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Farmers' Network Analysis on Diffusion and Adoption of CAU-R1 Variety in Imphal East District of Manipur

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Authors' contributions

This work was carried out in collaboration between both authors. Authors SSPJ and LD designed the study, performed the statistical analysis, wrote the protocol and the first draft of the manuscript and managed the analyses of the study. Both the authors read and approved the final manuscript.

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ABSTRACT

Food security with increased and sustained production of the major cereal crops in India is the need of the hour. The role of farmers as informal extension agents has been depicted in many recent studies emphasising the need for studies on network linkages between the farmer communities and the stakeholders in dissemination and adoption of improved technologies. The present study has been conducted to understand the role of social networks in the diffusion of CAU-R1 variety among the farmers of Manipur. The research design employed was exploratory and the sampling procedure was mixed sampling with purposive sampling for the selection of the state, district and key farmers. Snowball sampling was used to identify other farmers in the network. The sample size was 64 farmers from eight villages in Imphal East district. The socio-economic profile of the farmers showed that majority belonged to medium age between 36 years to 50 years, medium level of innovativeness, social participation, cosmopoliteness and risk bearing ability. The Social Network

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Analysis measures employed for the study were the centrality measures that include the degree, closeness and betweenness centrality to identify the most central, influential and powerful actors in the network. The average in-degree and out-degree was found to be equal for all the villages with a maximum degree centrality of 16. The betweenness centralization index of the networks was very low (24.55%) indicating very slow rate of spread of information and information sharing restricted only between few actors in the network. Social participation and trainings were positively correlated while the farming experience and time taken for adoption were negatively correlated with the network measures. The outcomes revealed that there is need for a more concerted effort by the farmers and stakeholders to sensitize farmers about the variety through exposure visits, trainings, incentives and timely input supply.

Keywords: Rice; CAU-R1; Manipur; social network analysis; centrality measures.

1. INTRODUCTION

Innovation diffusion has always been a challenging task in rural areas owing to the heterogeneity of the rural social structure bordered by cultural values, customs and beliefs of the rural dwellers, socio-economic factors and the inherent uncertainty associated with innovations. Indian economy is dominated by agriculture as its major occupation with farmers as their epicentre. The extension strategy behind the success of the Green Revolution programme lies in the fact that the large farmers reaped the most benefits while the small and marginal still remain departed from the advanced technology [1,2]. This was due to the limited number of extension personnel who could not make it to reach each and every farmer in the rural villages [3].The reason behind the failure of the system to reach the most needed farmer was not being able to make effective use of the informal farmer networks in the villages which function as competent innovation diffusion systems [4,5]. Farmers have diverse information needs and reach out to multiple sources of information among which the Agriculture department is just one. Most of the farmer's needs are satisfied by their peer farmers, neighbourhood farmers, relatives and friends followed by extension agents [6,7,8,9] expressed that interpersonal exchange of information is the heart of diffusion process. [10] orated that diffusion of an innovation lies in effective sharing about the innovation to a group of prospective adopters who will inspire majority of other adopters to think through, adopt, implement and sustain the value of the innovation. Village communities are heterogeneous units comprising of multifaceted networks of social relationships among different socio-economic groups and power relations. The rural agricultural societies are generally known for their lifelong strong social ties that prevail through their small informal networks [11]. These social relationships often result in informal invisible networks which provide strong basis for information sharing. Social networks are mechanisms that connect individuals to the society, providing patterns of social inclusion and identities [12]. Informal social networks are 'face-to-face relationships between a limited number of individuals who know each other and are bound together by kinship, friendship, or propinquity' [13].

The study was carried out in Manipur state of North East India. Rice is the staple principal food crop of the North East Region. Among the North Eastern States, Manipur stands third in area and production [14]. Population has increased by 12.05% during 2001-2011, whereas the state has registered negative annual growth (-0.48%) in the case of area under rice during 2000-01 to 2011-12 [15]. In this conjunction, the Central Agricultural University (CAU) located at Imphal has developed a series of CAU-R series High Yielding Varieties of Rice namely CAU-R1, CAU-R2, CAU-R3 and CAU-R4. Among them, the CAU-R1 locally named as Tamphaphou was released in 2009 and distributed among the farmers for cultivation. This variety has been recorded for its best performance in the farmers' field and bagged many prestigious awards from the Government of Manipur during the last few years. Hence the present study has been conducted with an objective to understand and analyse the role of farmers' informal networks in the diffusion and adoption of the CAU-R1 variety among the farmers of Manipur.

2. METHODOLOGY

The study has been conducted in Imphal East district of Manipur. The research design employed for the study is exploratory. The

sampling is mixed method sampling in which the state and district were purposively selected based on the best performance of the variety while the key farmers were selected purposively according to the list of farmers who procured CAU-R1 variety seeds from the office of the Directorate of Research of the CAU, Imphal. The remaining farmers were selected through name generator technique where the purposively selected farmers suggested names of other farmers with whom they shared information about CAU-R1 and subsequently those farmers were interviewed. The final sample size was 63 farmers from four major villages namely YairipokYambem, Nangbrung, Khurai, and Khabam Mamang Leikai. Primary data were collected using pre-tested structured interview schedules, focussed group discussions and key informant interviews during 2018. Statistical analysis was carried out using SPSS 21 version software and Social Network Analysis was done using the UCINET Version 6 software.

