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A study on the adaptability of farmers to n-nano fertilizer usage in Oryza *Sativa* L. cultivation in selected divisional secretariat divisions of Ampara district of Sri Lanka

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Abstract
Paddy is the major crop grown worldwide as well as Sri Lanka. Novel technology adoption is the only option to mitigate the food insecurity which would facilitate to face the impacts of growing population and climate change on crop production. Nowadays, Nano fertilizer and Nano technology are the most important topics among the researchers. These nano materials directly reduce the cost of production by the way of reduced the fertilizer usage. There are several problems created due to the chemical fertilizer usage such as environmental pollution, high cost of production and health issues. Losses of fertilizer and its effects on environment are coincided incidents which needs to be reduced immediately. Available nutrients present in bulk chemical forms are not fully accessible to plants. In addition, the utilization of macronutrient is very low due to their conversion to insoluble form in soil. Therefore, a questionnaire survey was conducted to find out the rate of adaptability to N-Nano fertilizer usage in the major paddy cultivating Addalaichenai and Nintavur Divisional Secretariat divisions of the Ampara district. Stratified random sampling method was used to select respondents for the survey and the collected data were statistically analyzed. The results revealed that 40% of farmers have 6-10 years farming experience and 64% of farmers in this selected area had used extension services for conventional farming. Approximately 80% of the farmers said that compared to current technologies farming by conventional methods is easy. There were 64% of the farmers reported that N-Nano fertilizer usage will increase the level of production. However, limitation to the access to N-Nano Fertilizer was also pointed out by 64% of the farmers. Consequently, the farmers in this study area have a lower than 20% adaptation rate for usage of N-Nano fertilizer in paddy fields. Hence, this study found out that only 20% of the farmers adopting the usage of N-Nano fertilizer. Therefore, promotion campaigns through the extension services should be enhanced to increase the farmers' awareness on the usage of the N-Nano fertilizer applications in the paddy fields of the Ampara district, Sri Lanka.

Keywords: Farmers, nano fertilizer, nano technology, nitrogen, paddy cultivation

Introduction

Oryza sativa L. is the most common stable food in worldwide particularly in Asia (Lahari *et al.*, 2021) [16]. In Sri Lanka, paddy is cultivated in 34% of total cultivated land area, it's around 1,208,000 hectares (Central Bank Report, 2020). Fertilizer is the key component in the cultivation practices in worldwide. Production of the fertilizers consumes large amount of fuels and unbearable level of pollution to the environment. Chemical fertilizers generate several deleterious effects to the environment and human health and they should be replenished in every cultivation season because, the synthetic N, P and K fertilizer is rapidly lost by either evaporation or by leaching in drainage water and it causes dangerous environmental pollution (Aisha *et al*., 2007) [1].

In Sri Lanka, farmers use chemical fertilizers in paddy cultivation for the fastest production without concerning the health and environmental effects (Chandrasiri *et al*., 2012) [8]. Chemical drought is the major negative impact in paddy cultivation and it completely removes the fertile land cover. Furthermore, chemical fertilizer leads to increase toxicity in the soil and excess and continuous use of fertilizer leads to eutrophication process in water bodies (Singh *et al*., 2022) [27]. The leaching nitrates can also impact drinking water supplies and is linked to gastro intestinal problems. Infants are severely affected while consuming water (Aisha *et al*., 2007 [1]; Li *et al*., 2018; Younas *et al*., 2020) [33]. Commonly nitrogen fertilizers cause natural bacteria to produce nitrous oxide which is a greenhouse gas and can also cause acid rain (Xu *et al*., 2023) [32]. It is also reported that between 1 to 60% N of nutrient based fertilizers such as urea is lost through ammonia volatilization (Hakeem *et al.*, 2011 [14]; Prasertsak *et al*., 2001) [24].

In addition, inorganic fertilizer like urea can lead to the buildup of salt in the soil. Salt accumulation in the soil forces the plants to expend more energy to draw water from the soil and can cause them to appear wilted or dried out. Soils with an excessive concentration of salt have a white crusty surface and can become compacted (Younas *et al.*, 2020) [33]. To reduce these detrimental effects with the consideration of yield uptake to up to date production to increase population rate, we must provide best source of fertilizers which should decrease its' detrimental effect on conventional practices mentioned above.

