Volume : 4 | Issue : 5 | May 2015 • ISSN No 2277 - 8179

Research Paper

Analyzing the motivating factors of weeds associated arthropods in agricultural field

Zoology

KEYWORDS : Motivating factors, Weeds associated arthropods, UsilampattiTaluk, DEMATEL

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ABSTRACT

Raising globalization, economic crisis and food scarcity results in tremendous augmentation on food products which further results in incremental focussed on agriculture. These hiking urges towards agriculture subsequently results in climb in the number of agricultural management activities. In the row, the modern agriculture results in integrated pest management (IPM) strategywhich is mainly based on the focus of developing nation like India. In Indian context especially in south region serves a big part in Indian agriculture which are having different crop cultivations. Under the IPM weeds and arthropods are being studied by many researchers but in the context southern India, very little literature were evolved, and also the weeds and arthropods possess a strong hands of agricultural yield. Hence it is need to analyze the factors which pressures the farmers to manage the weeds associated arthropods in agricultural field. In order to fill this gap, this study took itself a responsibility to explore the most influential factors which motivates the weeds associated arthropods management in agricultural field. For this, decision making trial and evaluation laboratory tool is used through the proposed model and further the model is validated with case study in UsilampattiTaluk, near Madurai district of Tamil Nadu. Finally, the results were explored with the feedback of industrial managers and existing literatures.

BACKGROUND

In recent decade, due to raising population and depleting natural resources results in huge impacts on agricultural systems. Hence many strategies are introduce and involved in the agricultural field to become the yield as an economic one. In the row, integrated pest management was introduced recently to manage the pest but still many farmers are unaware these strategies especially in Indian context where the agriculture is major economic tool. Hence this study attempt to explore the integrated pest management by particularly focussing on weeds associated arthropods. Weeds and arthropods are nothing but the flora and fauna occurred in the agricultural field respectively. Some researchers (Makowski et al., 2007; Altieri, 1999;Altieri and Liebman, 1988; Fuente et al., 2010) argued that the weeds associated arthropods management support the biodiversity conservation which is nothing but "formation and retention of soil fertility, nutrient cycling by soil microbiota, retention of water and soil particles, resource capture by crops, resistance to pests and diseases and the ability to better withstand environmental disturbance (Balvanera et al., 2006; Diaz et al., 2006; Moonen&Barberi, 2008; Fuente et al., 2010). In contrary to that some studies (Wolcott, 1928; Way and Cammell, 1981; Penfold et al., 195; Stonehouse et al., 1996; Clark et al., 1998; Barberi, 2002) focussed to eliminate the weeds and arthropods from the agricultural fields.

Hence the farmers are in chaos with the above two hypothesis. Hence it is time to crack this chaos by address the question. "Is it necessary to manage weeds associated arthropods in agricultural field and what extent?" For addressing this question, this study itself take the responsibility to analyse the significant importance of weeds associated arthropods management in agricultural field by analysing its motivating factors in Indian context particularly in Sothern region, UsilampattiTaluk(where most pest management concepts - unaware farmers are found) with the assistance of proposed model through Decision Making Trial and Evaluation Laboratory (DEMATEL).

The remaining sections of this study is as follows. Section 2 explains the research framework of the study. The solution methodology of the problems is detailed in Section 3. The framework is validated through a case study which is illustrated in Section 4. The Results with discussions along with the conclusions of the study is detailed in Section 5 & 6 respectively.

1.1 Research highlights

Even though this research provides many interesting insights but here some of the research highlights are highlighted.

Collection and identification of common motivating factors for weed associated arthropods in agricultural field

Based on the assistance of farmers and field experts, the motivating factors are analysed through DEMATEL.

The results are validated with the farmers and field experts.

