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Development and standardization of a knowledge test on fertilizer best management practices in major field crops

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ABSTRACT

The present study was carried out during 2023–2024 at Telangana to assess farmers' knowledge on FBMPs in major field crops. A total of six crops i.e. paddy (*Oryza sativa* L.), cotton (*Gossypium* spp.), maize (*Zea mays* L.), red gram [*Cajanus cajan* (L.) Millsp.], soybean [*Glycine max* (L.) Merr.] and Bengal gram (*Cicer arietinum* L.) were identified as the major field crops based on the average area under cultivation in both *kharif* and *rabi* seasons from 2018–2022 in Telangana state. For each crop, one district was randomly selected from the cultivating districts, resulting in six districts. To construct the knowledge test on FBMPs in major field crops, practices were identified by the author. A knowledge test was developed covering soil testing, nutrient management, weather monitoring, synthetic fertilizers, irrigation, manure, agronomic practices, soil reclamation, equipment handling, software use, and nutrient storage. The test initially included 90 items (multiple-choice, fill-in-the-blanks, reasoning, and image identification). After expert review, 87 items met the relevancy criteria (>70% Relevancy Percentage, >0.70 Relevancy Weightage, Mean Relevancy Score ≥3). Further statistical tests (item difficulty 20–80, discrimination index 0.2–0.8, significant point biserial correlations) refined the test to 44 items. The final test demonstrated high reliability (coefficient = 0.76) and strong content validity through expert validation, ensuring comprehensive coverage of FBMPs in major field crops.

Keywords: FBMPs, Fertilizer use, GAPs, Item analysis, Nutrient management

The Government of India launched the National Mission on Soil Health Card to promote soil test-based, balanced, and judicious fertilizer use nationwide (PIB 2021). This initiative is crucial as current fertilizer use practices reveal significant nutrient imbalances, particularly in nitrogen (N), phosphorus (P), and potassium (K) applications. In 2019, Telangana ranked first in NPK consumption per hectare, followed by Bihar, Haryana, Punjab, and Andhra Pradesh (Srinivasarao 2021). Therefore, such disparities raise concerns over soil degradation and declining crop productivity. Farmers face several challenges in adopting best nutrient management practices, including a lack of standardized recommendations, imbalanced fertilizer applications, and limited awareness of secondary and micronutrients. Farmers are struggling with limited knowledge of soil health cards, rising fertilizer costs, and determining appropriate fertilizer doses based on soil tests (Naruka *et al.* 2018). Limited adoption of soil testing and integrated nutrient management is further hindered by delays in soil test reports, financial constraints, and unawareness of acid soil reclamation (Mandal and Bharadwaj 2020).

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Without a systematic understanding of what farmers know, what they partially know and where their misconceptions lie, it becomes difficult to design effective extension programmes or policy interventions. A standardized knowledge test therefore serves as a scientific tool to quantify knowledge gaps, compare awareness levels across regions and crops and provide an evidence-based foundation for capacity-building initiatives. This makes the development of comprehensive knowledge test for FBMPs in major filed crops not only timely but also essential for promoting sustainable nutrient management.

According to Bloom *et al.* (1956) "Knowledge includes those behaviours and test situations which emphasize remembering, either by recognition or recall, of ideas, material and phenomena." This knowledge test aims to identify the gaps in farmers' understanding of FBMPs in major field crops. The test emphasizes on several practices that guide farmers toward sustainable fertilizer use. By identifying knowledge gaps, the test enables targeted educational interventions and region-specific recommendations based on soil health conditions. Improved awareness will lead to informed decisions on fertilizer use, improving soil fertility, productivity, and reducing environmental degradation. It can be used by researchers to track changes in farmers' awareness of FBMPs, assess the effectiveness of interventions and make

comparative studies on knowledge levels across regions, crops and socio-economic groups. The tool may also be adapted for other crops, regions and agricultural contexts with suitable modifications.

