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EVALUATION OF SOIL NUTRIENTS BY USING TYPE-1 FUZZY SET

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Abstract:

To study the status and quantity of available soil nutrients in soil study was conducted in typical farm of Miraj, Sangli district in Maharashtra sample from each farm were collected and scientifically analysed. The subjective information is quantified by using fuzzy sets. The problem of selection of soil containing "high" availability of Nitrogen (N), Phosphate (P) and "medium" Potassium (K) is demonstrated as application of type-1 fuzzy set.

Key Words: *Type-1 Fuzzy Set.*

Introduction:

In determining the relation, availability of nutrients in the soils, the chemical properties of soil play vital role. The literature evident that the soil of Maharashtra are clayey in texture, neutral of alkaline in reaction, low to medium in organic carbon and non-calcareous to calcareous in nature [Gajbe etal. 1976] and Malewar [1994]. Deficiency of these nutrients in spreading in soil at faster rate due to intensive cropping, imbalance fertiliser use and lack of efficient management. Therefore, it is the need of hour to maintain soil health for sustainable, productivity, food security and increasing agricultural production in order to meet the increasing demand against limited soil resource base. Therefore the study of chemical properties of soils like soil containing Nitrogen (N), Phosphate (P) and Potassium (K) and monitoring frequently these properties important. On that respective information it will beneficial to improve quality of soil and also improve production of crops. **Phosphorus:-**Phosphorus is a component of the complex nucleic acid structure of plants, which regulates protein synthesis. Phosphorus is, therefore, important in cell division and development of new tissue. Phosphorus is also associated with complex energy transformations in the plant.

Nitrogen:-Nitrogen is one of the macronutrients which is required in large amount for plant metabolism and growth act as a primary nutrient for plants. It is absorbed in Ammonium (NH_4^+), Nitrate (NO_3^-) ions forms. Nitrogen is the element which is not directly available to plants from atmosphere and earth's crust.

Potassium:-Normal plant growth requires large quantities of potassium. In fact, throughout growth most crops contain more potassium than any other nutrient including nitrogen (N). Small quantities of potassium are needed to support many of the crucial enzyme processes within the plant whilst much larger amounts are used to control the water relationships in the plant. Potassium also plays a vital role in the transport of sugars and other products of photosynthesis from leaves to storage organs.

Preliminaries:

Let X be any universe of discourse which is never fuzzy. Type-1 fuzzy set is mapping to the interval 0, 1. Which depends on the vague concept A of a linguistic variable [Zadeh, 1965]. The function A is usually called the membership function of the fuzzy set A. To each element $x \in X$ is adjoined an element $A(x) \in [0,1]$called the membership grade of X in the fuzzy set A.

$$A(x) = \begin{cases} 1 & \text{if } x \in A \\ 0 & \text{if } x \notin A \end{cases}$$

And $A(x) \neq [0,1]$if $x$partly belongs to A. If the real interval [0,1] is allowed to the valuation set$\{0,1\}$, A becomes a characteristic function on X to$\{0,1\}$. In this sense fuzzy set is generalization of a classical subject of a set.

Operations on fuzzy sets

Let U be domain and A, B be fuzzy sets on U.

Union of A and B, denoted by $A \cup B$, is a defined as that fuzzy set on U for which $(A \cup B)(x) = \max(A(x), B(x))$for every $x$in$U$.

Intersection of A and B, denoted by $A \cap$, is a defined as that fuzzy set on U for which $(A \cap B)(x) = \min(A(x), B(x))$for every $x$in$U$.

The set$\{x \in U / A(x) > 0\}$is called the *support* of A and is denoted by supp (A).

The height of A is defined to be that number ht (A),

- **i)** $A(x) \leq ht(A)$for all supp$(A)$for all $x$in supp (A)
- **ii)** $A(x) = ht(A)$For at least one supp(A).