Table 1: Common motivating factors for weed associated arthropods in agricultural field

S. No	Motivating factors	Source
1	Soil fertility maintenance **(F1)**	Gurr et al (2003)
2	Pollination **(F2)**	Gurr et al (2003)
3	Pest & disease suppression **(F3)**	Gurr et al (2003); Andow (1991); Landis et al (2000)
4	Enemies hypothesis and increased natural enemy density **(F4)**	Fuente et al., (2010); Makowski et al., (2007)
5	Yield losses**(F5)**	Gurr et al (2003); Hillocks (1998)
6	Biodiversity conservation **(F6)**	Gurr et al (2003)
7	Spread of plant pathogens **(F7)**	Fuente et al., (2010); Makowski et al., (2007)
8	Reduced visual aesthetics **(F8)**	Refered by experts
9	Death of Crop plants **(F9)**	Gurr et al (2003)
10	Trap crops **(F10)**	Hillocks (1998)

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RESEARCH FRAMEWORK

The research framework starts with the goal, which explains the aim of this research and extend with the collection of common motivating factor exists for weeds associated arthropods management in agricultural field. Next the common factors will judged based on the pairwise comparison with the assistance of the decision makers, further based on this pairwise comparison the factors are analysed through DEMATEL. Finally the results are validated through the feedback from the farmers and filed experts.

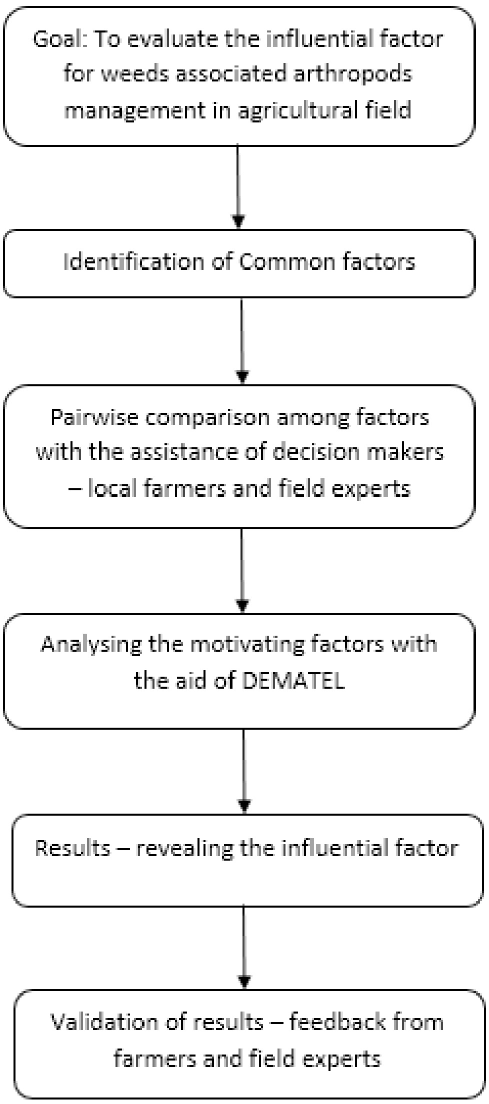

Fig 1: Research framework of the study

SOLUTION METHODOLOGY

In this paper, Multi criteria decision making tool (MCDM) is as a solution methodology which is nothing but a hard tool to select the best solution from the various given alternatives based on the criteria. In such MCDM there are several tools are exist, but in order to analyse the relationship among factors, decision making trail and evaluation laboratory (DEMATEL) is the best option. The DEMATEL was first proposed at Battelle Memorial Institute through Geneva research centre in 1973 (Chang et al 2011; Gabus and Fontela, 1973; Tseng and Ling, 2009; Wu and Lee, 2007). DEMATEL envisages complex, organizational, connecting relationship with matrices or diagraphs and has the capability to convert a relationship between causes and effects of criteria into a unique structural model (Falatoonitoosi et al., 2013; Yi et al., 2007; Lin 2013). Generally, DEMATEL consists of two groups; cause group and effect group in which the effect group have an impact by cause group further this estimates the weightage of criteria (Dalalah et al., 2011; Baykasoglu et al., 2013). Among system elements, DEMATEL delivers better comprehension in terms structural relationship which further assists the decision makers (Zhou et al., 2011). The main purpose of DEMATEL is to find the strength of influence and casual relationship between direct and indirect variables of a complicated system using matrix calculations (Lee et al., 2011)

Step 1: Set up direct relation matrix "T" in linguistic variables

Set up the direct relation matrix "T" with linguistic variables is the first step of DEMATEL. Table 2 shows Linguistic scale to corresponding numerical value.