MATERIALS AND METHODS

The study was carried out during 2023–2024 at Telangana. A total of six crops i.e. paddy, cotton, maize, red gram, soybean, and Bengal gram were randomly selected based on average cultivation area in *kharif* and *rabi* from 2018–2022 in the state. For each crop, one district was randomly chosen among the cultivating districts. Hence, a total of six districts i.e. Nizamabad, Nalgonda, Warangal, Vikarabad, Sangareddy, and Adilabad were selected. To construct the knowledge test on FBMPs in major field crops, the practices identified by following a scientific procedure and relevancy test were used.

Construction and standardization of the knowledge test: The knowledge test development procedure was in alignment with the procedure followed by Chatterjee *et al.* (2020) and Muyal *et al.* (2022).

Collection of items: Initially, a total of 90 knowledge test items were initially developed based on identified FBMPs in major field crops through literature review and expert consultations. The test included multiple-choice, fill-in-the-blanks, one-word answers, reasoning and assertions, and image identification. Content covered soil testing, nutrient management, soil and weather monitoring, synthetic fertilizers, manure, specialty fertilizers such as controlled/ slow release, water soluble fertilizers, liquid fertilizers, micronutrient fertilizers, nano fertilizers etc., agronomic practices, soil reclamation, preventive measures, equipment handling, nutrient management software, and storage of nutrient sources. Items were revised for clarity, reworded for better alignment, and irrelevant ones removed. Expert recommendations were followed to ensure comprehensive coverage.

Relevancy test: After revisions, a panel of experts was tasked with reviewing the items to assess their relevance in determining the knowledge on FBMPs (Vijayan *et al.* 2023). A total of 100 experts with expertise in Agricultural Extension Education were asked to evaluate each item on a 5-point scale, ranging from "most relevant" to "least relevant". Scores of 5–1 was assigned for "most relevant," to "least relevant", respectively. Out of the 100 experts, 53 responded within a 50-day period. Based on their response, the Relevancy Percentage, Relevancy Weightage, and Mean Relevancy Scores were calculated. Practices with a mean relevancy score of three or higher were considered relevant. All items in Table 1 represent relevant items. Relevancy percentage (RP) is calculated based on the number of respondents who rated the statements as "most relevant" or "more relevant."

$$RP_i = \frac{\text{Frequency score of most relevant and more relevant for } i^{th} \text{ statement}}{\text{Number of judges rated the relevancy}} \times 100$$

Relevancy weightage (RW) represents the ratio of the actual score achieved to the highest possible score for each statement.

$$RW_i = \frac{\text{Actual scores obtained for } i^{th} \text{ statement}}{\text{Maximum possible scores obtainable for } i^{th} \text{ statement}}$$

Mean Relevance Score (MRS) is the ratio of the actual score given by each judge to the single statement to the number of experts who rated the relevancy.

$$MRS_i = \frac{\text{Actual scores obtained for } i^{th} \text{ statement}}{\text{Number of judges rated the relevancy}}$$

Item analysis: Item analysis ensures test validity and reliability by assessing difficulty and discrimination. A total of 78 items were retained after relevancy rating. These items were pretested on 60 farmers cultivating the selected crops (10 farmers from each crop) in the sampling area from 3 districts i.e. Adilabad (Cotton, Red gram, Soybean and Bengal gram), Nizamabad (Paddy) and Warangal (Maize). A score of 1 and 0 was given for correct and incorrect responses, respectively. Based up on the total scores obtained by the farmers, they were arranged into descending order and divided into six equal groups i.e. G1, G2, G3, G4, G5 and G6. The middle groups, G3 and G4 were eliminated, leaving 20 high-scoring groups G1 and G2 as well as 20 low-scoring groups G5 and G6 for item analysis. Their responses were used to calculate the Item Difficulty Index, Discrimination Index, and Point-Biserial Correlation. The results of item analysis were presented in Table 1. Item Difficulty index (Pi) measures the degree of difficulty in answering a particular question. It is defined as the percentage of farmers who answered the item correctly.

$$Pi = \frac{\text{Number of farmers correctly answered the } i^{th} \text{ item}}{\text{Total number of farmers to which } i^{th} \text{ item was administered}} \times 100$$

