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# MEASURING FARMERS KNOWLEDGE ON CROP DIVERSIFICATION: A STANDARDIZED APPROACH

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**ABSTRACT**

This study aimed to develop and standardize a knowledge test to assess farmers' understanding of crop diversification. The test content was structured around key domains including the concept of crop diversification, types of cropping systems, associated benefits and limitations, local practices, and government schemes. Initial items were generated through expert consultations and literature review. After pretesting, item analysis was conducted using difficulty index, discrimination index, and point biserial correlation. Items with difficulty indices between 30 and 80, discrimination indices above 0.30, and statistically significant point biserial correlations at 1% or 5% significance levels were retained. From the initial 60 items, 30 were selected for the final version of the test. This standardized tool can be effectively utilized in extension programs, baseline assessments, and policy planning to address knowledge gaps among farmers.
***Keywords*****:** crop diversification, knowledge test, standardization, item analysis, farmers' awareness.

## Introduction

Agriculture remains the cornerstone of the Indian economy and continues to support the livelihoods of a significant portion of the population. However, it has historically been characterized by low income generation, particularly in comparison to industrial and service sectors. In recent years, crop diversification has emerged as a vital strategy to enhance agricultural sustainability, bolster resilience, and secure food and nutritional needs.

Crop diversification involves cultivating a broader array of crops either within a season or across multiple seasons, moving away from the risks associated with monoculture systems (Pingali, 2012; FAO, 2021; Thapa & Gaiha, 2020). It includes both horizontal diversification (growing more types of crops) and vertical diversification (value addition through processing). This practice enhances resource-use efficiency, mitigates climate risks, and stabilizes farmers' incomes (FAO, 2018; Dey *et al*., 2021).

In semi-arid regions such as Rayalaseema, Andhra Pradesh, where erratic rainfall and poor soil conditions prevail, crop diversification is both an economic necessity and an ecological imperative (Rao *et al*., 2020; Reddy & Mishra, 2020). Despite its recognized benefits, adoption rates remain uneven due to factors such as socio-economic constraints, limited market access, institutional inefficiencies, and inadequate knowledge (Ali & Byerlee, 2002; Singh *et al*., 2022).

Assessing the knowledge levels of farmers regarding crop diversification is crucial for designing effective extension strategies and interventions. Yet, a major gap exists in the availability of standardized, reliable, and valid tools for such assessments (Sharma *et al*., 2020). Knowledge, being a multifaceted construct involving information, conceptual understanding, application, and awareness (Bloom, 1956; Anderson & Krathwohl, 2001), must be measured using robust testing instruments.

The present study was undertaken to construct and standardize a knowledge test specifically designed to assess farmers' understanding of crop diversification. The developed tool aims to serve as a diagnostic instrument for identifying knowledge gaps and informing targeted capacity-building initiatives.

## Materials and Methods

### Locale of the study

In India, crop diversification has emerged as a sustainable approach to address multiple agronomic and economic challenges, especially in rainfed areas like the Rayalaseema region of Andhra Pradesh. This region is marked by irregular rainfall patterns, frequent droughts, and deteriorating soil quality, all of which undermine the productivity and viability of monocropping systems. In this context, crop diversification is recognized as a practical strategy to boost farm income, enhance resource efficiency, and mitigate production-related risks (Rao *et al.*, 2020). Despite its potential, the adoption of diversified cropping systems in Rayalaseema varies significantly across districts, influenced by diverse socio-economic and agro-climatic conditions. Given these factors, Rayalaseema was purposively chosen as the study area to assess farmers' knowledge of crop diversification.

To develop the knowledge test, a pilot study was conducted by randomly selecting sixty non-sample farmers from Puttaparthi village in the Sri Sathya Sai district. The purpose of this pretest was to evaluate the initial set of items in terms of clarity, relevance, and appropriate difficulty level. Recognizing the critical economic implications of crop diversification, a structured methodology was followed to construct and standardize a reliable knowledge test, as detailed below.

### Collection and framing of items

On perusal of relevant literature and discussion with the experts in extension & crop sciences, a total of 65 items were collected focusing on various aspects of crop diversification including the concepts, types, benefits and limitations, practices followed in the study area and also the government support schemes. Experts in the field of Agronomy and Agricultural Extension Education, S.V. Agricultural College, Tirupati were consulted for screening, fine tuning and editing of the items.