Descriptive statistics frequency and percentages were mostly used for all the variables. Socio-personal and economic variables (age, gender, education, family type, family size, occupation, farming experience, operational land holding and land ownership) were analysed based on frequency, percentages, mean and standard deviation. Communication variables like cosmopoliteness, social participation, innovativeness and risk bearing ability were measured on a 5 point continuum of Strongly Agree (5), Agree (4), Undecided (3), Disagree(2) and Strongly Disagree (1) for positive statements and vice versa for negative statements. The data collected was tested for normality using one-sample test of kurtosis and skewness. Based on the normality, the scores for these variables were categorised in low, medium and high categories using mean and standard deviation. Regarding the adoption variables, the five perceived innovation attributes identified in Roger's Diffusion of Innovations theory viz., relative advantage, complexity, compatability, trialability and observability were considered. Rating against each of the attributes was enumerated during the data collection and frequency percentage analysis was carried out. The extent of adoption was measured on a 3 point continuum of fully adopted, partially adopted and not adopted against 18 packages of practices. The 18 package of practices considered for the study are listed below (Table 1):

Table 1. List of package of practices

S.N	Package of Practice
1	**Nursery management**
	i. Seed rate
	ii. Recommended doses of fertilizers/pesticides
2	**Transplanting**
	i. Time of transplanting
	ii. Method of transplanting
	iii. Recommended spacing
	iv. No. of plants per hill
3	**Nutrient management**
	i. Recommended dose of Nitrogen (N)
	ii. Recommended dose of Phosphorus (P)
	iii. Recommended dose of Potassium (K)
4	**Irrigation management**
	i. Time of irrigation
	ii. Level of irrigation
	iii. Method of irrigation
5	**Pest and disease management**
	i. Brown Plant Hopper
	ii. Bacterial Leaf Blight
	iii. Blast
	iv. Others
6	**Harvesting and threshing**
	i. Time of harvesting
	ii. % moisture in the grain
	iii. Threshing method

The adoption index was calculated using the formula

$$\text{Adoption Index} = \frac{Individual\ obtaining\ score}{Maximum\ score\ possible} \text{ X } 100$$

The time taken for adoption of the CAU-R1 variety was measured in terms of number of years the respondent took to decide for cultivating the variety in his/her field from the time they knew or heard about the variety (arbitrarily taken as the year in which the variety was first introduced in their village i.e, 2009 for all the four villages). Five adopter categories given by Rogers [9] were adopted and classified from 2009 to 2017. The status of adoption decision was taken as adopted if continued cultivation of CAU-R1 in the field, rejected if not cultivating and replacement if the respondents have gone for any other varieties than CAU-R1.

The Social Network measures undertaken for the study were the centrality and cohesive measures. The Centrality measures were used to identify the most 'central' and 'influential' actors in the network. The degree centrality, closeness centrality and the betweenness centrality measures were computed for centrality. Centrality is a characteristic of an actor's position in a network. Degree centrality is the number of connections an actor (node) has in the network. There are two types of degree centrality measures namely In-degree and Out-degree. In-degree is the number of ties received by the actor and out-degree is the number of ties sent by the actor. Out-degree typically indicates influence while in-degree indicates prestige or popularity of the actor in the network. The Degree centrality was measured by asking to name three to five farmers with whom he/she has shared information about CAU-R1 variety and from whom he/she has received information about the variety. Closeness centrality emphasizes the distance of an actor to all others in the network. The closer one is to others in the network, the more favoured is that actor's position. Closeness centrality was measured by asking the geographical distance of closeness from home and field of the farmers with whom he/she has received and shared information about the variety. Degree centrality measures one's local position, while closeness centrality measures the position globally. However, Closeness is meaningful only for a connected network and indefinite for disconnected network [16]. Betweenness centrality is the extent to which an actor falls on the geodesic paths between other pairs of actors in the network. The more people depend on an actor to make connections with others, the more power that actor has in the network [17]. This property was measured by asking how frequently they share information about the variety such as daily, weekly, fortnightly, seldom and never. Network centralization Index is a group measure which measures the extent to which a set of nodes/ ties/ actors in a network are organized around a central point is used to measure the degree of scattering of centrality scores all the nodes in a network from the maximum centrality score obtained in the network. It is an overall network index used to measure the variability or heterogeneity of the node centralities. The network centralization index measures the centrality of the most central node in a network compared to other nodes [18]. A network with high centralization index value indicates a dominant communication between few influential actors in the network while low centralization index value implies many actors communicate freely with each other.

3. RESULTS AND DISCUSSION

3.1 Characteristics of the Adopters

As depicted in Table 2, majority of the respondents among all the four villages belonged to middle age category (35-50 years) accounting to 66% on the whole and 88.88% of them were male. The educational qualifications of the respondents when observed across the four villages showed that majority of them attained secondary education while in Khurai 55% of them were graduates. The overall proportion of the respondents indicates 53.96% to have attained secondary level of education. 71.42% of the overall respondents had medium family size of 4-6 members and 73.01% of them lived in joint families. Agriculture was the primary occupation of 84.12% of respondents across the four villages while 15.87% had other occupations such as drivers, carpenters, petty businesses and Teacher in addition to agriculture. The average annual income of the respondents in the four villages ranged between ≠49, 286 to ≠1, 38, 250 with 60.31% of them belonging to medium income category according to the classification given by Ncaer [19]. Except in Nangbrung (47.37%), remaining three villages had respondents with semi-medium (>2 to 4 ha)