Discrimination index ($E^{1/3}$) is a quantitative approach that assesses how effectively a test item distinguishes between farmers who achieved high and low overall scores on the test. Bean (1953 as cited in Roy and Kadian 2016) defined "Discrimination index as the degree to which the single item separates the superior from the inferior individuals in the trait or group of traits being measured."

$$E^{1/3} = \frac{(S1+S2)-(S5+S6)}{\text{Total number of farmers in the sample of the item analysis}/3} \times 100$$

Where, S1, S2 S5 and S6 are the frequencies of correct answers in G1, G2, G5 and G6 groups, respectively. Point biserial correlation (rpbis) was calculated to determine the internal consistency of the items, specifically the relationship between the total score and the dichotomized response of each item. This process effectively measures the validity of an item by correlating the individual item scores from the preliminary knowledge test.

$$\text{rpbis} = \frac{\text{Mp} - \text{Mq}}{\text{sd}} \times \sqrt{\text{pq}}$$

Where, Mp, Mean of the total scores of the respondents who answered the item correctly; Mq, Mean of the total scores of the respondents who answered the item incorrectly; SD, Standard deviation of the entire sample; p, Proportion of the respondents giving correct answer to the item; q, Proportion of the respondents giving incorrect answer to the item.

Standardization of the knowledge test: The test was further standardized by testing and confirming its reliability and validity. Reliability of the knowledge test refers to an instrument's capacity to produce consistent results across different sets of measurements. According to Kerlinger (1986) "Reliability is the accuracy or precision of a measuring instrument". To test the reliability of knowledge test, split-half technique was used. The test was divided into two halves based on odd and even-numbered items and then administered to 30 respondents. This process generated two separate sets of scores. The Spearman Brown formula to measure co-efficient of reliability was employed to determine the relationship between these two sets of scores and it was calculated by following formula:

$$\text{Co-efficient of reliability} = \frac{2\ \text{roe}}{1 + \text{roe}}$$

Where, roe, Correlation score of odd and even items.
Correlation score of odd and even items

$$= \frac{\sum XY - \sum X.\sum Y}{n} \Big/ \sqrt{\left[\frac{\sum X^2 - (X)^2}{n}\right]\left[\frac{\sum Y^2 - (Y)^2}{n}\right]}$$

Validity of the knowledge test was assessed by examining how effectively it measures the intended construct. To evaluate the test's validity, a method called "content validity" was used, which involves determining how well the test's content aligns with the subject matter it is designed to assess.

RESULTS AND DISCUSSION

FBMPs were operationalized as a set of effective practices that encompass soil health and water management, plant nutrient management, agronomic practices, monitoring of weather, plant health, and machinery, proper handling and storage of nutrient sources and preventive measures, all aimed at protecting the environment while considering economic factors, availability, technical feasibility, implementation capacity, and effectiveness.

Initially collection of knowledge test items on FBMPs, editing of items was done. The items were then sent to experts for relevancy rating on 5-point continuum. Using the criteria mentioned in the relevancy test, all the knowledge test items were assessed for their relevance. Items that had a relevancy percentage greater than 70%, a relevancy weightage above 0.70, and a Mean Relevancy Score of 3 or higher were selected in the knowledge test for farmers on FBMPs in major field crops, while the remaining items were discarded. The results are consistent with procedure used by Vijayan *et al.* (2023). In the end, 78 items were retained and revised according to the expert suggestions provided.

