of PUI for a PGR could be 0- 450. Again, Standardized PGR Use Index (SPUI) of each of the 13 items was computed by using the following formulae (Ali, 2009).

$$SPUI = \frac{PUI of the items}{Highest possible PUI (i,e, \ 450)} \times \ 100$$

Thus, SPUI of the items could range from 0 – 100, where ‘0’ indicating no use and ‘100’ indicating highest use of PGR. Based on the descending of SPUI, rank order was made to compare the extent of use of selected 13 items of PGRs.

Measurement of independent variables:

Selected socio-economic and psychological characteristics of the farmers such as age, family size, farming experience, training exposure, communication exposure, organizational participation, farm decision-making ability, knowledge on PGR, awareness on using PGR, and attitude towards using PGR were considered as the independent variables of the study. Measurements of these independent variables are sated below:

Age: Age of the respondents was measured by counting the period of time in completed years from his/her birth at the time of interview. A score of one (1) was assigned for each year of his/her age as used by Hosen (2016).

Family size: Family size of a respondent was measured by calculating the actual number of family members of individuals including the respondent him/herself, his wife/her husband, children, brothers, sisters, parents and other persons who live and eat together and share their earnings during the time of interview.

Farming experience: Farming experience score of a respondent was determined by the year(s) of his/her involvement in agricultural operations.

Training exposure: Training exposure refers to the total number of days of training received by a farmer.

Communication exposure: Communication exposure of the farmers was measured by asking their level of communication exposure of each of the 15 selected communication media with four alternative responses as ‘regular’, ‘occasional’, ‘rare’ and ‘not at all’ contact by assigning scores as 3, 2, 1, and 0 respectively.

Organizational participation: Organizational participation of a respondent was measured as per the nature of his/her participation and period of involvement in six selected different organizations.

Organizational participation score = $\sum P \times D$

Where,

P = Participation score

D = Duration score

Participation score of 0, 1, 2, and 3 were assigned for o participation, participation as General Member, participation as Executive Member, and participation as Executive Officer respectively. Duration scores of 1, 2 and 3 were assigned for participation upto 3 years, 4-6 years and above 6 years respectively.

Farm decision making ability: Farm decision making ability of a respondent was measured by asking to indicate the extent of his/her decision-making ability in each of the five selected item by checking any one of the responses viz. 'decision making by him/herself, 'decision making with family members' and 'decision making with others outside the family' with corresponding scores of 3, 2 and 1 respectively.

Knowledge on PGRs: A total of 18 questions related to knowledge on PGRs were collected based on Bloom's (1956) taxonomy as devised by Anderson and Krathwohl (2001) by taking three from each of remembering, understanding, applying, analyzing, evaluating and creating. Each of the questions was open ended. The score values of the questions varied from 1 to 3 for correct answer. The possible range could be 0 – 36; 0 indicating no knowledge and '36' very good knowledge on PGRs.

Awareness on using PGRs: Awareness was measured according to the respondent's extent of consciousness on 10 selected items to use of PGRs. Items were collected after thorough consultation with relevant experts. It was measured by using four-point scales such as 'fully aware 'mostly aware' 'slightly aware' and 'not aware' with the score of 3, 2, 1 and 0 respectively.

Attitude towards using PGRs

A total of 10 statements (five positive and five negative) were selected after through consultation with relevant experts and literatures, screening in the light of 14 criteria suggested by Edwards (1957), and pre-testing. The selected statements were expressed in positive and negative views towards use of PGR. The nature of responses of the respondents to the statements were 'strongly agree', 'agree', 'undecided', 'disagree' and 'strongly disagree' and scores were assigned as 4, 3, 2, 1 and 0 respectively for the positive statements and the reverse scores were given for the negative statements.

Data Validity and Reliability

The validity of the research mechanism was ensured through consultation with subject matter experts including agricultural scientists, professors and extension personnel. The content validity of the interview schedule was further verified during the pre-testing stage and required adjustments were made to improve its accuracy and relevance.

Reliability of the measurement scales was assessed using the split-half method. The results indicated a satisfactory level of internal stability among the items used in measuring key variables, suggesting that the instrument was reliable for data collection.

Data Processing and Analysis

Collected data were coded, classified, tabulated and analyzed using Microsoft Excel and Statistical Package for the Social Sciences (SPSS). Descriptive statistics such as frequency, percentage, mean and standard deviation were used to summarize the data.

Inferential statistical technique like stepwise multiple regression analysis was conducted to determine the contribution of the selected characteristics of the farmers to their use of PGRs.