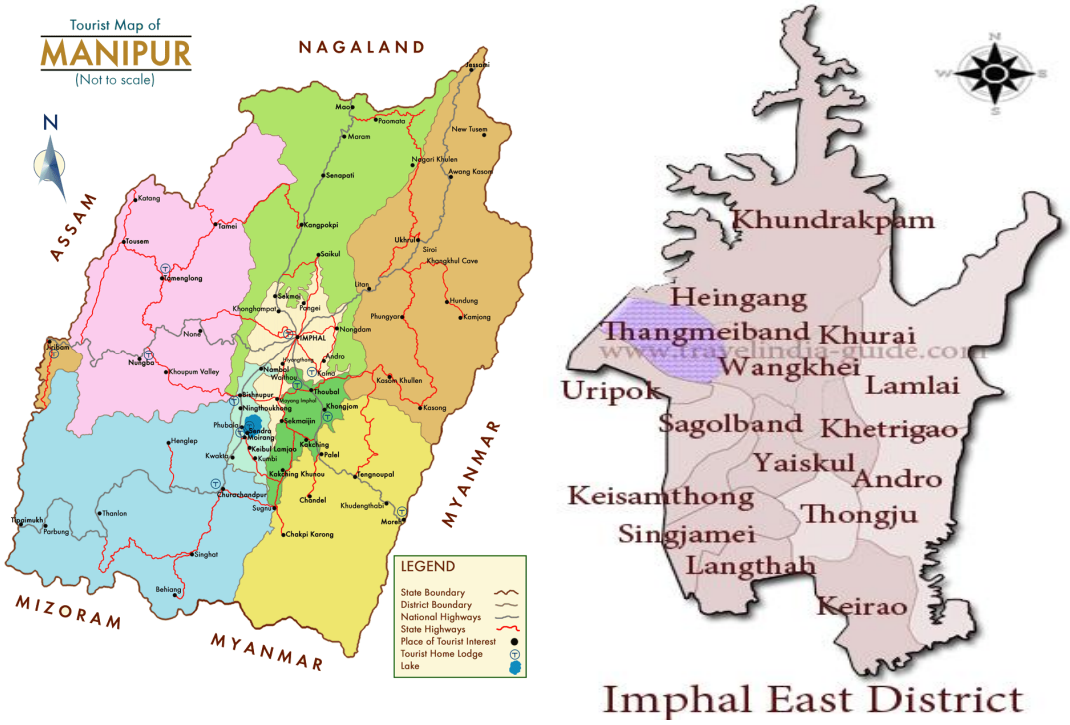


Fig. 1. Location of the study area

operational landholding with an overall of 44.44% and the farming experience was medium ranging between 10-20 years holding 68.25% of the respondents. 79.36% of respondents on the whole practised farming in their own lands and 20.36% of them leased in the land for cultivation. The respondents had high social participation in Yairipok (82.35%) and Nangbrung (84.2%), medium participation in Khurai (53.84%) and low in Khabam Mamang leikai (100%). In Yairipok and Nangbrung all the respondents were members of the social organizations prevailing in their villages such as Farmers Cooperatives, Farmer Clubs, Civil society organizations etc. In Yairipok, the Langei Producers Cooperative Limited organization is present in which majority of the farmers are members. This organization in collaboration with the CAU, Imphal conducts and monitors the Participatory Seed Production Programme while in Nangbrung, Progressive Farmers Club has all the respondents as members. This organization works for providing technical inputs and advisory services regarding SMART practices of Paddy cultivation. However, the overall social participation of the respondents was high totalling to 57.14 percent. 74.60 percent, 60.31% and 61.90% of the respondents showed medium level of cosmopoliteness, innovativeness and risk bearing ability. However, in Khabam village 71.43% of them had low risk bearing ability. The trainings attended by the respondents was found to have considerable impact on the adoption and diffusion of the variety and hence the variable was studied in detail and the results revealed that 55.65% and 15.79% of the respondents from Yairipok and Nangbrung did not attend any trainings while 25% and 57.14% from Khurai and Khabam attended trainings once. 37.5% each of the respondents from Yairipok reported that they attended trainings twice and thrice respectively while 25% attended trainings more than four times. In Nangbrung, 56.25% and 43.75% of them attended trainings twice and thrice respectively and 35%, 25% and 15%of the respondents from Khurai attended trainings twice, thrice and more than four times respectively. In Khabam no one attended trainings more than three times while 42.85% of them attended trainings twice. On the whole 46.03% of the respondents attended training once. Trainings on CAU-R1 revealed that 100% from Khabam, 63.15% from Nangbrung and 35.29% from Yairipok attended trainings while no one attended any training on CAU-R1 from Khurai. However, on the whole only 39.68% of respondents attended trainings on CAU-R1.

Table 2. Profile of CAU-R1 adopters

S.N	Variable	Yairipok (N = 17)	Nangbrung (N = 19)	Khurai (N = 20)	Khabam (N = 7)	Overall(N = 63)
1.	**Age**					
	Young (<35 years)	3 (17.64)	4 (21.05)	3 (15)	1 (5)	11(17.46)
	Middle (35-50 years)	12 (70.58)	12 (63.15)	14 (70)	4 (20)	42 (66.66)
	Old (>50 years)	2 (11.76)	3 (15.78)	3 (15)	2 (10)	10 (15.87)
2.	**Gender**					
	Male	15 (88.23)	16 (84.21)	18 (94.73)	7 (100)	57 (88.88)
	Female	2 (11.77)	3 (15.79)	1 (5.26)	0 (0)	6 (9.52)
3.	**Educational Qualifications**					
	Illiterate	0 (0)	1 (5.26)	0 (0)	0 (0)	1(1.58)
	Primary	1 (5.88)	0 (0)	1 (5)	0 (0)	2 (3.17)
	Secondary	13 (76.47)	9 (47.37)	8 (40)	4 (57.14)	34 (53.96)
	Graduate	2 (11.77)	9 (47.37)	11 (55)	3 (42.86)	25 (39.68)
	Post Graduate	1 (5.88)	0 (0)	0 (0)	0 (0)	1 (1.58)
4.	**Family Type**					
	Joint	10 (58.82)	15 (78.94)	15 (75)	6 (85.71)	46 (73.01)
	Nuclear	7 (41.18)	4 (21.06)	5 (25)	1 (14.28)	17 (26.98)
5.	**Family Size**					
	Small (<4)	0 (0)	2 (10.53)	3 (15)	0 (0)	5 (7.93)
	Medium (4-6)	11 (64.70)	15 (78.9)	14 (70)	5 (71.43)	45(71.42)
	Large (>6)	6 (35.29)	7 (36.84)	3 (15)	2 (28.57)	18(28.57)
6.	**Occupation**					
	Agriculture	15 (88.23)	17 (89.47)	15 (75)	6 (85.71)	53(84.12)
	Agriculture + Others	2 (11.76)	2 (10.53)	5 (25)	1 (14.28)	10 (15.87)
7.	**Annual Income**					
	Low (≤ 33,750)	3 (17.65)	1 (5.26)	0 (0)	2 (28.57)	6 (9.52)
	Medium (33,751 - 1,44,000)	13 (76.47)	12 (63.15)	8 (40)	5 (71.42)	38 (60.31)
	High (> 1,44,000)	1 (5.88)	6 (31.6)	12 (60)	0 (0)	19 (30.15)
	Mean	89,706	1,25,000	1,38, 250	49, 286	
8.	**Farming Experience**					
	Low (>10yrs)	0 (0)	1 (5.26)	0 (0)	0 (0)	1 (1.58)
	Medium (10-20yrs)	16 (94.11)	14 (73.68)	8 (40)	5 (71.43)	43 (68.25)
	High (20-30yrs)	1 (5.88)	4 (21.05)	12 (60)	1 (14.28)	18 (28.57)