### Selection Criteria for Items

Items were selected based on the following criteria:

- Encouraged critical thinking rather than rote memorization.
- Demonstrated the ability to differentiate between well-informed and less-informed respondents.
- Represented all key aspects of crop diversification.

After initial screening, 60 items were retained for pretesting.

### i. Form of items

Items were framed in objective formats such as multiple choice, fill-in-the-blank, true/false, and yes/no. These formats were chosen to minimize bias and enable easy scoring.

### ii. Pre-testing

To ensure clarity, relevance, and an appropriate level of difficulty, the selected items were subjected to a pre-test involving 60 farmers who were purposefully chosen from outside the main study sample. This was done to eliminate any potential bias and ensure that the test items were evaluated independently of the primary research group. The pretesting process helped assess how well the items were understood by respondents, identify any ambiguous questions, and determine their appropriateness in measuring the intended knowledge areas.

### Item analysis

To evaluate the quality and effectiveness of the test items, item analysis was conducted using three key indices: the difficulty index, discrimination index, and point biserial correlation coefficient.

- The difficulty index measures how challenging an item is by calculating the percentage of respondents who answered it correctly. This helps determine whether an item is too easy, too difficult, or appropriately balanced in difficulty.
- The discrimination index assesses how well an item distinguishes between high-performing and low-performing respondents. A higher discrimination value indicates that the item effectively differentiates knowledgeable individuals from those with lower understanding.
- The point biserial correlation coefficient ($r_{pbi}$) evaluates the internal consistency of each item by examining the relationship between the score on a specific item and the total test score. It reflects how well an individual item aligns with the overall construct being measured namely, knowledge on crop diversification.

These indices together provide a comprehensive assessment of each item's quality, guiding the selection of the most reliable and valid items for the final knowledge test.

### Difficulty index (P)

To conduct the item analysis, 60 selected items related to crop diversification were administered to a group of 60 respondents who were not part of the main sample. Each response was scored as one (1) for a correct answer and zero (0) for an incorrect one. Based on their total scores, all 60 respondents were ranked from highest to lowest and subsequently divide into six equal groups: G1, G2, G3, G4, G5, and G6, each comprising 10 individuals.

For analytical purposes, the middle two groups (G3 and G4) were excluded to enhance the contrast between high and low performers. The item difficulty index was calculated as the percentage of respondents who correctly answered each item. Items with difficulty index values (p-values) ranging between 30% and 70% were deemed appropriate for inclusion in the final knowledge test. The computed values for each item's difficulty level are summarized in Table 2.

$$Difficulty\ Index = \frac{Total\ number\ of\ correct\ answers}{Total\ number\ of\ respondents}$$

### Discrimination Index ($E^{1/3}$)

The frequencies of correct responses in groups G1, G2, G5, and G6 are denoted as S1, S2, S5, and S6, respectively. The total number of respondents involved in the item analysis was 60, represented by 'N'. The discrimination index, which ranges from 0 to 1, was used to determine how effectively each item differentiated between more knowledgeable and less knowledgeable respondents. Items with discrimination index values between 0.30 and 0.70 were considered suitable for inclusion in the final knowledge test. This index serves as the second criterion for item selection, assessing whether each item successfully distinguishes well-informed individuals from those with limited understanding of the topic. The discrimination index, referred to as '$E^{1/3}$', was calculated using a specific formula. The results of this analysis are presented in Table 1.

$$E^{1/3} = \{(S1 + S2) - (S5 + S6)\}/(N/3)$$

Where, S1, S2, S5 and S6 are frequencies of correct answers from groups G1, G2, G5 and G6 respectively and N denotes the total sample size for item analysis. The discrimination index varies from 0 to 1.

### Point biserial correlation ($r_{pbi}$)

The primary purpose of calculating the point biserial correlation coefficient ($r_{pbi}$) was to assess the internal consistency of each test item. Specifically, it measures the relationship between a respondent's total score and their response (correct or incorrect) to a particular item. This analysis helps evaluate the construct validity of each item by examining how well it aligns with the overall test performance.

