2012
Syllabus and Sample Questions for JRF
AGRICULTURAL AND ECOLOGICAL RESEARCH UNIT

[Test Code: RAE]

The candidates have to take two tests: Test **RAE I** in the forenoon session and test **RAE II** in the afternoon session. Both tests will comprise of three groups (Groups A, B and C). Group A is for candidates having M.Sc. (Ag) in Agronomy, Group B for candidates having M.Sc. in Botany/ Environmental Science and Group C for candidates having M. Sc. in Statistics/ M.Stat.
For both tests, Full Marks will be 100 and Time: 2 hours.

Syllabus

Group A (Agriculture)
Standard: M.Sc. (Agriculture) in Agronomy of Indian University.

1. Agrometeorology:
    What is agrometeorology; weather forecasting; water balance model; available moisture index model; factors limiting growth, development and yield of crop as affected by light, temperature, humidity and precipitation. Growth and development in adverse environmental conditions like drought, flood.

2. Basic Agronomy:
    The inventory of potentialities in a) climate, b) soil types, c) irrigation, d) manure and fertilizers, and e) package of practices, and their utilization.

3. Crop improvement:
    Mechanism of variability and selection-seed production and distribution, seed testing and certification and storage of seeds-description and variety improvement of cereals (rice, wheat, maize), pulses (gram, pigeon pea, green gram, black gram), oilseeds (rape mustard, groundnut, linseed, sesame) and commercial crops (jute, sugarcane, potato).

4. Crop growth and nutrition:

Growth and development in adverse conditions like acidity, salinity and alkalinity of soil. Role of nutrient elements- major and minor. Factors affecting their availability.

5. Soil fertility and water management:
Soil fertility problems; role of organic matter, soil reaction and crop rotation in soil fertility; important manure and fertilizers including biofertilizers, their application and behaviour in different soils; soil testing methods and fertilizer recommendation; role of water in plant development and crop production; systems of irrigation and drainage; irrigation requirement of different field crops.

6. Crop husbandry:
Advanced studies in the cultural practices of rice, wheat, maize, cotton, jute, potato, forage crops, pulses and oilseeds; economics of crop production; different cropping systems including inter and mixed cropping.

7. Field experimentation:
Objects and trends in agronomic experiments; application, layout and analysis of data of principal experimental designs viz. Randomized block, Latin squares, factorial experiments, split-plot and confounding; computation of linear and curvilinear regressions and their uses.

Group B (Botany/Environmental Science)

1. Structure, function and metabolism of carbohydrates, lipids, proteins, vitamins and minerals; nucleic acids; metabolic pathways; enzymes and coenzymes.

2. Respiration and photosynthesis; protein synthesis; growth promoting plant hormones, response to stress. Principles of taxonomy as applied to the systematics of classification of plant kingdom.

3. Mendelian genetics, recombination; DNA structure, replication, transcription, translation; DNA footprinting; control of gene expression; polymerase chain reaction; recent trends in molecular biology.

4. Ecosystem structure, food chain and energy flow, ecosystem diversity, productivity and biogeochemical cycles, limnology; environmental pollution, sustainable development, biodiversity, global change.

5. General laboratory analytical techniques and principles.

6. Basic Statistics and Computation: Descriptive statistics, correlation, simple regression, probability, analysis of variance, Microsoft Excel.

Group C (Statistics)

Mathematics
1. Functions and relations. Matrices - determinants, eigenvalues and eigenvectors, solution of linear equations, and quadratic forms.

2. Calculus and Analysis - sequences, series and their convergence and divergence; limits, continuity of functions of one or more variables, differentiation, applications, maxima and minima. Integration, definite integrals, areas using integrals, ordinary linear differential equations.

Statistics
1. *Probability*: Basic concepts, elementary set theory and sample space, conditional probability and Bayes' theorem. Standard univariate and multivariate distributions. Transformation of variables. Moment generating functions, characteristic functions, weak and strong law of large numbers, convergence in distribution and central limit theorem. Markov chains.

2. *Inference*: Sufficiency, minimum variance unbiased estimation, Bayes estimates, maximum likelihood and other common methods of estimation. Optimum tests for simple and composite hypotheses. Elementary sequential and non-parametric tests. Analysis of discrete data - contingency chi-square.

3. *Multivariate Analysis*: Standard sampling distributions. Order statistics with applications. Multiple regression, partial and multiple correlation. Basic properties of multivariate normal distribution, Wishart distribution, Hotelling's T-square and related tests.