(A) Is said to be normal if $A(x) = 1$ for at least one $x$in$U$. The set $\{x \in U / A(x) = 1\}$is called the *core* of the fuzzy set (A). Normal fuzzy set on R whose support is bounded and whose α -cuts are closed intervals for all α in (0,1]

$A=\{a1,a2,.....an\}$Is the set of alternatives and $C=\{c1,c2,.....cn\}$is the set of criteria. Let

$w1,w2,......wn$ be set of weights indicating the important of the criteria. Let $w=\sum wi$be the sum of weight. Then Type-1 fuzzy relation is given by

$\boldsymbol{R = [rij]}$ **On** $\boldsymbol{C \times A}$.

For each alternative $aij(j=1,2,3,......,n)$we determine m number of fuzzy sets $S(i, j)$ $S(i, j)= \min(rij , wj)i = 1 \text{to } m$. We use Max-Min or Max-Product composition of W and R to obtain the decision of fuzzy set D , where $D = R \circ W$

Defuzzification. We take that alternatives $a$in supp D as the best one for which $D(a)= ht (D)$

Model for nutrient Assessment in soil samples:

$S=\{s1,s2,.....sn\}$Is the set representing soil samples specified farming system and $C=\{c1,c2,.....cn\}$is the set of criteria used for assessing soil sample. Let $w1,w2,......wn$ be the set of weights indicating the importance of criteria.

Let $w=\sum wi$ be the sum of weight. Then Type-1 fuzzy relation is given by $R = [rij]$on $C \times S$.

For each alternative $sj(j=1,2,3,......,n)$we determine $m$number of fuzzy sets $S(i, j)$ $S(i, j)= \min(rij , wj)i = 1 \text{to } m$

Materials and Methods:

Total 50 samples were collected from 10 different farms of the single typical village in Miraj tehsil during 2021-22. These samples were analysed in the soil analysis lab for their chemical properties as per standard methods see (Jackson 1978). Nitrogen was estimated by alkaline permanganate methods see (Subbjah and Asija, 1956). Potassium was determined with neutral normal ammonium acetate and the potassium in the extract was determined by using flame photometer (Jackson 1973).

Formulation of fuzzy sets

$$\text{‘Medium” content of } K,\ K(x) = \begin{cases} 0 & x \le 300 \\ \dfrac{x-300}{400} & 300 < x < 700 \\ 1 & x \ge 700 \end{cases}$$

$$\text{“High” content of } P,\ P(x) = \begin{cases} 0 & x < 6 \\ \dfrac{x-6}{11} & 6 \le x \le 17 \\ 1 & x > 17 \end{cases}$$

$$\text{“High” content of } N,\ N(x) = \begin{cases} 0 & x < 120 \\ \dfrac{x-120}{230} & 120 \le x \le 350 \\ 1 & x > 350 \end{cases}$$

Table 1
Characteristic of fuzzy values

Soil Sample / Criteria	s_1	s_2	s_3	s_4	s_5	s_6	s_7	s_8	s_9	s_{10}	W_s
NC_1	0.263	0.273	0.209	0.209	0.229	0.089	0.292	0.667	0.976	0.746	0.4
PC_2	0.309	0.064	0.100	0.300	0.382	0.527	0.864	0.955	0.955	0.945	0.4
KC_{31}	0.817	0.556	0.584	0.691	0.412	0.597	0.625	0.453	0.063	0.975	0.2

"High" Nitrogen content of (N)

$$=\frac{0.263}{s_1}+\frac{0.273}{s_2}+\frac{0.209}{s_3}+\frac{0.209}{s_4}+\frac{0.229}{s_5}+\frac{0.089}{s_6}+\frac{0.292}{s_7}+\frac{0.667}{s_8}+\frac{0.976}{s_9}+\frac{0.746}{s_{10}}$$

"High" Phosphate content of (P)

$$=\frac{0.309}{s_1}+\frac{0.064}{s_2}+\frac{0.100}{s_3}+\frac{0.300}{s_4}+\frac{0.382}{s_5}+\frac{0.527}{s_6}+\frac{0.864}{s_7}+\frac{0.955}{s_8}+\frac{0.955}{s_9}+\frac{0.945}{s_{10}}$$