The point biserial correlation is particularly suited for analyzing items with dichotomous outcomes (i.e., correct vs. incorrect answers). In addition to face validity, construct validity was assessed using this method. An $r_{pbi}$ value was computed for every item in the preliminary knowledge test. While an $r_{pbi}$ value of 0.15 is generally acceptable, a value of 0.25 or higher is considered preferable, indicating stronger internal consistency. The formula used to calculate the $r_{pbi}$ value is provided below.

$$r_{pbi} = \frac{(\overline{y_1} - \overline{y_2}).\sqrt{pq}}{S_y}$$

### Selection of the items

Items that satisfied all of the following criteria were selected for inclusion in the final knowledge test: a difficulty index (P) ranging between 0.30 and 0.80, a discrimination index greater than 0.30, and a point biserial correlation coefficient that was statistically significant at either the 5% or 1% level. Based on these criteria, 30 items out of the initial 60 were retained for the finalized version of the knowledge test.

### Reliability of knowledge test

To assess the reliability of the test, the split-half method was used, as it is considered more robust compared to other reliability testing approaches. One key advantage of this method is that it allows for the collection of all necessary data in a single administration, thereby minimizing variability that might arise from conducting multiple test sessions (Garret, 2007). In this procedure, the test items were first randomized and then divided into two equal halves, one consisting of odd-numbered items and the other of even-numbered items. The correlation coefficient between the scores of the two halves was then calculated, yielding a value of 0.868, which was statistically significant at the 1% level. This high correlation indicates that the knowledge test possesses strong internal reliability.

**Table 1:** Correlation coefficient value in split-half method

| | | Odd item | Even item |
|---|---|---|---|
| **Odd Item** | Pearson Correlation | 1 | **0.868**** |
| | Sig. (2-tailed) | | 0.000 |
| | N | 60 | 60 |
| **Even Item** | Pearson Correlation | **0.868**** | 1 |
| | Sig. (2-tailed) | 0.000 | |
| | N | 60 | 60 |

### Validity of the test items

In scale development, content validity is typically emphasized as a primary criterion (Lal *et al*., 2014; Lal *et al*., 2015). More recently, Lynn's approach has been adopted to compute the scale-content validity index (Lal *et al*., 2016). In this study, the validity of the knowledge test was established through both content validity and construct validity.

Construct validity was assessed using the point biserial correlation coefficient, which determines the extent to which individual items correlate with the overall test performance. Regarding content validity, Anastasi (1968) describes it as a systematic evaluation of whether the test content adequately represents the entire domain of the concept being measured in this case, farmers' knowledge on crop diversification. Accordingly, a comprehensive set of statements covering various dimensions of crop diversification was compiled. These statements were further examined using difficulty and discrimination indices to finalize the most suitable items. Based on this rigorous process, the test can be considered to possess strong content validity.

**Table 2:** Item difficulty, discrimination indices and point biserial correlation values for items of knowledge test

| Question No. | Questions | Difficulty Index (P) | Discrimination Index ($E^{1/3}$) | Point Biserial Correlation ($r_{pbi}$) | Selected/ Rejected |
|---|---|---|---|---|---|
| Q1 | Which of the following is a major benefit of crop diversification?<br>a) Increased water usage<br>b) Monoculture sustainability<br>c) Risk reduction<br>d) Pest resistance loss | 0.517 | 0.625 | 0.5** | S |
| Q2 | In crop rotation, legumes are beneficial because:<br>a) They fix nitrogen<br>b) They consume more fertilizer<br>c) They attract pests<br>d) They deplete soil fertility | 0.55 | 0.5 | 0.391 | R |
| Q3 | Which crop combination is an example of recommended intercropping?<br>a) Groundnut + Castor<br>b) Paddy + Sugarcane<br>c) Tomato + Brinjal<br>d) Onion + Garlic | 0.45 | 0.688 | 0.552** | S |
| Q4 | Millets are promoted under crop diversification due to:<br>a) High water requirement<br>b) Climate resilience<br>c) High pesticide usage<br>d) Low yield | 0.383 | 0.688 | 0.621** | S |
| Q5 | Which of these is NOT a benefit of crop diversification?<br>a) Enhanced income<br>b) Employment generation<br>c) Soil degradation<br>d) Pest control | 0.567 | 0.438 | 0.446 | R |
| Q6 | In Rayalaseema, which millet is traditionally grown as part of diversified farming?<br>a) Wheat<br>b) Sorghum<br>c) Maize<br>d) Barley | 0.433 | 0.562 | 0.38** | S |
| Q7 | Crop diversification helps farmers mainly to:<br>a) Increase labor costs<br>b) Depend on one crop<br>c) Manage climatic risks<br>d) Reduce market options | 0.517 | 0.562 | 0.399* | S |
| Q8 | Which of these is considered a commercial crop?<br>a) Redgram<br>b) Cotton<br>c) Sorghum<br>d) Foxtail millet | 0.35 | 0.5 | 0.471** | R |