S.N	Variable	Yairipok (N = 17)	Nangbrung (N = 19)	Khurai (N = 20)	Khabam (N = 7)	Overall(N = 63)
9.	**Operational Landholding**					
	Marginal (<1ha)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
	Small (≥1 to 2ha)	6 (35.29)	9 (47.37)	7 (35)	2 (28.57)	24 (38.09)
	Semi Medium (>2 to 4 ha)	9 (52.94)	5 (26.31)	11 (55)	3 (42.86)	28 (44.44)
	Medium (>4 to <10 ha)	2 (11.76)	5 (26.31)	2 (10)	2 (28.57)	11 (17.46)
	Large (>10 ha)	0 (0)	0 (0)	0	0 (0)	0(0)
10.	**Land Ownership**					
	Own	14 (82.35)	14 (73.68)	16 (80)	6 (85.71)	50 (79.36)
	Lease	3 (17.64)	5 (26.31)	4 (20)	1 (14.28)	13 (20.63)
11.	**Social Participation**					
	Low	0(0)	0 (0)	0 (0)	7 (100)	7 (11.11)
	Medium	3 (17.65)	3 (15.78)	7 (53.84)	0(0)	13 (20.63)
	High	14 (82.35)	16 (84.2)	6 (46.15)	0(0)	36 (57.14)
12.	**Cosmopoliteness**					
	Low	1 (5.88)	5 (26.31)	9 (45)	1 (14.28)	16 (25.39)
	Medium	16 (94.11)	14 (73.68)	11 (65)	6 (85.71)	47 (74.60)
	High	0 (0)	0 (0)	0 (0)	0 (0)	0(0)
13.	**Innovativeness**					
	Low	3 (17.64)	7 (36.84)	5 (25)	1 (14.28)	16 (25.39)
	Medium	11 (64.70)	12 (63.15)	11 (55)	4 (57.14)	38 (60.31)
	High	3 (17.64)	0 (0)	4 (20)	2 (28.57)	9 (14.28)
14.	**Risk Bearing Ability**					
	Low	4 (23.53)	5 (26.31)	5 (25)	5 (71.43)	19 (30.15)
	Medium	12 (70.59)	12 (63.15)	13 (65)	2 (28.57)	39 (61.90)
	High	1 (5.88)	2 (10.52)	2 (10)	0 (0)	5(7.93)
15.	**Number of agriculture related trainings attended**					
	Never	9 (55.65)	3 (15.79)	0 (0)	0 (0)	12 (19.04)
	Once	0 (0)	0 (0)	5 (25)	4 (57.14)	29 (46.03)
	Twice	3 (37.5)	9 (56.25)	7 (35)	3 (42.85)	22 (34.92)
	More than twice	5 (62.5)	7(43.75)	8 (40)	0 (0)	20 (31.74)
16.	**Attended trainings on** CAU-R1	6 (35.29)	12 (63.15)	0 (0)	7 (100)	25(39.68)

**Figure in parenthesis indicate percentage to the total*

3.2 Adoption Characteristics of the Adopters

In order to understand the adoption of CAU-R1, certain adoption characteristics of the selected respondents were studied and the results are presented in Table 3. 100% of the respondents from Yairipok, Nangbrung and Khabam reported relative advantage of CAU-R1 variety was higher than the other traditional or HYV varieties while in Khurai only 60% of them opined relative advantage as favourable. The perceived advantages of CAU-R1 were high yield, short duration and resistant to drought as reported by the farmers. Nangbrung, Khurai and Khabam respondents reported that the cultivation of CAU-R1 was not complex while 11.76% of them from Yairipok felt it as complex to cultivate than other varieties. All the respondents from Nangbrung, Khurai and Khabam perceived the CAU-R1 variety as highly compatible with the existing agro-ecological condition and also with the previous grown varieties while in Yairipok 88.23% perceived CAU-R1 as compatible. 52.94%, 68.42%, 55% and 100% of the respondents from Yairipok, Nangbrung, Khurai and Khabam said that the CAU-R1 variety was easy to try in their fields. All the respondents from the four villages confirmed that the varietal performance of CAU-R1 was highly observable in terms of average yield of 5-6t/ha which was very high compared to local and other high yielding varieties giving 3-4t/ha and uniform plant height with beautiful golden lustrous shine (Tampha – local meaning gold).

The extent of adoption revealed that 58.82% from Yairipok, 47.37% from Nangbrung, 50% from Khurai and 71.42% from Khabam partially adopted the recommended package of practices while 41.17% of the respondents from Yairipok fully adopted the practices. Totally 53.96% of them partially adopted the recommended package of practices. Among the 18 recommended package of practices mentioned above, it was observed that seed rate, time of harvesting and threshing method were having high adoption score (93) because the practises are same for other varieties as well and doesn't require much technical knowledge or skills. The practice with least adoption score was the pest and disease management (79) reason being the farmers used the commonly available pesticides/fungicides available at the local input dealers rather than applying the recommended crop protection measures. This can also be attributed to the lack of awareness and knowledge about the recommended package of practices about the CAU-R1 variety. This is because the previous crop grown is rice which is having similar package of practices except for a few recommended practices such as seed rate, fertilizers and pesticides etc. Hence the farmers did not emphasize much on the specific practices assuming that there would not be much difference in the production. Similar findings were reported by Prasad et al. [20] in their study among rice farmers of Rajasthan.

The time taken for adoption of the CAU-R1 variety was measured in terms of number of years the respondent took to decide for cultivating the variety in his/her field from the time they knew or heard about the variety (arbitrarily taken as the year in which the variety was first introduced in their village i.e, 2009 for all the four villages). Five adopter categories given by Rogers [9] were adopted and classified from 2009 to 2017 and the results revealed that very few (5.88%, 15.79% and 5%) of them from Yairipok, Nangbrung and Khurai respectively adopted the variety within one year and in Khabam no one adopted. In Yairipok village, 41.17% of them adopted during 2011-2012, in Nangbrung 36.84% of them adopted during 2016-2017, in Khurai 70% (35% during 2013-2015 and 45% during 2016-2017) of them were found to adopt the variety during 2013 – 2017 and in Khabam 57.14% in 2016-2017 followed by 42.86% during 2013-2015. 11.76% of them from Yairipok, 21.05% from Nangbrung and 10% from Khurai have adopted the variety in the year 2018 thereby constituting the laggards category of adopters. It can be observed that 34.92% of the total respondents adopted the variety during 2016-2018 i.e., after 6-8 years of first information there by belonging to the late majority category of adopters.