Nano technology is one of the important technologies that has the important to revolutionize the food production in agriculture sector (Manjunatha *et al*., 2016 [20]; Opera, 2004). Nanotechnology is the manipulation of individual atoms, molecules, or cluster of molecules into defined structures to generate the new materials with novel different features (Mousavi and Rezaei, 2011 [21]: Tarafdar, 2012) [30]. Benzon (2015) [4] stated that Nano fertilizers are the product in nanometer regime that delivers essential nutrients to crops. For example, encapsulation inside nanomaterials coated with a thin protective polymer film or in the form of particles or emulsions of nanoscale dimensions. It provides enormous surface area and compact size might promote improved nutrient uptake and interaction during crop

fertilization (DeRosa *et al*., 2010 [12]; Liu and Lal 2014) [18]. The use of nanotechnology into fertilizer product industry has the potential to enhance the nutrient releasing ability and boost the absorption efficiency due to increased surface area and higher dissolving capacity (Chahal *et al*., 2012 [7]; Eichert. 2008) [13].

Moreover, Nano fertilizer is the viable source to reduce the whole problems into certain level and an alternative to conventional practices which reduce the ill effects to environment (Davarpanah *et al.,* 2017) [10]. Urea as Nano fertilizer during initial trials with rice at the Rice Research and Development Institute, Bathalagoda indicated that the Nano - fertilizer can save urea by about 40%. This is significant considering that during fertilization up to 70% urea is lost to crops because of leaching and volatilization (Aisha *et al*., 2007) [1]. Considering the above, Government spends over Rs. 30 billion on the fertilizer subsidy, even a 10% saving can accrue great benefits to the country's agriculture sector (SLINTEC, 2012) [28].

Using the Nano fertilizer will make benefits on many levels at filed level. Nano Fertilizers slowly release plant nutrients and plants use it when needed (Arora *et al.,* 2022) [3]. The application of Nano fertilizer will reduce the losses in the paddy field because of the slow releasing ability in nature. It will enhance the fertilizer use efficiency and will reduce the cost of cultivation (Wang *et al* 2021 [31]; Yomso and Menon, 2021) [34]. Davarpanah *et al*. (2018) stated that 100% application of N-Nano fertilizer has increased the growth and yield characters of rice cultivar BG 250. In paddy cultivation, usage of Nano based nitrogen fertilizer had beneficial effects to improve the yield, reduces the losses of nutrients and reduce the environmental pollution.

Acceptability of farmers to new technology such as Nano technology is affected by several factors like age, education level, marital status, farming experience and availability of extension services (Chi and Yamada, 2002) [9]. Hence, it is essential to analyze the effects of different factors on acceptability rate of farmers to N-Nano fertilizer in paddy cultivation. Therefore, this study was conducted with the objective to find out the rate of adaptability in the usage of N-Nano fertilizer for paddy cultivation in the major paddy cultivation areas of Addalaichenai and Ninthavur divisional secretariat divisions of the Ampara district, Sri Lanka.

Methodology

Research Area

The survey was conducted in selected twenty Grama Niladari divisions (GN divisions) of selected Nithavur and Addalaichenai Divisional Secretariat (DS) areas of Ampara district, Sri Lanka (Fig.1) from June 2017 to October 2017.

Fig 1: Map Showing the Survey Area of Nintavur (a) and Addalachenai (b).

Ampara District is located in the Southeast of Sri Lanka in the Eastern Province. It has an area of 4,415 square kilometers. Ampara District's population is 691,000 in 2016 (Dept. of Census & Statistics, 2016). This district is one of the most diverse in Sri Lanka, both ethnically and religiously.

The survey was conducted in Addalaichenai and Nintavur DS divisions of Ampara district where Nano fertilizer is being practiced by farmers in paddy cultivation predominantly compare to other DS divisions Nintavur consisting of 25 GN divisions with the extend of 40.031 sq.km and they are cultivating 7000 acres with the incorporation of 3157 farm families. Addalaichenai DS Division consisting of 32 GN divisions including three villages namely Deegabaviya, Oluvil, Palamunai and Addalaichenai and meantime they are cultivating 3050 acres with the incorporation of 1500 farm families.

Sampling technique

The population of this survey consisted of farmers engaged in paddy cultivation. The Stratified Random Sampling method was used for the selection of DS and of GN divisions. Accordingly, total of 20 GN divisions were selected where farmers doing intense cultivation from both DS Divisions in which 100 farmers were used for this questionnaire survey.