The final knowledge test was designed to comprehensively assess knowledge of farmers on FBMPs in major field crops. Careful selection of test items was undertaken to ensure that they met specific psychometric criteria. The items included in the test had difficulty index values ranging from 20–80, indicating a balanced level of challenge for the participants. The results are consistent with procedure used by Bharti and Sagar (2022). Additionally, the discrimination index values of the selected items ranged between 0.2 and 0.8, reflecting the ability of each item to effectively differentiate between higher and lower levels of knowledge among the respondents. The results are consistent with procedure used by Chatterjee *et al.* (2020). Furthermore, the selected items demonstrated significant point biserial correlation at either the 1% or 5% level, supporting their validity in distinguishing correct and incorrect responses The results were consistent with procedure used by Marbaniang *et al.* (2021). The knowledge test encompassed 44 items with five distinct types: multiple-choice questions, fill-in-the-blanks, one-word answers, image identification, and reasoning and assertions. Hence, the maximum possible and minimum possible score for the instrument would be 44 and 0, respectively. These question formats were used to provide a comprehensive evaluation of the farmers' knowledge across different cognitive levels. Table 1 presents the selected items along with their respective Pi, $E^{1/3}$ and rpbis values. Care was taken to ensure that the final test items comprehensively covered the knowledge test for farmers on FBMPs in major field crops.

The resulting reliability coefficient was 0.76. The Co-efficient of reliability value was significant at the 1% level of significance. This high level of significance demonstrates that the test is highly reliable. Therefore, it can be confidently said that the test is dependable for measuring knowledge of farmers on FBMPs in major filed crops. The results were in conformity with Chandhana *et al.* (2022). Two methods namely content validity and point biserial correlation were employed for estimating the validity of knowledge test. The content validity was accomplished by consulting with experts in agricultural extension and soil health management to ensure that the test included all relevant items covering the full range of FBMPs in major filed crops. With input from these experts, the test was deemed to have strong content validity. Items with point biserial correlations of 1 or 5% level were included in the standard knowledge test which indicated the strong item validity. The results were in conformity with Marbaniang *et al.* (2021) and Thakur *et al.* (2024).

The knowledge test to assess the knowledge of farmers on FBMPs in major field crops encompassed 44 items with five distinct types: Multiple-choice questions, fill-in-the-blanks, one-word answers, image identification, and

Table 1 Item difficulty and discrimination indices values of the items and their selection in the knowledge test

Items	(Pi)	($E^{1/3}$)	(rpbis)	S
Which is the best time for soil sampling?	18.33	0.05	0.1508 ^{NS}	✗
In field crops, soil sample should be taken from the depth of _____ centimetres.	43.33	0.50	0.4285**	✓
What is the specific location within the field where the soil sample will be gathered from?	31.67	0.55	0.4100**	✓
The Soil Health Card contains crucial information on?	11.67	0.05	0.1324 ^{NS}	✗
What is the basis for application of fertilizers in the field?	45.00	0.35	0.4081**	✓
Which of the following methods contribute to improving soil fertility?	38.33	0.25	0.3475**	✓
Which of the following condition is required for fertilizer application concerning soil?	46.67	0.20	0.2020 ^{NS}	✗
Where can you access information regarding the weather in your area?	51.67	0.15	0.2261 ^{NS}	✗
Which of the following actions is advisable when rain is anticipated within 24 hours?	51.67	0.20	0.1077 ^{NS}	✗
What is the optimal time to irrigate the field in relation to fertilizer application?	36.67	0.20	0.3544**	✓
Which type of fertilizers should be used for alkaline soils?	16.67	0.00	0.1883 ^{NS}	✗
Assume if a plant is deficient in a single macro nutrient i.e Potassium, then what type of fertilizer should be preferred to overcome the deficiency?"	35.00	0.35	0.3945**	✓
How many nutrients are supplied by a straight fertilizer?	31.67	0.05	0.2142 ^{NS}	✗
How many nutrients are supplied by a complex fertilizer?	31.67	0.15	0.2496 ^{NS}	✗
What does this number on the fertilizer bag indicates?	25.00	0.40	0.3753**	✓
Which time of the day is most suitable for spraying of fertilizers?	31.67	0.25	0.4891**	✓
What is the optimal timing for applying nitrogenous fertilizer to the crop grown by you?	35.00	0.55	0.5742**	✓
What is the optimal timing for applying potassic fertilizer to the crop grown by you?	38.33	0.50	0.4807**	✓
What is the recommended method for applying phosphatic fertilizers to the crop grown by you?	33.33	0.30	0.4142**	✓
What is the recommended method for applying potassic fertilizers to the crop grown by you?	33.33	0.10	0.1099 ^{NS}	✗
Higher phosphatic fertilizer use efficiency can be obtained through _____ method of fertilizer application.	26.67	0.10	0.2153 ^{NS}	✗
How does the application of nitrogenous fertilizers differ for light soil and heavy soil?	36.67	0.05	0.2300 ^{NS}	✗
What is the recommended rate for applying nitrogenous fertilizers to the crop grown by you?	41.67	0.50	0.4204**	✓
Which irrigation system has higher efficiency for fertigation?	40.00	0.30	0.2264 ^{NS}	✗
Can you name any fertilizer that can be used for fertigation?	28.33	0.35	0.5179**	✓
If it is recommended to you to apply 4 bags urea, 2 bags SSP and 2 bags MOP per acre but you are able to purchase only 1 bag MOP instead of two? Then how will you balance the fertilizer application?	35.00	0.40	0.3695**	✓
Which is the appropriate time for application of FYM?	33.33	0.35	0.5039**	✓
Assertion: It is recommended to apply organic manures along with chemical fertilizers. Reason: Organic manures improve soil physical properties such as structure, water holding capacity, and nutrient availability.	28.33	0.55	0.5655**	✓
What is the recommended quantity of vermicompost/ha?	30.00	0.05	0.1855 ^{NS}	✗
The plants used for green leaf manuring are _____	15.00	0.05	0.2125 ^{NS}	✗
What is the ideal stage of crop growth for incorporating green manure into the soil?	8.33	0.05	0.1813 ^{NS}	✗
How much gap must be maintained between incorporation of green manure and sowing of main crop?	38.33	0.10	0.0917 ^{NS}	✗
Which of the following methods is not advised in the management of crop residues? i. Burning them in the field; ii. Burning them outside the field; iii. Incorporating into soil; iv. Recycling them for composting	48.33	0.35	0.4006**	✓