Out of the adopter respondents selected for the study, around half of the respondents in all the villages continued adoption of CAU-R1 till the time of data collection. The remaining respondents had replaced CAU-R1 with other rice varieties, mainly due to disenchantment. The proportion of replacement of the variety due to previous experience in terms of taste and market price was predominant than that of adoption. In Yairipok, 58.8% of them adopted while 41.18% replaced the variety with the local traditional varieties such as Maniphou, Moirangphou etc and the RCM series varieties developed by the ICAR-RC Manipur Centre. In Nangbrung 57.89% of them replaced the variety owing to the similar

reasons highlighted above and 42.10% adopted the variety. In Khurai village, 60% of them adopted and 40% of them replaced while in Khabam 57.14% replaced the variety and 42.85% adopted it. The overall% of adoption was higher (52.38%) when compared to replacement due to disenchantment (47.61%). The reasons for replacement were that generally Manipuri people prefer sticky aromatic rice for their daily consumption. The local traditional varieties are known for their stickiness and fragrance. The CAU-R1 variety has been developed as a cross between Leimaphou and BR1 variety, therefore the gluten content is not as high as the traditional variety and less chalkiness was observed. This was the primary reason for replacement to traditional varieties and if the farmer wants to sell the produce in the market for income generation, the market demand for the variety was negligible. Only those farmers who were producing the quality seed for CAU, Imphal under the Participatory Seed Production programme could get some revenue as a part of the buyback policy of the institute and all others were left out with no options to disburse the produce. With these limitations the farmers have replaced the variety. Similar findings were reported by Tura et al. [21] Oladele and Wakatsuki [22]. Another major reason cited by the respondents for replacement of the variety was lack of monitoring and evaluation from the developing institute in terms of performance of the variety at the farmers field. The farmers expected to have frequent visits and feedback mechanisms from the CAU, Imphal regarding their queries about the varietal performance.

3.3 Centrality Measures

The centrality measures of the selected villages and the respondents are presented in Table 4.

The adoption or rejection of an innovation is in general affected by peer groups in a system. Network may be of various types such as small-world networks, star networks, free-scale networks etc. For the speedy diffusion and adoption of an innovation within a social system, identification of potential adopters is required. In the present study though eight villages were surveyed and 79 respondents were interviewed, only 63 of them from four major villages were considered for network analysis. This was because Luwang, Heingang, Pangei and Utlonglok had respondents in very small number (<5) and the centrality measures for these villages could not be generated owing to their small size. Hence for the study only four villages

Table 3. Adoption profile of the adopters

S.N	Variable	Yairipok (N=17)	Nangbrung (N=19)	Khurai (N=20)	Khabam (N=7)	Overall (N=63)
1.	**Perceived innovation attributes**					
	Relative Advantage	17 (100)	19 (100)	12 (60)	7 (100)	63 (100)
	Complexity	2 (11.76)	0 (0)	0 (0)	0 (0)	2 (3.17)
	Compatibility	15 (88.23)	19 (100)	20 (100)	7 (100)	61 (96.82)
	Trialability	9 (52.94)	13 (68.42)	11 (55)	7 (100)	40 (63.49)
	Observability	17 (100)	19 (100)	20 (100)	7 (100)	63 (100)
2.	**Extent of adoption of recommended package of practices**					
	Fully Adopted	7 (41.17)	3 (15.78)	3 (15)	2 (28.57)	15 (23.80)
	Partially Adopted	10 (58.82)	9 (47.37)	10 (50)	5 (71.42)	34(53.96)
	Not Adopted	0 (0)	7 (36.84)	7 (35)	0 (0)	14 (22.22)
3.	**Time taken for adoption**					
	>1yr	1 (5.88)	3 (15.79)	1 (5)	0 (0)	5 (7.93)
	1-2yrs	7 (41.17)	2 (10.52)	1 (5)	0 (0)	10 (15.87)
	3-5yrs	5 (29.41)	3 (15.79)	7 (35)	3 (42.86)	18 (28.57)
	6-8yrs	2 (11.76)	7 (36.84)	9 (45)	4 (57.14)	22 (34.92)
	>8yrs	2 (11.76)	4 (21.05)	2 (10)	0 (0)	8 (12.69)
4.	**Status of adoption decision**					
	Continued Adoption	10 (58.8)	8 (42.10)	12 (60)	3 (42.85)	33 (52.38)
	Replacement (Disenchantment discontinuance)	7 (41.18)	11 (57.89)	8 (40)	4 (57.14)	30 (47.61)

Figure in parenthesis indicate percentage to the total

Table 4. Centrality measures of the villages

S.N	Villages	Network size	Social network properties								
			Average In-degree	Maximum In-degree	Average Out-degree	Maximum Out-degree	Network Centralization (Out-degree)	Network Centralization (In-degree)	Network Betweenness Centralization	Network in-closeness centralization	Network out-closeness centralization
1	Yairipok Yambem	17	7.3	16	7.3	16	57.81	57.81	28.68	73.34	74.38
2	Nangbrung	19	4.7	13	4.7	12	59.11	52.00	36.29	99.78	28.96
3	Khurai	20	3.9	8	3.9	8	22.72	22.72	24.55	-	-
4	Khabam Mamang Leikai	7	3.6	6	3.6	6	47.22	47.22	43.70	69.06	69.67

were considered and in Table 4, it can be observed that among the four villages studied, the maximum network size is inKhurai (20), Nangbrung (19) and YairipokYambem (17). The reason for having more respondents from these villages was that Yairipok and Nangbrung villages were involved in the Participatory Seed Production Programme of the Central Agricultural University, Imphal. Most of the farmers grew the variety as per the recommended SMART package of practices of the variety and CAU buyback the seeds for further distribution to other areas. Khurai village though not involved any official agreement with the CAU had many respondents because of its more geographical area and comparatively closely located to the CAU College of Agriculture, Iroisemba and CAU Directorate of Research office, Lamphelphatthan the other three villages i.e., Yairipok, Nangbrung and KhabamMamangLeikai. Below displayed and explained are network maps of the selected villages.