Results and Discussion

Extent of Use of Plant Growth Regulators

The extent of use of Plant Growth Regulators was considered as the dependent variable of the study. The observed PGR use score of the farmers ranged from 7 to 34 against a possible range of 0 to 39 with a mean of 19.83 and a standard deviation of 5.81 respectively. Based on their scores, farmers were categorized into three groups: low use (1–13), medium use (14–26) and high use (>26) as presented in Table 1.

Table 1. Distribution of the farmers based on their PGRs use

Categories	Range		Respondent		Mean	SD
	Possible	Observed	Number	Percent		
Low use (1-13)	0-39	7-34	23	15.3	19.83	5.81
Medium use (14-26)			106	70.7		
High use (above 26)			21	14.0		
Total			150	100		

Results revealed that the majority (70.7%) of the farmers were medium users of Plant Growth Regulators (PGRs) followed by 15.3% low users and 14.0% high users. Overall, 86% of the farmers belonged to low to medium user categories. This indicates that though awareness and adoption of PGRs exist in the study area, the amount of use remains moderate. This moderate adoption level may be attributed to limited technical knowledge, high input costs and inadequate extension services.

Bhuiyan et al. (2009) found that farmers did not use any chemicals and hormones for vegetables cultivation. But they found that PGR was used in banana cultivation. Majority (58%) of the banana farmers were the low users of PGR compared to 40.6% no users and only 1.4% medium to high users. The findings are partially similar with earlier studies, although the present study found an increasing trend in PGRs adoption.

Comparative Use of PGRs

To compare the use of 13 items of PGR, standardized PGR use Index (SPUI) were determined for each item. Among these 13 PGRs Nitrobenzene' ranked number one (1) based on its extent of use. According to descending order of SPUI of the 13 items of PGRs, rank order was made as shown in Table-2.

Table 2. SPUI of the Items with rank order

Sl. No.	Items of the PGRs use	Number of farmers based on extent of use (n= 150)				PGRs use index	SPUI (%)	Rank
		Never Use	Seldom Use	Occasionally Use	Frequently Use			
1.	Humic acid for stimulating seeds germination and improvement of soil structure	17	34	57	42	274	60.89	7
2.	Gibberellic acid (GA_3) for breaking seed dormancy and controlling unexpected growth of plant	15	13	55	67	324	72.00	3
3.	1-Naphthalene acetic acid (NAA) for root development of plant	21	46	58	25	237	52.67	8
4.	Alpha Naphthalene acetic acid (Alpha NAA) for root development and growth of plants.	23	78	38	11	187	41.56	9
5.	Indole-3-Acetic Acid (IAA) for regulating growth and developmental processes	49	61	33	7	148	32.89	10
6.	4-Chlorophenoxyacetic acid (4-CPA) for flower and fruit setting	12	9	42	87	354	78.69	2
7.	Tricontanol for fruit setting and yield of tomato/potato	140	10	0	0	10	2.22	13
8.	Combined formulated PGR (Humic acid + fulvic acid + potassium) for vegetative growth of plants	127	15	7	1	32	7.11	12
9.	Nitrobenzene for overall better production	1	3	31	115	410	91.11	1
10.	Sea weeds extract for growth and development of crops	11	33	74	32	277	61.56	6
11	Amino acid for increase flower and fruits	15	28	67	40	282	62.67	5
12.	Micronutrient supplements as PGR	16	18	54	62	312	69.33	4
13	Ethephon for fruit ripening	69	40	35	6	128	28.44	11

Based on descending order of Standardized PGR Use Index, ‘Nitrobenzenes’ ranked first followed by ‘4-Chlorophenoxyacetic acid (4-CPA), ‘Gibberellic acid (GA_3)’, ‘Micronutrient supplementary as PGR’ and ‘Amino acid. Positions of other PGRs are mentioned in table 2.

Selected Characteristics of PGR Using Farmers

The selected characteristics of the farmers like age, family size, farming experience, training exposure, communication exposure, organizational participation, farm decision-making ability, knowledge on PGR, awareness on using PGR, and attitude towards using PGR were considered as the independent variables of the study. Salient features of these selected characteristics are presented in Table 3.