4. *Linear Models and Design of Experiments*: Inference in linear models. Standard orthogonal and non-orthogonal designs. Inter and intra-block analysis of general block designs. Factorial experiments. Response surface designs. variance components estimation in one and two-way ANOVA.

5. *Sample Surveys*: Simple random sampling, Systematic sampling, PPS sampling, Stratified sampling. Ratio and regression methods of estimation. Non-sampling errors, Non-response.

Sample Questions
[Forenoon session]
RAEI

Select the correct answer from the multiple choices:

GROUP A (Agriculture)

1. For getting 10% advantage, the LER should be

    (a) 1.00 (b) 0.50 (c) 1.10 (d) 110

2. From the following select one medium duration rice cultivar
    (a) Pankaj (b) Masuri (c) Jaya (d) Sabita.

3. The optimum row spacing of wheat is
    (a) 22.5cm (b) 15.5cm (c) 30cm (d) 5cm.

4. Triple super phosphate is
    (a) Water soluble (b) alkali soluble (c) Acid soluble (d) Citrate soluble.

5. Which of the following disease affects young seedlings at nursery stage
    (a) Fusarium wilt (b) Little leaf (c) Early blight (d) Damping off.

6. In a RBD experiment with ten sowing dates of wheat replicated thrice, the error MSS value is estimated as 24.6. Select the correct CD value.
    (t at 0.05 P = 2.101)
    (a) 5.32 (b) 7.57 (c) 8.51 (d) 10.02.

7. IW/CPE ratio in wheat under alluvial soil condition is
    (a) 0.92 (b) 0.88 (c) 0.78 (d) 0.67.

8. In a 120 days rice variety initiation of panicle primordia is noticed after
    (a) 40 (b) 50 (c) 60 (d) 70 (Days after transplanting)

9. In an intercropped plot mixture of ij and ji crop yielded 3867 and 1254 kg/ha respectively whereas as sole crops ii and jj yielded 4775 and 4321 kg/ha. LER calculated is
(a) 1.10 (b) 1.34 (c) 1.00 (d) 1.2

10. Which one of the following parts of the tobacco plant synthesizes nicotine?
(a) Root (b) Stem (c) Branch (d) Leaf

GROUP B (Botany/Environmental Sciences)

1. Thylakoid membrane has lateral asymmetrical positioning of photosystem in chloroplast. Which statement is correct?
   (i) PS-I in non appressed portion and PS-II in appressed portion
   (ii) PS-II in non appressed portion and PS-I in appressed portion
   (iii) Both PS-I and PS-II in a appressed portion
   (iv) Both PS-I and PS-II in non appressed portion of thylakoid.

2. The simplest Ketose sugar is
   (i) Xylulose
   (ii) Dihydroxyacetone
   (iii) Ribulose
   (iv) Fructose

3. Which of the following plant hormones is considered as the natural constraint that keeps developing embryos in their embryogenic state?
   (i) Ethylene
   (ii) Gibberellic Acid
   (iii) ABA
   (iv) IAA

4. The uncoupling of oxidative phosphorylation in a mitochrodrial system describes which of the following actions?
   (i) The phosphorylation of ADP to ATP accelerates.
   (ii) The phosphorylation of ADP continues but oxygen uptake stops.
   (iii) The phosphorylation of ADP stops but oxygen uptake continues.
   (iv) Oxygen uptake stops.

5. The maximum possible rate of increase of population of a given species under ideal condition would depend upon its
   - (i) Biotic potential
   - (ii) Potential natality
   - (iii) Carrying capacity
   - (iv) Biomass

6. In ponds and lakes, the open-water zone to the depth of effective light penetration is called
   - (i) Littoral zone
   - (ii) Profundal zone
   - (iii) Pool zone
   - (iv) Limnetic zone

7. Which steps of translation does not consume high energy phosphate bond?
   - (i) Translocation
   - (ii) Peptidyl transferase reaction
   - (iii) Amino acid activation
   - (iv) Aminoacyl tRNA binding to A-site

8. RFLP analysis is a technique that
   - (i) uses hybridization to detect specific DNA restriction fragments in genomic DNA
   - (ii) is used to determine whether a gene is transcribed in specific cells
   - (iii) measures the transfer frequency of genes during conjugation
   - (iv) is used to detect genetic variation at the protein level

9. If the correlation between body weight and annual income were high and positive, we could conclude that:
   - (i) High incomes cause people to eat more food.
   - (ii) High income people tend to spend a greater proportion of their income on food than low income people, on average.
   - (iii) High income people tend to be heavier than low income people, on average.
   - (iv) High incomes cause people to gain weight.