i. Degree Centrality

The average in-degree and out-degree was equal for all the villages which was similar to the findings as reported by Oladele and Wakatsuki [22] and the highest was YairipokYambem with 7.3 and Nangbrung approximately 5 (4.7). The maximum in-degree and out-degree centrality were 16 in Yairipok. The nodes with higher out-degree are more central while the ones with higher in-degree are the most prestigious. From Fig. 2 we can visualize that in Yairipok Yambem village farmers Jugindro Singh, James Kumar Singh, Ch. Borajao, L Mohindro and Kh. Ibocha Singh are more central with highest in-degree and Jugindro Singh, KhIbocha Singh, and James Kumar Singh are more prestigious with high out-degree values. However, Shantikala Devi, S. Sandhya Devi, Thoithoi and Y. Inguo have the least in-degree and out-degree values. In Nangbrung village, LaishramIbomcha is most powerful and prestigious with highest In-degree (22) and Out degree (10). I Angonjam is next central to Laishram Ibocha with an in-degree of 10 followed by Shyamjai, Ningombam Bina, Biren and Koken with In-degree 9. Highest out-degree is seen for N. Biren (12) followed by LaishramIbomcha, N Shyamjai and M Samjai without-degree of 10 implying their prestige. Khurai village had the highest network size with 20 respondents but the network is very scattered showing no linkages between few actors with fragments and components. The important central actors are Th. Brajamohan (10), Ch. Thambalngou (9) and Ngankham Chouba (8) in-degree values. Regarding the prestigious actor only Ngankham Chouba with a value of 8 was found while remaining others had a maximum out-degree value of 5. Among the seven actors in Khabam village only one respondent Y. Bhogendro was the most central and prestigious with the highest in-degree and out-degree value of 6 which implies that all the actors in the network reached him and he reached all the actors in the network.

The Network Centralization Index is a measure of hierarchy in centrality measures where the

closer the centralization scores is to 100% the more unequal the centrality scores are in different positions of the network [23]. The Network centralization Out-degree Index was more in all the four villages than the In-degree index implying greater hierarchy in the out-degree. The findings of the study were in complete conformity with the findings reported by Wasserman and Faust [24].

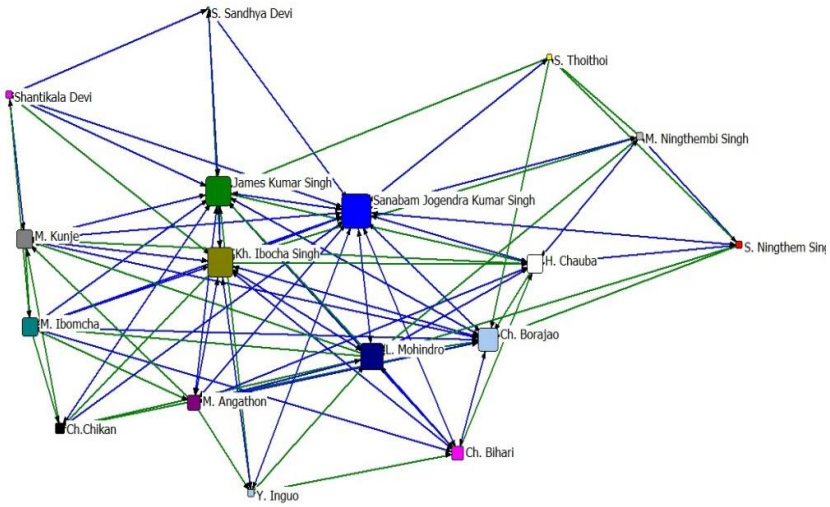
ii. Closeness Centrality

Closeness can be regarded as a measure of how long it will take to spread information from one node to all other nodes sequentially. The network closeness centralization index was generated for both in-degree and out-degree and according to Table 4 it was revealed that the closeness centralization for both in-degree and out-degree are the same for Yairipok and Khabam villages while zero for Khurai since there were assymetric graphs for which closeness centralization could not be generated. In case of Nangbrung village, it can be observed that network in-closeness centralization was very high approximately 100% (99.78%) and very low out-closeness centralization (28.96%) indicating that the reach of all the nodes to the central node was more easy than the central node reaching all other nodes in the network. The variation in the values is due to high centrality value for Laishram Ibomcha

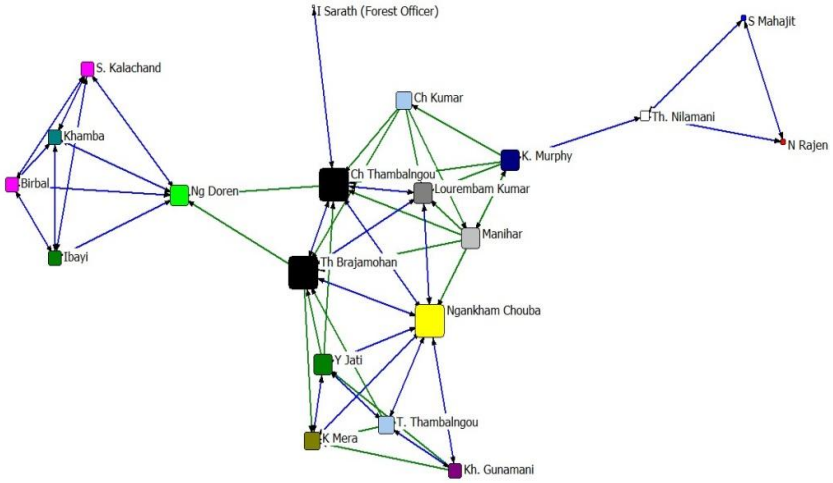
iii. Betweenness Centrality

Betweenness centrality is a measure for assessing the control of a node on the communication pattern in a social network. Nodes that have a high probability to occur on a randomly chosen shortest path between two randomly chosen vertices have a high betweenness. Actors with high betweenness are the ones whose removal from the network will most disrupt communications between other vertices because they lie on the largest number of paths taken by messages. From Table 4 the betweenness centralization index for all the villages was found to be very less. Yairipok (28.68%), Nangbrung (36.29%) and Khurai (24.55%) imply that communication is dominantly happening only between few central actors in the network while most of the farmers were not linked with the actors sharing the information. Khabam village had moderate (47.22%) betweenness centralization indicating that more than half of the actors had frequent communication on information sharing regarding CAU-R1 variety.