| | | | | | |
|---|---|---|---|---|---|
| Q9 | Which farming practice involves growing two or more crops in the same field simultaneously?<br>a) Crop rotation<br>b) Intercropping<br>c) Relay cropping<br>d) Monocropping | 0.567 | 0.625 | 0.428* | S |
| Q10 | Crop rotation helps in:<br>a) Monoculture promotion<br>b) Pest and disease buildup<br>c) Soil fertility improvement<br>d) Soil erosion | 0.45 | 0.562 | 0.405** | S |
| Q11 | Intercropping benefits include:<br>a) Competition between crops<br>b) Wastage of resources<br>c) Efficient resource use<br>d) Higher pest attack | 0.667 | 0.562 | 0.522** | S |
| Q12 | Which crop is best suited for dryland diversification in Rayalaseema?<br>a) Rice<br>b) Banana<br>c) Pearl millet<br>d) Sugarcane | 0.45 | 0.312 | 0.298 | R |
| Q13 | Which oilseed crop is commonly grown in Kurnool under diversification?<br>a) Mustard<br>b) Sunflower<br>c) Groundnut<br>d) Soybean | 0.6 | 0.562 | 0.409* | S |
| Q14 | Which system involves growing short-duration crops between main crops?<br>a) Mixed cropping<br>b) Relay cropping<br>c) Sequential cropping<br>d) Fallowing | 0.55 | 0.75 | 0.581* | S |
| Q15 | Which crop combination is an example of mixed cropping?<br>a) Groundnut + Redgram<br>b) Maize + Bengalgram<br>c) Paddy + Wheat<br>d) Jowar + Cotton | 0.533 | 0.5 | 0.413 | R |
| Q16 | Organic manures are important in diversified farming because they:<br>a) Kill beneficial microbes<br>b) Improve soil health<br>c) Increase pesticide demand<br>d) Cause pollution | 0.583 | 0.375 | 0.346 | R |
| Q17 | Diversification into horticulture is beneficial due to:<br>a) Low market demand<br>b) High perishability<br>c) Higher returns<br>d) Labor unavailability | 0.567 | 0.375 | 0.336 | R |
| Q18 | Crop diversification helps reduce:<br>a) Biodiversity<br>b) Pest resistance<br>c) Financial risk<br>d) Input costs | 0.55 | 0.438 | 0.375 | R |
| Q19 | Which government scheme promotes crop diversification?<br>a) RKVY<br>b) NREGA<br>c) PMAY<br>d) Mid-Day Meal Scheme | 0.467 | 0.5 | 0.394 | R |