Table 2: Linguistic scale with corresponding numerical values

Linguistic terms	Numerical Value
No influence (N)	0
Very low influence (VL)	1
Low influence (L)	2
High influence (H)	3
Very high influence (VH)	4

Step 2: Initial relation matrix "A"

The next step is to transform the linguistic term to corresponding numerical values. The form of matrix is shown in Eqn 3.

$$\bar{A} = \begin{bmatrix} 1 & a_{12} & a_{13} & \cdots & a_{1(n-1)} & a_{1n} \\ a_{21} & 1 & a_{23} & \cdots & a_{2(n-1)} & a_{2n} \\ \cdots & \cdots & \cdots & \cdots & \cdots & \cdots \\ \cdots & \cdots & \cdots & \cdots & \cdots & \cdots \\ a_{(n-1)1} & a_{(n-1)2} & a_{(n-2)3} & \cdots & 1 & a_{(n-1)n} \\ a_{n1} & a_{n2} & a_{n3} & \cdots & a_{n(n-1)} & 1 \end{bmatrix} \quad (3)$$

$$K = \frac{1}{max_{1<i<n}} \sum_{j=1}^{n} a_{ij} \quad (4)$$

$$S = K \times A \quad (5)$$

Step 4: Set up total relation matrix "M"

The next step is to set up the total relation matrix M. The normalized matrix is processed by the formula in Equation (6) where I denote identity matrix.

$$\mathbf{M = S (I - S)^{-1}} \quad (6)$$

Step 5: Obtain sum of sum of rows and columns

D and R denote the sum of rows and sum of columns. This should be calculated through Equations (7) and (8):

$$D = \left[\sum_{j=1}^{n} mij\right]_{n\times 1} \quad (7)$$

$$R = \left[\sum_{i=1}^{n} mij\right]_{1\times n} \quad (8)$$

$$M = m_{ij}, \quad i, j = 1, 2, \ldots, n$$

Step 6: Set up causal diagram

This step will provide causal and effect graph obtained by dataset of (**D + R, D − R**), where horizontal axis (**D + R**) is made by adding **D** to **R**, and vertical axis (**D − R**) is made by subtracting **R** from **D**.

CASE STUDY: AN ILLUSTRATION

To validate the proposed model, the proposed model is applied in the UsilampattiTalukwhich is situated in southern side of Indian geography. In which manufacturing managers are act as decision makers to provide the respond for this research. This application of proposed model in a case firm is implemented in four Phases, the detailed description of those four Phases are as follows.

***Phase I** Identification and collection of common motivating factors of weeds associated arthropods management in agricultural field:*

The common motivating factors of weeds associated arthropods of agricultural field were collected from the existing literatures which were published in the leading journals like Springer, Elsevier, Emerald, etc. by searching the key terms like "weeds associated arthropods", "influence of weeds in agricultural field", "influence of arthropods in agricultural field" and so on. For this study, some grey literatures are also considered into account but due to the reliability concern it is accounted very limited in numbers.

Phase II *Data validation:*

Once the common motivating factors of weeds associated arthropods management in agricultural field were collected from existing literature, then the collected data is validated through the notions of technical experts who include both the industrial experts and experienced field experts in Phase II. The communication of these experts were through email and telephonic inquires. In addition our research team a meeting in the village panchayat office in UsilampattiTaluk, for which the farmers and agricultural officers were invited. The motivation and importance of the study were cleared to those experts who attend the meeting once the importance of the study were revealed then the collected factors from Phase I were circulated among the technical experts and farmers to know their opinion among these collected factors. In addition to this, this discussion among the practitioners bridge the gap between the virtual and state of art scenario.After the many rounds of discussion, the final list of common motivating factors of weeds associated arthropods management in agricultural field are listed in Table 1.

Phase III *Analysing the motivating factors of weeds associated arthropods management in agricultural field using DEMATEL*:

Once the common motivating factors of weeds associated arthropods management in agricultural field were collected from existing literature and validated with the farmers and agricultural officers of UsilampattiTaluk, then it is need to analyse those collected common factors with the assistance of DEMATEL in Phase III. The Phase III is the application of solution methodology. The six step methodology is utilized to analyse these factors which is summarized below.