Data collection
Data were collected through face to face interviews with the sampled farmers using a pre-tested questionnaire. Secondary data were collected from Central Bank of Sri Lanka, Department of Census and Statistics, Department of Agriculture, District Secretariat of Ampara and the Agriculture Instructors who are working in the region.

Primary data
Primary data were collected from the selected respondents by using questionnaires and interview at their door step in the study area. The survey was carried out from June 2017 to October 2017.

Questionnaire preparation
Structured questionnaires were designed for interviewing paddy farmers in Addalachenai and Ninthavur DS divisions. Questions were arranged to get the following information such as Personal details of the farmers, details of the paddy cultivation, Nano fertilizer application etc.

Pre test
Before the commencement of data collection, the questionnaires were pre-tested to assess its suitability. Necessary changes were made to enable easy recording of responses from farmers as per the results of the pre-test.

Questionnaire Survey
Primary data required for this study were collected from selected respondents through personal interviews using questionnaires at door steps. Observations were also made around the field to find the practicesespecially Nano fertilizer application, field practices etc.

Secondary Data
Secondary data were gathered from the following sources:
1. Agricultural Extension office
2. Rice Research Station, Sammanturai
3. DS office of Addalachenai and Nintavur
4. District Secretariat, Ampara
5. Library materials such as report, research papers, books, magazines
6. Technical bulletins and administration reports
7. Publications of Central Bank, Sri Lanka.
8. Publications of Department of Census and Statistics, Sri Lanka.
9. Relevant web pages.

Personal interview with farmers was made to obtain data.

Data analysis
The collected questionnaires were checked for completeness and the data were analyzed using SPSS 11.0. Data were confined to estimate frequencies and descriptive statistics.

Results and Discussions
Demographic Details of the Respondents
1. Gender
The results Fig.2 showed that the adoption in paddy farming in selected GN divisions were 100% male. Mostly the men were engaged in paddy cultivation and the women take care of their children and other household activities. Gender differences was not found to be one of the factors influencing the adoption of new technologies. Due to many socio-cultural values and norms, males have the freedom of mobility and participation in different meetings and consequently have greater access to information (Tadesse, 2008) [29].

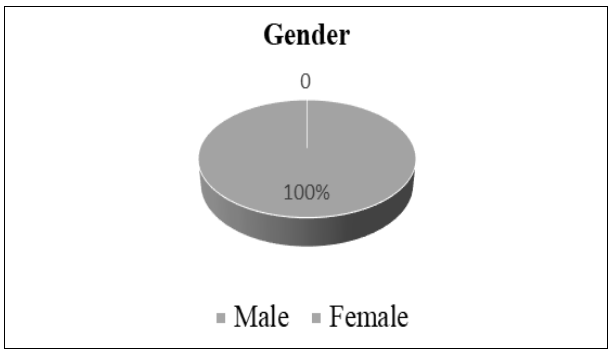

Fig 2: Gender of respondents on paddy cultivation in the study area.

2. Age
Age distribution of respondents engaged in paddy cultivation in this study area was shown in Fig.2. Age is one of the important factor that influence the decision making of individuals. Age has a bearing on the farmer's risk taking attitude and innovativeness in adopting new technologies. Majority of paddy farmers (48.8%) were in the age category of 41-50, while 30.2% were more than 55 years. It was found that mostly middle aged (41-50 years) farmers were cultivating paddy in conventional way, which could be due to their better awareness of the benefits of yield. Thus, enhancing technologies such as Nano technology is due to enthusiasm and experiment with a new technology of facing risks. Rahmeto (2006) [25] reported that younger farmers have more probability of adopting improved rice varietal technologies than older farmers.

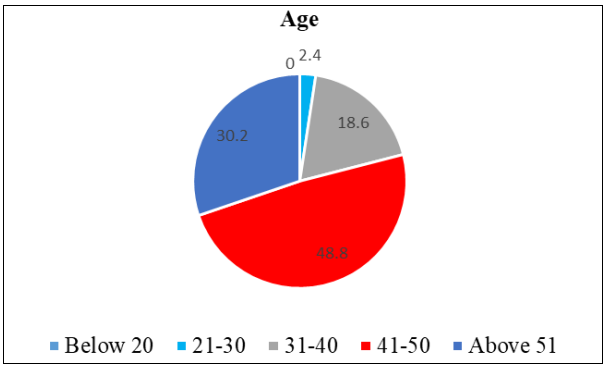

Fig 3: Age distribution of respondents on paddy cultivation in the study area.