| | | | | | |
|---|---|---|---|---|---|
| Q20 | Which cropping system can include pulses and oilseeds to enhance income?<br>a) Sole cropping<br>b) Intercropping<br>c) Continuous cropping<br>d) Monoculture | 0.6 | 0.375 | 0.362 | R |
| Q21 | In Anantapur district, which crop is commonly intercropped with groundnut to optimize soil moisture and land use?<br>a) Cotton<br>b) Castor<br>c) Paddy<br>d) Onion | 0.417 | 0.625 | 0.505** | S |
| Q22 | What is a major benefit of oilseed intercropping in dryland areas like Kurnool?<br>a) Increased water consumption<br>b) Nutrient competition<br>c) Stabilized income through crop diversity<br>d) Pest susceptibility | 0.617 | 0.375 | 0.303 | R |
| Q23 | What should a farmer in Kurnool consider when choosing crops for diversification?<br>a) Market demand and soil type<br>b) Celebrity endorsements<br>c) Uniform crop prices<br>d) High irrigation requirement | 0.65 | 0.438 | 0.407 | R |
| Q24 | How does intercropping contribute to pest management?<br>a) By increasing monocultures<br>b) By encouraging pest growth<br>c) By creating crop diversity that disrupts pest cycles<br>d) By reducing yields | 0.517 | 0.688 | 0.516* | S |
| Q25 | Traditional knowledge in Anantapur helps farmers in:<br>a) Practicing harmful superstitions<br>b) Ignoring scientific methods<br>c) Choosing time-tested, location-specific crop combinations<br>d) Abandoning farming | 0.533 | 0.375 | 0.328 | R |
| Q26 | Market access is important in crop diversification because:<br>a) It increases transportation costs<br>b) It helps farmers sell surplus produce and earn better returns<br>c) It reduces farmer profits<br>d) It limits crop choices | 0.55 | 0.562 | 0.407* | S |
| Q27 | Which of the following is a suitable cropping plan for a 5-acre dryland farm in Anantapur?<br>a) Sugarcane + Banana<br>b) Paddy + Maize<br>c) Groundnut + Castor + Foxtail millet + Redgram<br>d) Wheat + Tomato | 0.55 | 0.438 | 0.324 | R |
| Q28 | Crop diversification leads to more pesticide use. (Yes/No) | 0.5 | 0.75 | 0.569** | S |
| Q29 | Growing only one crop on the same land every year is called monoculture. (Yes/No) | 0.55 | 0.375 | 0.327 | R |
| Q30 | Growing different crops in different seasons improves soil fertility. (Yes/No) | 0.483 | 0.75 | 0.545** | S |
| Q31 | Crop diversification increases dependency on middlemen. (Yes/No) | 0.417 | 0.625 | 0.481* | S |
| Q32 | Leguminous crops add nitrogen to the soil. (Yes/No) | 0.5 | 0.5 | 0.356 | R |
| Q33 | Crop diversification helps mitigate the effects of drought. (Yes/No) | 0.683 | 0.312 | 0.24 | R |
| Q34 | Organic farming and crop diversification are unrelated. (Yes/No) | 0.567 | 0.375 | 0.336 | R |
| Q35 | Diversification reduces crop failure risks. (Yes/No) | 0.633 | 0.125 | 0.17 | R |
| Q36 | Farmers need certification to practice diversified cropping. (Yes/No) | 0.583 | 0.5 | 0.484 | R |

| | | | | | |
|---|---|---|---|---|---|
| Q37 | Market access is important for successful crop diversification. (Yes/No) | 0.55 | 0.5 | 0.420* | S |
| Q38 | Crop diversification ensures better utilization of farm resources. (Yes/No) | 0.467 | 0.625 | 0.476** | S |
| Q39 | Diversification discourages on-farm employment. (Yes/No) | 0.55 | 0.562 | 0.439** | S |
| Q40 | Soil health can be maintained through diversified cropping. (Yes/No) | 0.567 | 0.812 | 0.618** | S |
| Q41 | Diversification is possible only in irrigated areas. (Yes/No) | 0.55 | 0.562 | 0.426** | S |
| Q42 | A variety of crops reduces pest and disease spread. (Yes/No) | 0.583 | 0.438 | 0.257 | R |
| Q43 | Groundnut + Castor intercropping is a common practice in Rayalaseema for efficient use of rainfall. (Yes/No) | 0.617 | 0.562 | 0.404 | R |
| Q44 | Farmers in Anantapur prefer ______ as a pulse crop during kharif under low rainfall conditions. | 0.45 | 0.562 | 0.36 | R |
| Q45 | Groundnut + Redgram is an example of ______ cropping. | 0.55 | 0.688 | 0.527** | S |
| Q46 | Jowar, Bajra, and Ragi are examples of ______ crops. | 0.6 | 0.312 | 0.17 | R |
| Q47 | ______ crops are known for fixing atmospheric nitrogen. | 0.583 | 0.688 | 0.481* | S |
| Q48 | ______ is a suitable dryland pulse crop in Ananthapuramu. | 0.583 | 0.375 | 0.336 | R |
| Q49 | Growing crops in a sequence is called ______ cropping. | 0.55 | 0.5 | 0.369** | S |
| Q50 | Crop diversification helps in reducing ______ dependency. | 0.583 | 0.812 | 0.565* | S |
| Q51 | Adding fruits and vegetables to a farm system is called ______ diversification. | 0.433 | 0.812 | 0.672* | S |
| Q52 | Soil erosion is reduced by growing ______ crops. | 0.583 | 0.25 | 0.187 | R |
| Q53 | A cropping system that includes livestock, horticulture, and cereals is called ______ farming. | 0.45 | 0.562 | 0.387* | S |
| Q54 | Intercropping ______ with groundnut helps in pest control and better resource utilization in Anantapur district. | 0.483 | 0.75 | 0.24 | R |
| Q55 | Intercropping castor with groundnut helps in controlling ______ in dryland regions. | 0.567 | 0.438 | 0.438 | R |
| Q56 | The process of growing different crops on the same land over time is called ______. | 0.467 | 0.5 | 0.37** | S |
| Q57 | Crop diversification in Rayalaseema helps reduce the risk of complete ______ failure. | 0.483 | 0.5 | 0.46* | S |
| Q58 | Relay cropping involves sowing a second crop before the ______ of the first crop. | 0.467 | 0.625 | 0.538** | S |
| Q59 | _____ is a major oilseed crop promoted in Kurnool under diversification initiatives. | 0.483 | 0.375 | 0.388 | R |
| Q60 | Inclusion of legumes in crop rotation improves ______ content in soil. | 0.6 | 0.866 | 0.56 | R |