10. In Microsoft Excel, which of the following methods cannot be used to edit the content of cell?
   (i)   Pressing the Alt key
   (ii) Clicking the formula bar
   (iii) Pressing F2
   (iv) Double clicking the cell

GROUP C (Statistics)

1. Suppose D(X) and D(Y) are a measure of dispersion of the variables X and Y respectively, where values of X lies between 0 and 1. The relationship between X and Y is $Y=X^2$. Then
   (1) D(Y)=D(X)
   (2) D(Y)={D(X)}^{2}
   (3) D(Y)>D(X)
   (4) D(Y)<D(X)

2. Men tend to marry women who are slightly younger than themselves. Suppose that every man married a woman who was exactly 0.5 of a year younger than themselves. Which of the following is CORRECT?
   (1) The correlation is -0.5.
   (2) The correlation is 0.5.
   (3) The correlation is 1.
   (4) The correlation is -1.

3. Suppose $X = (X_1, X_2, ..., X_n)$ is a random vector with density f given by:

$$f(x_1, x_2, ..., x_n) = \begin{cases} c & \text{if } x'x \le r^2 \\ 0 & \text{otherwise} \end{cases}$$

Then the value of c is:
   (1) $\dfrac{\Gamma(\frac{n}{2}+1)}{\pi^{\frac{n}{2}} r^n}$
   (2) $\dfrac{\Gamma(\frac{n}{2})}{\pi^{\frac{n}{2}} r^n}$
   (3) $\dfrac{\Gamma(\frac{n}{2}+1)}{\pi^n r^{\frac{n}{2}}}$
   (4) *none of these*

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4.   Consider the usual linear regression model:
$$y_i = \alpha + \beta x_i + e_i; \ i = 1,2,...,n$$
where e_i's are i.i.d. $N(0,\sigma^2)$. Suppose $\hat{\alpha}$ and $\hat{\beta}$ are the least squares estimates of α and β respectively and $Q = \sum_{i=1}^{n}(y_i - \hat{\alpha} - \hat{\beta}x_i)^2$. Let CI_1 and CI_2 be two confidence intervals for β, defined as:
$$CI_1 = [\hat{\beta} - t_{n-2,\alpha/2}\sqrt{Q/(S_{xx}(n-2))}, \hat{\beta} + t_{n-2,\alpha/2}\sqrt{Q/(S_{xx}(n-2))}]$$
$$CI_2 = [\hat{\beta} - t_{n-1,\alpha/2}\sqrt{Q/(S_{xx}(n-1))}, \hat{\beta} + t_{n-1,\alpha/2}\sqrt{Q/(S_{xx}(n-1))}]$$
where $S_{xx} = \sum_{i=1}^{n}(x_i - \bar{x})^2$ and $\alpha = 0.07$. Then,

(1) $P(\beta \in CI_1) > P(\beta \in CI_2)$
(2) $P(\beta \in CI_2) > P(\beta \in CI_1)$
(3) $P(\beta \in CI_2) + P(\beta \in CI_1) < 1$
(4) $P(\beta \in CI_2, \beta \in CI_1) = P(\beta \in CI_2)P(\beta \in CI_1)$

5. Let X_1 and X_2 be two independent random variables from the distribution with p.d.f. $f(x) = 2x, \ 0 < x < 1$. Then $P(X_1 < X_2 \mid X_1 < 2X_2)$ will be equal to

(1) 1/7
(2) 2/7
(3) 3/7
(4) 4/7

6. In a standard logistic regression model, the m.l.e. estimator of the odds ratio is
(1) unbiased and consistent   (2) neither unbiased nor consistent
(3) unbiased but not consistent   (4) not unbiased but consistent

7. It has been postulated that the variance of the annual examination scores in a subject is twice that of the half-yearly examination scores. A student, who suspects that this ratio is in reality less than what is postulated, collects data on the half-yearly and annual scores of 4 randomly chosen students as follows: (13,29), (18,31), (18,36) and (19,33). Based on the given data, do you think that
(1) the student's suspicion is justified
(2) the student's suspicion is not at all justified
(3) no conclusive evidence can be made
(4) none of these

8. Let r_{ij} be the correlation coefficient between x_i and x_j $(i, j = 1, 2, 3, ..., p)$. If $r_{1j} = r(j = 2, 3, ..., p)$ and $r_{ij} = r_0(i, j = 2, 3, ... p; \; i \neq j)$, then $r^2_{1.23...p}$ would be equal to