Based on the centrality values, the important central actors have been identified for all the four villages. In Yairipok village, Jugindro, Ch. Borajao, James Kumar Singh and Kh. Ibocha Singh were found to be most central, easy to reach and influential. In Nangbrung, L. Ibomcha, Leimba, Koken, M Shyamjai, N Biren, Ningombam Bina and N Samjai were found to be most central, easy to reach and influential. In Khurai, ThBrajamohan, ChThambalngou, NgankhamChouba and Lourembam Kumar were most central and in Khabam Y Bhogendro was the central actor.



A



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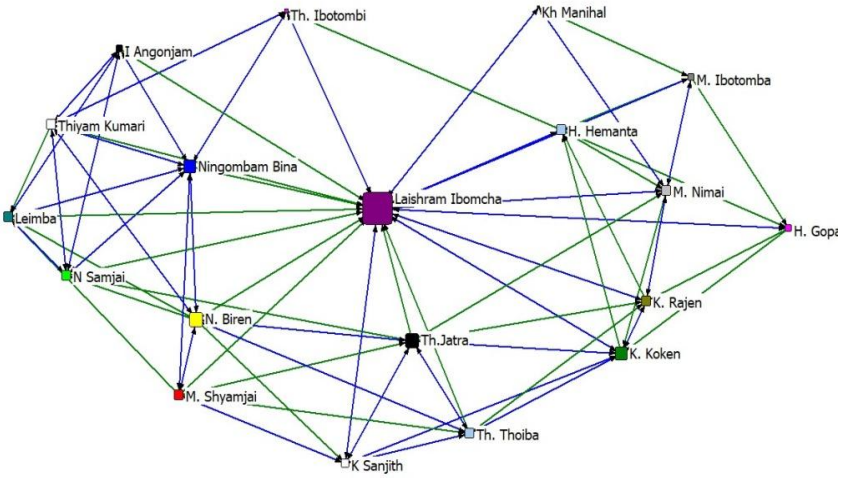
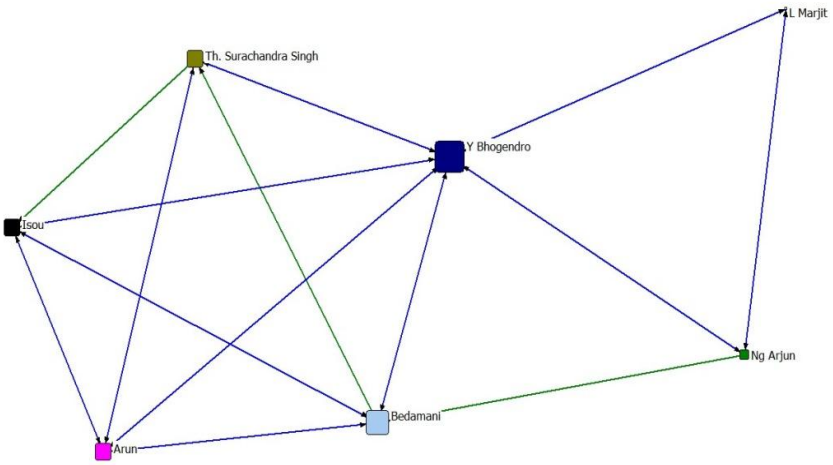


C



D

Fig . 2. Social network maps of Yairipok Yambem (A), Khurai (B), Nangbrung (C) and Khabam (D)

Table 5. Important actors in the village networks

Network measures	Yairipok	Nangbrung	Khurai	Khabam
Maximum In-Degree	Jugindro (24), Ch. Borajao (14), James (14), KhIbocha Singh (12), M Kunje (10)	L. Ibocha (22), Leimba (10), K Koken(9), N Shyamjai(9) Biren (9)	ThBrajamohan (10), ChThambalngou (9), NgankhamChouba (8), Lourembam Kumar (7)	Y.Bhogendro (6)
Maximum Out-Degree	Jugindro (25), Kh Ibocha Singh (19), James (14), L Mohindro(10), ChBorajao (10)	N Biren (12), M Shyamjai(10), N Samjai(10), L. Ibomcha (10), Ningombam Bina (9)	Ngankham Chouba (8), K.Murphy(5), Ch. Thambalngou(5), Th Brajamohan(5), Y Jati (5)	Y.Bhogendro (6)
Maximum In-Closeness	Jugindro (100), James (84.2), ChBorajao (80), KhIbocha (76.2), M Kunje (69.6)	L Ibomcha (100), K Koken (62.1), M Nimai (60), K Rajen (60) K Sanjith (60)	S Kalachand (100), Ng Doren (48.7), Khamba, (35.2), Birbal(35.2), Ibayi (35.2), ChThambalngou (15.6)	Y. Bhogendro (100)
Maximum Out-Closeness	Jugindro (100), KhIbocha (80), James (76.2), L Mohindro (72.7), M Angathon (66.7)	N Biren (66.7), Ningombam Bina (64.3), ThiyamKumari(62.1), MShyamjai (62.1), LaishramIbomcha (58.1)	S. Kalachand (100), Ch.Thambalngou(47.5) Th. Brajamohan (47.5), K Murphy (46.3), Lourembam Kumar (41.3)	Y. Bhogendro (100)
Maximum Betweenness	Jugindro (73.5), James (20.5), Kh.Ibocha (17.6), L. Mohindro (9.4), Ch. Borajao (6.8)	L Ibomcha (121.8), K Koken (28.7), Ningombam Bina (24.2), Th. Jatra (18.9), N. Biren (17.3)	NgankhamChouba (102.8), K Murphy (100), Ch. Thambalngou (77.8), Th. Nilamani (58.0), Th. Brajamohan (31.9)	Y Bhogendro (13.7)