**Significant at 1 per cent level; *Significant at 5 per cent level

## Results and Discussion

The study's item analysis results, retaining 30 items from 60 with difficulty indices between 0.30-0.80, discrimination indices above 0.30, and significant point biserial correlations, align with established psychometric standards for knowledge tests in agriculture. These criteria ensure items are neither too easy nor too difficult while effectively distinguishing knowledgeable farmers from others, as moderate difficulty (around 0.50) maximizes discrimination potential in multiple-choice formats. Similar thresholds have validated knowledge tests on rice technology (Sharma *et al.*, 2020) and extension personnel topics, confirming the tool's suitability for assessing crop diversification awareness in rainfed regions.

The split-half reliability coefficient of 0.868 (significant at 1% level) demonstrates high internal consistency, comparable to 0.78 in extension knowledge tests and other agricultural scales using the same method. This reliability stems from odd-even item splitting after randomization, minimizing administration variability and supporting single-session data collection for farmer surveys (Garrett, 2007). Content validity, secured via expert consultations covering concepts, benefits, local practices, and schemes, matches comprehensive domain representation in Bloom's taxonomy-based agricultural assessments (Bloom, 1956; Anderson and Krathwohl, 2001).

In Rayalaseema's semi-arid context, the test's focus on millets, intercropping (e.g., groundnut-castor), and risk reduction addresses documented knowledge gaps hindering diversification adoption (Rao *et al.*, 2020). Low retention of items on schemes like RKVY reflects real barriers such as erratic rainfall and market access, consistent with regional studies showing uneven uptake despite promotion (Pingali, 2012; FAO, 2021). Construct validity via point biserial correlations further justifies results, as items correlating strongly with total scores (e.g., >0.40) indicate robust measurement of multifaceted knowledge

## Conclusion

The study successfully developed and standardized a reliable 30-item knowledge test for measuring farmers' understanding of crop diversification, demonstrating strong psychometric properties including difficulty indices of 0.30-0.80, discrimination indices above 0.30, significant point biserial correlations, and a split-half reliability of 0.868. This validated tool enables precise baseline assessments in extension programs, identifying gaps in practices like legume rotation for nitrogen fixation, relay cropping, millets, and intercropping in drylands such as Rayalaseema. Policymakers can deploy it to evaluate interventions under schemes promoting pulses and millets, enhancing climate resilience and sustainable agriculture adoption amid erratic rainfall and market barriers.

Future refinements could integrate Likert-scale perceptions for holistic farmer profiling, building on similar studies linking knowledge to diversification outcomes. Overall, the instrument provides a robust foundation for capacity-building, policy design, and educational interventions to bridge knowledge gaps and promote diversified farming in rainfed regions.

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