Table 3. Salient features of selected characteristics of the farmers

Characteristics	Measuring Unit	Range		Mean	SD
		Possible	Observed		
Age	1 score for years	Unknown	24-73	41.40	10.57
Family size	1 score for 1 family member	Unknown	1-11	4.33	1.55
Farming experience	1 score for 1 years of experience	Unknown	5-55	22.27	11.43
Training exposure	1 score for 1 day training	Unknown	0-25	10.06	6.54
Communication exposure	Score	0-45	5-38	21.63	7.99
Organizational participation	Score	0-54	1-23	10.37	4.72
Farm decision making ability	Score	5-15	5-15	9.24	2.98
Knowledge on PGRs	Score	0-36	5-33	18.42	6.86
Awareness on using PGRs	Score	0-30	0-27	11.92	5.47
Attitude towards using PGRs	Score	0-40	7-33	20.35	6.15

Contribution of the Selected Characteristics of the Farmers to their Use of PGR

Use of PGRs was the dependent variable (Y) and 10 characteristics of the farmers like age (X_1), family size (X_2), farming experience (X_3), training exposure(X_4), communication exposure(X_5), organizational participation(X_6), farm decision-making ability(X_7), knowledge on PGR(X_8), awareness on using PGR(X_9), and attitude towards using PGR(X_{10}) were selected as the independent variables of this study.

Before conducting stepwise multiple regression, Pearson's Product Moment Correlation and Full model multiple regression analyses were conducted. It was observed that the full model regression results were misleading due to the existence of interrelationships among the independent variables. It was evident from correlation matrix showing the interrelationships among the independent variables and existence of contradiction in the sign of correlation coefficients and regression coefficients. Droper and Smith (1981) suggested running stepwise multiple regression analysis to insert variables in turn until the regression equation is satisfactory. Therefore, to avoid the misleading results due to the problem of multicollinearity and to determine the best explanatory variables, the method of stepwise multiple regressions was employed by involving the independent variables with the use of PGRs by the farmers. Ali (2009) used this method for their studies.

Result of stepwise multiple regression analysis showed that only (4) fourindependent variables namely knowledge on PGRs, attitude towards use of PGRs, farming experience, and awareness on use of PGRs enteredregression equation and exhibited contribution to the use of PGRs by the farmers. Results of stepwise multiple regression analysis has been presented in Table 4.

Table 4. Summary of the stepwise multiple regression analysis

Farmers' characteristics	Standardized partial 'b' Coefficient	Adjusted R^2	Increased R^2	Variation explained in percentage
Constant	6.689			
Knowledge on PGRs(X_8)	0.294	0.406	0.406	40.6
Attitude towards use of PGRs(X_{10})	0.226	0.454	0.048	04.8
Farming experience (X_3)	0.149	0.471	0.017	01.7
Awareness on use of PGRs (X_9)	0.200	0.483	0.012	01.2
Total			0.483	48.3

Multiple R = 0.705, R- square = 0.497, Adjusted R- square= 0.483, F- ratio= 35.766 at 0.000 level of significant.

The findings indicate that the whole model explained 48.3% of the total variation in use of PGR by the farmers. But since the standardized regression co-efficient of four (4) variables formed the equation and were significant, it might be assumed that whatever contribution was there, it was due to these four (4) variables like knowledge on PGRs (X_8), attitude towards use of PGRs (X_{10}), farming experience (X_3), and awareness on use of PGRs (X_9). Based on the result of step- wise regression analysis, the regression equation was formed as follows:

$Y= 6.689 + 0.294X_8+ 0.226X_{10}+ 0.149\ X_3+ 0.200X_9$

Results of stepwise multiple regression analysis indicated that the knowledge on PGRs of the farmers was the most important characteristic which strongly and positively contributed to their use of PGRs. Attitude towards use of PGRs, and farming experience had 2nd and 3rd significant positive contribution to use of PGRs. Awareness on use of PGRs had 4th positive significant contribution to use of PGR. Other characteristics of the farmers either had multicollinearity problems or had minimum contribution to use of PGR. Almost Similar observations were experienced by different researchers like Karim (1992).

Conclusion

Based on findings and their logical interpretations, following conclusions were drawn:

i. Overwhelming majority (86%) of the farmers had low to medium use of PGRs. Therefore, it may be concluded that there is scope to increase the judicious use of PGRs for better vegetables cultivation. Knowledge on PGRs, attitude towards use of PGRs, farming experience and awareness on using PGRs of the farmers had significant contribution to their use of PGRs. Therefore, it may be concluded and recommended that attempts should be taken by the concerned authority like DAE to increase judicious use of PGRs for better and time demanded crop management by providing necessary and authentic information on PGRs to the farmers.

ii. Farmers mainly used Nitrobenzene, 4-CPA, GA_3, Micronutrient supplements and Amino acid for overall better production, flower and fruit setting, breaking seed dormancy and controlling unexpected plant growth, micronutrient supplements as PGR respectively. Therefore, it is concluded and recommended that a clear-cut principles and guidelines for the use of all types of PGRs for different purposes like plant growth and development, seed germination and improvement of soil structure, root development and growth of plant for better yield at farm level should be developed by the concerned authority like Department of Agricultural Extension (DAE).

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