3. Marital Status
The Fig.3 showed the marital status of respondents engaged in paddy cultivation in the study area. Marital status is an important social factor having manifestation in the social standing and the sense of responsibility of married individuals in the society (Samson, 2007). It is assumed that married couples shared experience in adoption of new technology such as Nano based nitrogen usage in the study area. Higher percentage of married respondents (76.7%) were shared the experiences among them and 16.3 % of them was not sharing meanwhile 9.0% of them did not have enough attention to share anything with paddy cultivation practices.

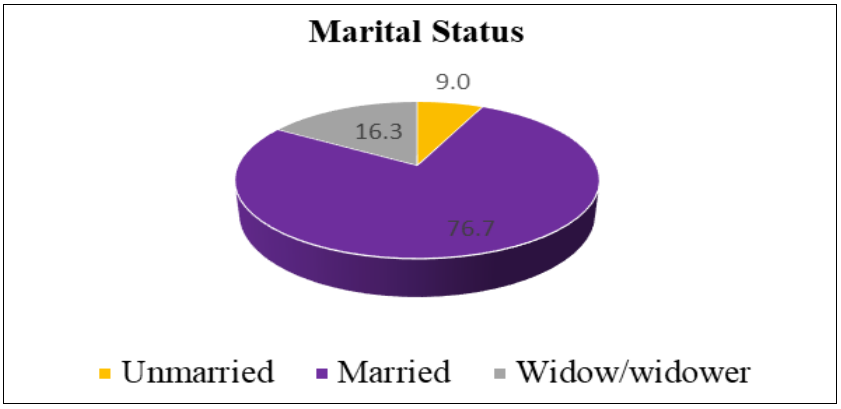

Fig 4: Marital Status of respondents on paddy cultivation in the study area.

4. Education

In this present survey, the sample farmers were categorized into five groups with respect to literacy status. Educational background of respondents engaged in paddy cultivation in the study area was shown in Fig.5. According to the results 32.6% of the farmers completed secondary school and 30.2% completed primary education while 4.6% of farmers have never attended school. Education is a crucial component that enhances the expansion and advancement of any industry. Education is being the act of gaining Knowledge and habits through study or instruction which leads to general behavioral changes. However, Chi Square test revealed that there were significant association between education and adoption of Nano based urea usage ($P<0.05$) based on the data obtained in this survey. It was in agreement with Cary and Barr (2002) [5] and Rahmeto (2006) [25] who stated that, the educational status of the farmers plays a vital role in the adoption of any new technology.

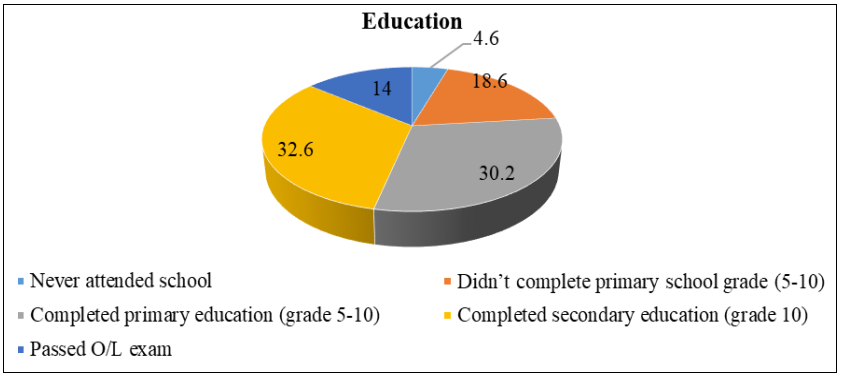

Fig 5: Educational background of respondents on paddy cultivation in the study area.

5. Farming Experiences

Farming experience is the valuable concern to adopt any mode of practices. According to the results in Fig. 6, 40% of the farmers were involved in paddy cultivation with 6-10 years' experience and 30 % of them was engaged over 15 years of experience. Prasad *et al.* (2014) [23] reported that farming experience is useful in early stages of adoption of a given technology when farmers are still testing its potential Benefits, which later determines its retention or dis-adoption over time. These obtained results are supported with the statements of Kamarudin *et al.*, (2015) [15] who stated that knowledge and experiences on climate changes, local farmer innovations, natural resources management and indigenous knowledge could be captured in order to document best practices in agricultural activities.