(1) $\dfrac{pr^2}{1+(p-1)r_0}$ (2) $\dfrac{pr_0^2}{1+(p-1)r}$ (3) $\dfrac{(p-1)r^2}{1+(p-2)r_0}$ (4)

$\dfrac{(p-1)r_0^2}{1+(p-2)r}$

9. A necessary and sufficient condition for a connected block design to be variance-balanced is that its C-matrix is of the form
   (1) $a\mathbf{I}+b\mathbf{JJ'}$ (2) $(a\text{-}b)\mathbf{I}+b\mathbf{JJ'}$ (3) $a\mathbf{I}+(a\text{-}b)\mathbf{JJ'}$ (4) $a\mathbf{I}$

10. A population contains N units, the variate value of one unit being known to be y_0. A simple random sample without replacement of size n is drawn from the remaining N−1 units. Let $T_1 = y_0 + (N-1)m_y$ and $T_2 = Nm_y$ be two unbiased estimates of the population total, where m_y is the sample mean. Then

   (1) $V(T_1) = V(T_2)$
   (2) $V(T_1) > V(T_2)$
   (3) $V(T_1) < V(T_2)$
   (4) $V(T_1) = V(T_2) + 1$

Sample Questions
[Afternoon session]
RAEII

[To be answered in separate answer script, not in the Question Paper]

GROUP A (Agriculture)

1. What is LER? How LER is calculated? What are the differences between inter and mixed cropping? State the importance of intercropping.

2. State the criteria for essentiality of nutrients for plant? State the roles of Mo and B in crop nutrition. Classify phosphatic fertilizers.

3. What are the different forms of soil water? What is available Water? What is wilting point? State how soil moisture may be conserved for crops?

4. What is the dominant pulse crop in India? Write down its climatic requirements and rotations followed with this crop. Name five improved varieties of this crop.

5. Write down the differences between :
   a) Water use efficiency and Consumptive use of water.
   b) Phytoclimate and Microclimate.
   c) Cropping system research and Farming system research
   d) Intercropping and Sequential cropping

GROUP B (Botany/Environmental Sciences)

1. Distinguish between enzymatic and non-enzymatic catalysts. What are their common features? Mention five important practical utility.

2. What are mycorrhiza? Describe the relationship between mycorrhiza and plant roots and how each benefits the other.

3. What is the difference between the concepts of food chain and food web? Draw a typical (food) pyramid of energy. Include the relative amounts of energy.

4. How splicing in pre-tRNA is distinguishable from that in pre-mRNA ? Define and indicate the significance of a) Okazaki fragments, b) DNA ligase and c) primer RNA during DNA replication.

5. The length of a particular internode of 50 samples of a plant species and their frequency is given in class intervals. Find the mean internodal length and standard deviation.

Length of internodes: (in cms)	2-2.9	3-3.9	4-4.9	5-5.9	6-6.9
Frequency:	6	13	11	8	12

Determine the probability that a plant of genotype CcWw will be produced from parental plants of genotypes CcWw and Ccww.

GROUP C (Statistics)

1. Let $V_1, V_2, V_3, X_1, X_2, X_3$ be independently and identically distributed $N(0,1)$ variables. Find the distribution of
$$T = \frac{V_1 X_1 + V_2 X_2 + V_3 X_3}{\sqrt{V_1^2 + V_2^2 + V_3^2}}.$$
Hence find the distribution of
$$S = \frac{V_1 X_1 + V_2 X_2 + V_3 X_3}{V_1^2 + V_2^2 + V_3^2}.$$

2. Suppose that $X_1, X_2, X_3, \ldots,$ are i.i.d. random variables with $EX_1 = 0$, $EX_1^2 = 1$, $EX_1^4 < \infty$. Show that
$$n^{-1/2} \left[\sum_{i=1}^{n} (X_i - \overline{X}_n)^2 - n \right]$$
converges in law to a normal distribution with zero mean, as $n \to \infty$.
Here $\overline{X}_n = \dfrac{1}{n} \sum_{i=1}^{n} X_i$.

3. A company desires to operate S identical machines. These machines are subject to failure according to a given probability law. To replace these failed machines the company orders new machines at the beginning of each week to make up the total S. It takes one week for each new order to be delivered. Let X_n be the number of machines in working order at the beginning of the nth week, and let Y_n denote the number of machines that fail during the nth week.
   (a) Establish the recursive formula $X_{n+1} = S - Y_n$, and show that X_n, $n \geq 1$ constitutes a Markov Chain.
   (b) Suppose that the failure rate is uniform i.e.,
$$P[Y_n = j \mid X_n = i] = \frac{1}{i+1}, \quad j = 0, 1, \ldots, i.$$
   Find the transition matrix of the Chain, its stationary distribution, and expected number of machines in operation in the steady state.