'Medium" Potassium content of (K)

$$=\frac{0.817}{s_1}+\frac{0.556}{s_2}+\frac{0.584}{s_3}+\frac{0.691}{s_4}+\frac{0.412}{s_5}+\frac{0.597}{s_6}+\frac{0.625}{s_7}+\frac{0.453}{s_8}+\frac{0.063}{s_9}+\frac{0.975}{s_{10}}$$

Fuzzy weights (W) $W = \{0.4, 0.4, 0.2\}$

Decision fuzzy set (D)

$D(x) = (R \circ W)(x), R : C \times S \rightarrow [0,1]$

$D = \{0.309, 0.273, 0.209, 0.3, 0.382, 0.4, 0.292, 0.4, 0.4, 0.4\}$

One way of interpreting this is that, any one out of four soil samples $s6$, $s8$, $s9$ and $s10$ can be selected satisfying C 1 , $C2$ and $C3$. To signal out only one soil sample we look at the weights of the criteria and find that tie occurs at the row C 1 and $C2$ ignoring this two rows we form composition again to get D = {0.2, 0.2, 0.2, 0.2, 0.2, 0.2, 0.2, 0.2, 0.2, 0.2} Again tie occurs. Either we break the tie arbitrary ignoring $C1$ to select soil sample out of $s6$, $s8$, $s9$, $s10$. Ignoring C 1 we get D = {0.309 , 0.2, 0.2, 0.3, 0.382 , 0.4, 0.4, 0.4, 0.4, 0.4} Again we select $s6$, $s7$, $s8$, $s9$, $s10$and out of this either of sample is selected. Ignoring $C2$.

We get D = {0.263 , 0.273 , 0.209 , 0.229 , 0.229 , 0.2, 0.292 , 0.4, 0.4, 0.4} $D(s6)$= 0.2,$D(s8,s9,s10)$= 0.4. Therefore soil samples $s8$, $s9$, $s10$are satisfying C 1, $C2$, $C3$ Therefore both these samples could be selected and sample $s6$ is ignored.

Study Area:

Sangli District is located in southern-western part of Maharashtra State having area 8522 Sq.km. geographical area which is situated between 16° 4′ to 17° 1′ North latitude and 73°43′ to 75° 00′ East longitude. This district consists of 11 Tahsils with total 723 villages. The district is divided into two major regions viz., Western area along Krishna river basin with abundant water supply and arid region includes drought prone zone along Eastern part. The arid region includes Kadegaon, Khanapur, Atpadi, Tasgaon, Jath, and Kavathe-Mahankal Tahsil and Eastern part of Miraj Tahsil. The average rain fall is about 620 mm per year due to South-West Monsoon. The average temperature of this area ranges from 13^{o}C to 45^{o}C.

Conclusion:

The available N and P were medium and high in respect of K. The soil sample $s8$, $s9$, $s10$ satisfying criteria. The average lowest N content was observed in soil sample $s6$, whereas, the highest N

content in soil sample $s9$. The average lowest P content observed in soil sample $s3$ and highest P content in soil sample $s8$. The average lowest K content was observed in soil sample $s9$, whereas, the highest K content in soil sample $s10$. Remaining soil sample need to improve the health texture based on recommendation of soil analysis report by expert.

Appendix

Characteristics of crisp values

Soil Sample / Criteria	s_1	s_2	s_3	s_4	s_5	s_6	s_7	s_8	s_9	s_{10}
$N\ kg/ha$	180.52	182.9	168.1	168.1	172.8	140.4	187.2	273.3	344.5	291.6
$P\ kg/ha$	9.4	6.7	7.1	9.3	10.2	11.8	15.5	16.5	15.3	16.4
$K\ kg/ha$	626.7	522.5	533.7	576.2	464.7	538.9	550	481	325	690

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