Figure in parenthesis indicate centrality values

3.4 Effect of the Socio-economic Characteristics of the Farmers on the Network Measures

Studies have revealed that the personal, economic, social and psychological characteristics of the respondents have considerable influence on the network centrality measures in a social network. In light of this, correlation test has been done between the farmer characteristics and the network measures to analyse association if any. The correlation was done for the adopter characteristics and network measures only for those respondents who were included in the study and not all the respondents interviewed. This was to elucidate more accurate results that will represent the entire adopters. The Table 6 below is the output of the correlation results and their level of significance. The variables when tested for normality using the one sample test of kurtosis and skewness in SPSS reported that the age, annual income, family size, cosmopoliteness, innovativeness, risk bearing ability, time taken for adoption, number of trainings attended and extent of adoption were normal, therefore Pearson correlation has been used. The variables gender, education, occupation, family type, land ownership, farming experience, family size, social participation, adoption decision, trainings on agriculture and CAU-R1were non normal and hence Spearman Rank Correlation has been used. The dependant variables considered for the test were in-degree, out-degree, incloseness, outcloseness and betweenness. Among the farmer variables age, gender, education, occupation, family type, land ownership, cosmopoliteness, innovativeness,

Table 6. Correlation matrix of farmers' characteristics and network measures (n = 63)

Variable	Statistical tool	In-degree	Out-degree	Incloseness	Outcloseness	Betweenness
Age	Pearson Correlation	.176	.114	-.172	-.214	.229
Annual Income	Pearson Correlation	.168	.076	-.133	-.160	.360**
Family Size	Pearson Correlation	.176	.265*	.029	.026	.201
Cosmopoliteness	Pearson Correlation	.116	.053	.169	.215	.007
Innovativeness	Pearson Correlation	-.053	-.001	-.178	-.147	.006
Risk Bearing Ability	Pearson Correlation	.360**	.290*	.134	.167	.456**
Time Taken for Adoption	Pearson Correlation	-.315*	-.288*	-.212	-.110	-.349**
Number of Trainings attended	Pearson Correlation	.459**	.371**	-.059	.014	.455**
Extent of Adoption	Pearson Correlation	.207	.143	.059	.099	.248
Gender	Spearman Rank Correlation	-.037	.017	.165	.112	-.072
Education	Spearman Rank Correlation	.062	-.099	-.078	-.118	.065
Occupation	Spearman Rank Correlation	.075	-.034	-.028	-.042	.239
Family Type	Spearman Rank Correlation	.101	.101	.139	.106	.146
Land Ownership	Spearman Rank Correlation	-.050	-.024	.001	-.051	-.100
Farming Experience	Spearman Rank Correlation	-.080	-.134	-.285*	-.256*	.117
Family Size	Spearman Rank Correlation	.043	.015	-.043	-.020	.057
Social Participation	Spearman Rank Correlation	.480**	.615**	.714**	.789**	.366**
Adoption Decision	Spearman Rank Correlation	-.066	.100	.014	-.023	-.009
Trainings on Agriculture	Spearman Rank Correlation	.061	-.182	-.237	-.250*	.131
Trainings on CAU-R	Spearman Rank Correlation	.281*	.194	.170	.183	.168

***. Correlation is significant at the 0.01 level (2-tailed)*. Correlation is significant at the 0.05 level (2-tailed)*

extent of adoption and adoption decision had insignificant relation with all the network measures. Risk bearing ability, number of trainings attended and social participation were found to be positively correlated with the In-degree centrality of the farmers at 1% level of significance. This can be explained that the higher the risk capacity of the respondent, he will be approached by many other fellow farmers. More the trainings attended by the farmer will enhance his knowledge on the crop variety and thereby more fellow farmers will choose him as their source of information. Higher social participation implies that being member of social organizations in the village and outside the village will make them more informative and knowledgeable and hence many farmers will approach them for information about new varieties and technologies. This increases their degree centrality, closeness and betweenness centrality making them more central actors in the network. Training on CAU-R1 was positively correlated at 5% level of significance with the In-degree centrality. Farmers who have attended trainings on CAU-R1 are considered as the most potential source of information and hence degree centrality increases. The time taken for adoption was negatively correlated at 5% level of significance with the in-degree implying that the more the In-degree the lesser will be the time taken for adoption and vice versa. It holds true even in the case of out-degree centrality. The family size and risk bearing ability were positively correlated at 5% level of significance with the out-degree centrality while the number of trainings attended and the social participation were positively correlated with the out-degree at 1% level of significance. The farming experience was negatively correlated with the closeness centrality implying that more years spent in farming by the respondent makes him older in age resulting in less social participation and therefore rate of reaching other farmers and vice versa in the network will be reduced. Social participation was positively correlated at 1% level of significance with the closeness centrality and training on agriculture was negatively correlated with out-closeness at 5% level of significance. The annual income, risk bearing ability, number of trainings attended and social participation were positively correlated at 1% level of significance with the betweenness centrality implying that the actors with more annual income, higher risk bearing ability, more number of trainings attended by the respondents and higher social participation will make the actor appear more number of times between two pairs of actors. These actors play central role in controlling the communication flow in the network.

4. CONCLUSIONS

From the findings of the study we can infer that majority of the farmers belonged to middle aged group with basic education and medium level of innovativeness, social participation, risk bearing ability and cosmopoliteness. These factors might be one among the reasons for the medium and low adoption of the CAU-R1 variety. Information on advanced practices and varieties is an essential input for moderating the rate of diffusion and adoption of technology by the farmers. In the current scenario, the network analysis of the farmers depicts that information sharing and resource exchange has been to the minimum or restricted to only few prominent actors in the network. If these actors are contacted and provided with all the required inputs and services will play very effective role as informal extension agents among the rural villages and enhance the rate of diffusion of the variety in a shorter span of time. Also there is lack of monitoring and evaluation from the CAU, as stated by the farmers in meeting their crop requirements. Multi-stakeholder involvement is required and effective linkage among the farmers and institutions needs to be strengthened. Use of mass media and ICTs has not been used to its fullest, which may also add to the success of the programme on a larger scale. Hence, future scope of the study can be aimed at understanding and establishing mechanisms for strengthening the horizontal and vertical linkages and creating more awareness and persuasion using ICTs.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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