Step 1: Set up direct relation matrix in linguistic numbers

The initial direct relation matrix is set up with the assistance of the decision makers. In our case the farmers and agricultural officers of UsilampattiTaluk are considered as decision makers. This study consider three decision makers, in which two farmers and one agricultural officer were presented. As a representative of all farmers in that region, these two farmers (decision makers) were selected. Hence these three decision maker's decisions are combined and formed the direct relation matrix. Initially our research team provided the questionnaire considering factors one over another to those decision makers which can be rated by linguistic values which starts from N for No influence to VH for Very Highinfluence (Table 3). Further this linguistic values are converted into numerical values. Which is shown in Table 4.

Table 3: Direct relation matrix in linguistic form

	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10
F1	N	H	VL	VH	L	L	H	VH	VH	H
F2	VL	N	VL	H	VL	VL	VL	L	H	VL
F3	L	H	N	VH	L	L	H	VH	VH	H
F4	VL	VL	VL	N	VL	VL	VL	VL	VL	VL
F5	VL	L	VL	H	N	L	L	H	H	L
F6	VL	L	VL	H	VL	N	L	H	H	L
F7	VL	L	VL	H	VL	VL	N	L	H	VL
F8	VL	VL	VL	H	VL	VL	VL	N	H	VL
F9	VL	VL	VL	H	VL	VL	VL	VL	N	VL
F10	VL	L	VL	H	VL	VL	L	H	H	N

Step 2: Initial direct relation matrix - A

The matrix is obtained from step 1 is converted into numerical value in this step, the converted values are shown in Table 4.

Table 4: Initial relation matrix "*A*"

	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10
F1	0	3	2	4	1	1	3	4	4	3
F2	2	0	2	3	2	2	2	1	3	2
F3	1	3	0	4	1	1	3	4	4	3
F4	2	2	2	0	2	2	2	2	2	2
F5	2	1	2	3	0	1	1	3	3	1
F6	2	1	2	3	2	0	1	3	3	1
F7	2	1	2	3	2	2	0	1	3	2
F8	2	2	2	3	2	2	2	0	3	2
F9	2	2	2	3	2	2	2	2	0	2
F10	2	1	2	3	2	2	1	3	3	0

Step 3: Normalized direct relation matrix "S"

Using the eqns. (4) and (5), the direct relation matrix is gets normalized. The normalized matrix is shown in Table 5.

Step 4: Total relation matrix "M"

With the assistance of the eqn. (6). The total relation matrix was set up and shown in Table 6.

Step 5: Obtain Sum of rows and columns

The sum of rows (D) and sum of Columns (R) is obtained through eqns. (7) and (8) which is shown in Table 7.

Step 6: Set up casual diagram

With the assistance of sum of rows and sum of columns the causal diagram is set up and it is shown in fig 2.

Phase IV: Result validation

Once the result obtained from Phase III, then the results are validated in Phase IV. In this phase theresults were validated through the feedback of case industrial managers through the discussions.

Table 5: Normalized direct relation matrix "*S*"

	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10
F1	0	0.12	0.08	0.16	0.04	0.04	0.12	0.16	0.16	0.12
F2	0.08	0	0.08	0.12	0.08	0.08	0.08	0.04	0.12	0.08
F3	0.04	0.12	0	0.16	0.04	0.04	0.12	0.16	0.16	0.12
F4	0.08	0.08	0.08	0	0.08	0.08	0.08	0.08	0.08	0.08
F5	0.08	0.04	0.08	0.12	0	0.04	0.04	0.12	0.12	0.04
F6	0.08	0.04	0.08	0.12	0.08	0	0.04	0.12	0.12	0.04
F7	0.08	0.04	0.08	0.12	0.08	0.08	0	0.04	0.12	0.08
F8	0.08	0.08	0.08	0.12	0.08	0.08	0.08	0	0.12	0.08
F9	0.08	0.08	0.08	0.12	0.08	0.08	0.08	0.08	0	0.08
F10	0.08	0.04	0.08	0.12	0.08	0.08	0.04	0.12	0.12	0

Table 6: Total influence matrix "*M*"