Contd.

Table 1 (*Continued*)

Items	(Pi)	($E^{1/3}$)	(rpbis)	S
Which of the following methods is recommended for the application of zinc and phosphatic fertilizers?	43.33	0.25	0.3250*	✓
Application of phosphorus containing complex fertilizers for top dressing should be_____?	36.67	0.45	0.4907**	✓
Application of phosphorus containing complex fertilizers after 40 DAS should be_____?	38.33	0.20	0.0741 ^{NS}	✗
Name two micro nutrient fertilizers?	31.67	0.60	0.5904**	✓
Which is the recommended method for application of ZnSO4 in the crop grown by you?	38.33	0.40	0.5133**	✓
Which method is recommended for the application of biofertilizers?	43.33	0.45	0.4880**	✓
Which biofertilizers are suitable for application in the crop grown by you?	26.67	0.35	0.4153**	✓
Which biofertilizers are suitable for application in leguminous crops?	38.33	0.05	0.1516 ^{NS}	✗
Which biofertilizers are suitable for application in non-leguminous crops (other than Paddy)?	36.67	0.05	0.2442 ^{NS}	✗
Blue-green algae (BGA) and Azolla biofertilizer are used in which crop?	28.33	0.20	0.2178 ^{NS}	✗
What is the recommended method soil application of Neem Coated Urea in the crop grown by you?	38.33	0.45	0.5606**	✓
Which method is recommended for application of Neem Coated Urea in the crop grown by you?	36.67	0.05	0.0997 ^{NS}	✗
What is the recommended dose for the application of nano urea in field crops?	40.00	0.60	0.6258**	✓
By which method nano DAP can be applied?	8.33	0.05	0.1813 ^{NS}	✗
Which of the following option is recommended for intercropping?	40.00	0.40	0.3776**	✓
Which of the following option is recommended for crop rotation?	38.33	0.50	0.5752**	✓
Which crops can be grown in the off season to trap and release applied nutrients for next year's crop?	35.00	0.10	0.0487 ^{NS}	✗
Which varieties are recommended for maximizing crop productivity while minimizing fertilizer waste?	41.67	0.05	0.2167 ^{NS}	✗
Which practice can be adopted to reduce nutrient losses, conserve soil moisture, and suppress weed growth?	35.00	0.50	0.5128**	✓
Colour charts can be used to _____	25.00	0.50	0.5202**	✓
Identify the nutrient deficiency shown in the photograph?	23.33	0.30	0.4747**	✓
Identify the nutrient deficiency shown in the photograph?	28.33	0.10	0.0789 ^{NS}	✗
Which nitrogen-fixing trees or shrubs are utilized in agroforestry systems to naturally improve soil fertility?	8.33	0.05	0.1813 ^{NS}	✗
Which of the following practices are not considered to be beneficial for soil health?	26.67	0.35	0.4227**	✓
Which of the following practice is effective to conserve soil moisture and suppress weed growth?	30.00	0.10	0.1961 ^{NS}	✗
Which of the following practice can be followed to prevent nutrient loss through erosion?	36.67	0.40	0.4260**	✓
How pesticides are applied with fertilizers?	38.33	0.35	0.3224*	✓
How nutrients should be applied under deficit moisture condition?	38.33	0.45	0.3439**	✓
What management practice should be followed in waterlogged condition during cultivation of crop?	36.67	0.25	0.3830**	✓
What management practice should be followed under dry spell?	33.33	0.55	0.5616**	✓
What is the primary purpose of using Personal Protective Equipment (PPE) kits while applying fertilizers on the farm?	23.33	0.05	0.2533 ^{NS}	✗
What components make up a PPE kit that should be worn during fertilizer application?	35.00	0.30	0.4302**	✓
Which management practice should be followed if the soil is saline?	8.33	0.05	0.1813 ^{NS}	✗
How many day(s) water is retained in the field for saline soil reclamation?	11.67	0.05	0.1324 ^{NS}	✗