4. In a forest there are *50* elephants and an unknown number L of tigers. Assume that $50+L$ animals randomly move in the forest. A naturalist sights *5* different tigers and *15* different elephants in the course o a trip in the forest. Estimate, stating assumptions and with theoretical support, the number of tigers in the forest.

5. Let $Y_{(1)} < Y_{(2)} < ... < Y_{(n)}$ be the ordered random variables of a sample of size n from the rectangular $(0,\theta)$ distribution with θ unknown, $0 < \theta < \infty$. By a careless mistake the observations $Y_{(k+1)},...,Y_{(n)}$ were recorded incorrectly and so they were discarded subsequently (Here $1 \le k \le n$).
(a) Show that the conditional distribution of $Y_{(1)},...,Y_{(k-1)}$ given $Y_{(k)}$ is independent of θ.
(b) Hence or otherwise, obtain the maximum likelihood estimator of θ and show that it is a function of $Y_{(k)}$.
(c) If $\frac{k}{n} \to p$ as $n \to \infty$, for some $0 < p < 1$, what can you say about the asymptotic distribution of the maximum likelihood estimator of θ?

6. Let X be a random variable having a density $\frac{1}{\theta}e^{-x/\theta}$, $x,\theta > 0$. Consider $H_0 : \theta = 1$ vs. $H_1 : \theta = 2$. Let ω_1 and ω_2 be two critical regions given by $\omega_1 : \sum_1^n X_i \ge C_1$ and $\omega_2 : (number \ of \ X_i's \ge 2) \ge C_2$.
   (a) Determine approximately the values of C_1 and C_2 for large n so that both tests are of size α.
   (b) Show that the powers of both tests tend to 1 as $n \to \infty$.
   (c) Which test would you require more sample size to achieve the same power? Justify your answer.

7. Let $\mathbf{X} = (X_1, X_2, X_3, X_4)$ have a multivariate normal distribution with unknown mean vector $\mu = (\mu_1, \mu_2, \mu_3, \mu_4)$ and unknown dispersion matrix Σ which is non-singular. Let $\mathbf{X_1}, ..., \mathbf{X_n}$ be a random sample of size n from the population. Develop a test for testing the hypothesis $H_0 : \mu_1 + 2\mu_2 = \mu_2 + 2\mu_3 = \mu_3 + 2\mu_4$. State the distribution of the test statistic.

8. In a linear model $Y = A\beta + \varepsilon$, $E(\varepsilon) = 0$, $D(\varepsilon) = \sigma^2 I$, $\beta' = (\beta_1,...,\beta_p)$, let $C_1,...,C_p$ denote the column vectors of the matrix A. Prove that,

(i) β_1 is estimable if and only if C_1 does not belong to the vector space spanned by $C_2, C_3, ..., C_p$.

(ii) $\lambda_1 \beta_1 + \lambda_2 \beta_2$, $\lambda_1 \neq 0$, $\lambda_2 \neq 0$ is estimable if and only if C_1 does not belong to the vector space spanned by $\lambda_2 C_2 - \lambda_1 C_1, C_3, ..., C_p$.

9. A sample $s^{(1)}$ of n units is selected from a population of N units using SRSWOR and the values of a variable y are ascertained for those n_1 units among the n units of $s^{(1)}$ who responded. Later, a further sub-sample $s^{(2)}$ of m units is selected using SRSWOR out of the $(n - n_1)$ units of $s^{(1)}$ which did not respond. Assuming that the y-values of all m units of $s^{(2)}$ could be obtained, find the following:
    (a) an unbiased estimator of the population mean $\bar{Y}$ on the basis of available y-values.
    (b) an expression for the variance of the proposed estimator.

10. Consider the following 2^4 factorial design with factors A, B, C and D in the usual order.
    Block 1: (0,0,0,0), (0,1,0,1), (1,0,1,0), (1,1,1,1), (1,1,0,1), (0,0,1,0)
    Block 2: (0,0,1,1), (0,1,1,0), (1,0,0,1), (1,1,0,0), (1,1,1,0), (0,0,0,1)
    Block 3: (0,1,0,0), (0,1,1,1), (1,0,0,0), (1,0,1,1)
    Examine whether the main effect of A is estimable.