	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10	D
F1	0.323346	0.418836	0.412705	0.658951	0.348407	0.335503	0.434945	0.551739	0.635417	0.451673	4.571521
F2	0.323678	0.239263	0.336127	0.509748	0.31169	0.300145	0.325388	0.362227	0.491542	0.337903	3.537711
F3	0.348407	0.403323	0.323346	0.634545	0.335503	0.323077	0.418836	0.531304	0.611883	0.434945	4.365169
F4	0.312546	0.302561	0.324567	0.385075	0.300971	0.289824	0.314198	0.382884	0.442751	0.326283	3.38166
F5	0.301412	0.261161	0.313005	0.474683	0.216175	0.245205	0.271205	0.403356	0.45773	0.281636	3.225569
F6	0.313005	0.271205	0.325044	0.49294	0.301412	0.216175	0.281636	0.41887	0.475335	0.292468	3.388091
F7	0.31169	0.267438	0.323678	0.490868	0.300145	0.289029	0.239263	0.348811	0.473337	0.325388	3.369647
F8	0.336127	0.325388	0.349055	0.529353	0.323678	0.31169	0.337903	0.337697	0.510448	0.3509	3.712238
F9	0.324122	0.313767	0.336588	0.510448	0.312118	0.300558	0.325835	0.397065	0.385075	0.338368	3.543944
F10	0.325044	0.281636	0.337545	0.511899	0.313005	0.301412	0.292468	0.434981	0.493617	0.265256	3.556863
R	3.219377	3.084579	3.38166	5.19851	3.063103	2.912618	3.241679	4.168933	4.977135	3.40482	

RESULTS

Table 8: Sum of influences given and received on criteria

Factors	D	R	D-R	D+R
F1	4.571	3.219	1.352	7.790
F2	3.537	3.219	0.453	6.622
F3	4.365	3.219	0.983	7.746
F4	3.381	3.219	-1.816	8.580
F5	3.225	3.219	0.162	6.288
F6	3.388	3.219	0.475	6.300
F7	3.369	3.219	0.127	6.611
F8	3.712	3.219	-0.456	7.881
F9	3.543	3.219	-1.433	8.521
F10	3.556	3.219	0.152	6.961

Fig 2: Causal diagram with degree of central role and degree of relation

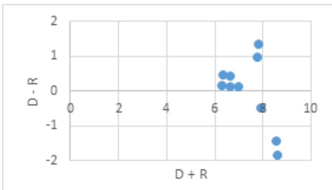

Table 9: Influential rank among factors

S. No	Factors	Influence rank
1	Yield losses **(F1)**	1
2	Pollination **(F2)**	4
3	Pest & disease suppression **(F3)**	2
4	Enemies hypothesis and increased natural enemy density **(F4)**	10
5	Soil fertility maintenance **(F5)**	5
6	Biodiversity conservation **(F6)**	3
7	Spread of plant pathogens **(F7)**	7
8	Reduced visual aesthetics **(F8)**	8
9	Death of Crop plants **(F9)**	9
10	Trap crops **(F10)**	6

CONCLUSIONS

In this paper, the common motivating factors which has a significant importance to manage the weeds associated arthropods in agricultural field were collected from two way assistance namely collected from existing literatures and validated through agricultural expert's opinion. The collected factors are analysed through DEMATEL to predict the most influential factor which has a positive impact on weeds associated arthropods management in agricultural field. From this study it is clearly revealed that Yield losses **(F1)** is the most influential factor among other common factors because the even though weeds associated arthropods possess many benefits but still lack behind in the economic advantage in terms of yields loss and according to . Next to **F1**, No pest & disease suppression **(F3)**, bio diversity conservation**(F6)** and pollination **(F2)** are captured the second, third and fourth position respectively in most influential factors which pressures the weeds associated arthropods management. With the assistance of this study,farmers and agricultural officers can able to know the importance of weeds associated arthropods in agricultural field. Even though this provides many societal contributions but still not exception with limitations. This study consider a single location in UsilampattiTalukto validate the model, hence the generalization of the study is still a question, and hence this study can be extended with statistical analysis. In future, this study also extended with more motivating factors of weeds associated arthropods management from different are of agricultural field. However this study shed some light on the integrated pest management concept in theSouth region of India, UsilampattiTaluk.

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