Contd.

Table 1 (*Concluded*)

Items	(Pi)	($E^{1/3}$)	(rpbis)	S
What is the required frequency of flooding for saline soil reclamation?	18.33	0.05	0.1508 ^{NS}	✗
What management practice should be followed if soil is alkaline?	40.00	0.55	0.4647**	✓
How many years of time it will take for reclamation of problematic soil?	11.67	0.15	0.1929 ^{NS}	✗
How much fertilizers are required in saline/alkali soils after reclamation?	35.00	0.35	0.3837**	✓
Why is it necessary to inspect fertilizer application equipment annually?	33.33	0.25	0.4787**	✓
Name any nutrient management software or apps to track and optimize fertilizer applications	40.00	0.40	0.4066**	✓
When managing fertilizer inventory, which fertilizers should be used first to avoid waste and ensure effectiveness?	41.67	0.30	0.3000*	✓
What is the recommended practice for storing fertilizers to prevent potential groundwater contamination in case of spills or leaks?	40.00	0.05	0.1372 ^{NS}	✗
What is the recommended practice for storing fertilizers to ensure their quality and effectiveness?	38.33	0.45	0.3941**	✓
What is the recommended practice for storing fertilizers to ensure proper identification and prevent confusion on the farm?	31.67	0.15	0.0946 ^{NS}	✗
Which of the following is the better practice for storing fertilizers?	31.67	0.65	0.5904**	✓

NS, Non Significant; *Significant at 1% level; **Significant at 5% level; S, Decision on selection of item; ✓, selected; ✗, rejected.

reasoning and assertions. The knowledge test possesses high reliability and validity. Given the increasing concerns regarding the efficient and safe use of fertilizers, it is crucial to understand the level of knowledge among farmers about these practices. This test can be used to evaluate farmers' knowledge beyond the study area (for other crops) with appropriate adjustments. The results of the test will provide valuable insights into farmers' understanding of FBMPs, enabling extension services to better tailor their educational programs. Farmers who demonstrated a strong understanding of FBMPs can be supported through advanced training and capacity-building initiatives, while those with less knowledge may require additional resources and targeted outreach.

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