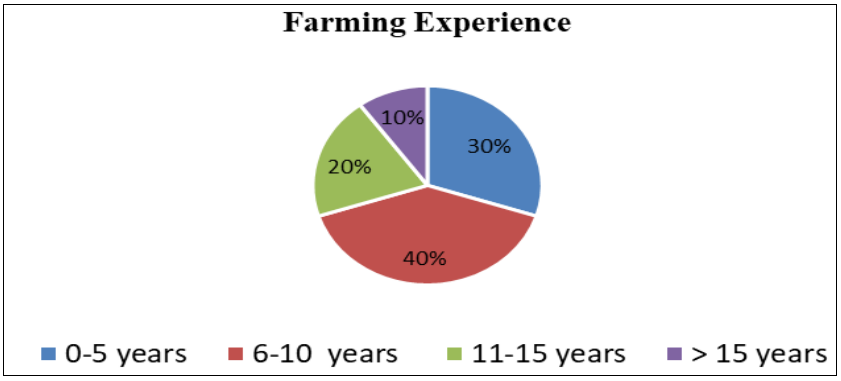

Fig 6: Farming experiences of respondents on paddy cultivation in the study area

6. Reasons for Non- Adoption to Nano Based Nitrogen Usage

According to the statements of farmers, Fig.7 depicted several reasons for non adoption of Nano based nitrogen fertilizer application. Adoptive rate for Nano based Nitrogen usage is decided by many factors such as discouragement by fellow farmers, lack of available irrigation facilities and lack of promotion campaign. Normally available cultivation land allocated for this technology was very low meanwhile 50% Of the farmers stated that high production cost for Nano based fertilizer usage in cultivation which indicates the negative mindset of the farmers. Furthermore, 20% of the farmers were responded that lack of promotional campaigns programs related to Nano fertilizer usage. Some farmers indicated that, lack of irrigation facilities and discouragement by fellow farmers also affect the adoptive rate of the farmers to Nano based nitrogen.

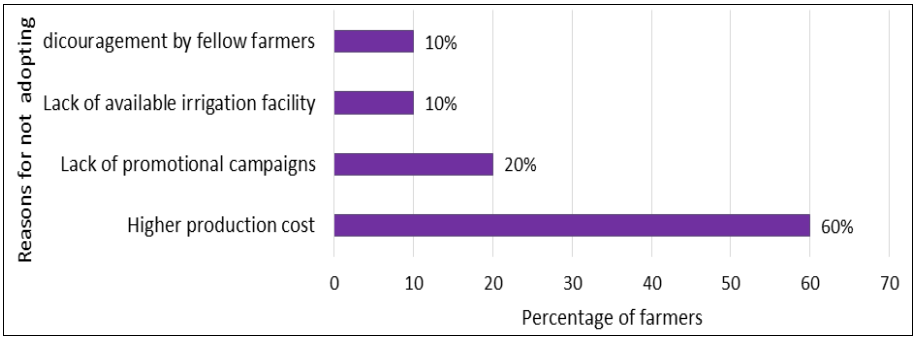

Fig 7: Details of reasons for Non -Adoption to Nano Based Nitrogen Usage in GN divisions of selected DS divisions of Addalachenai and Nintavur of Ampara District

7. Reasons for Adoption of Conventional Urea Fertilizer in Paddy Cultivation

Analyzing the status of the current level practices is important to find out the reasons for not adopting the Nano based fertilizers. The results shown in Fig.8 indicated that about 80% of the farmers felt it is easy to do conventional way of paddy cultivation than Nano fertilizer based cultivation. Further, 60% of farmers said that they are doing conventional farming due to lower market prize of conventional urea fertilizers. Therefore, extension services should be demonstrated to handle this problematic mind set to good mind set in order to encourage the usage of Nano based urea fertilizer in paddy cultivation in selected DS divisions. If the respondents believe only that the usage of Nano based nitrogen fertilizer is the good option in field level paddy cultivation then only the agro chemical marketing shops would ensure the availability of the Nano based fertilizers in future.

Further, more than 40% of the farmers responded that conventional farming leads to lower market demand for Nano based fertilizers and farmers believed that Nano based fertilizer would be made severe crop loss. Thus, if the researchers provide enough evidences for the minimal crop loss when Nano based fertilizers are used, it will promote the farmers to adopt this technology since it has been proved thatsignificant increases in yields have been reported due to foliar application of Nano particles as a fertilizer (Tarafdar *et al*., 2012) [30].

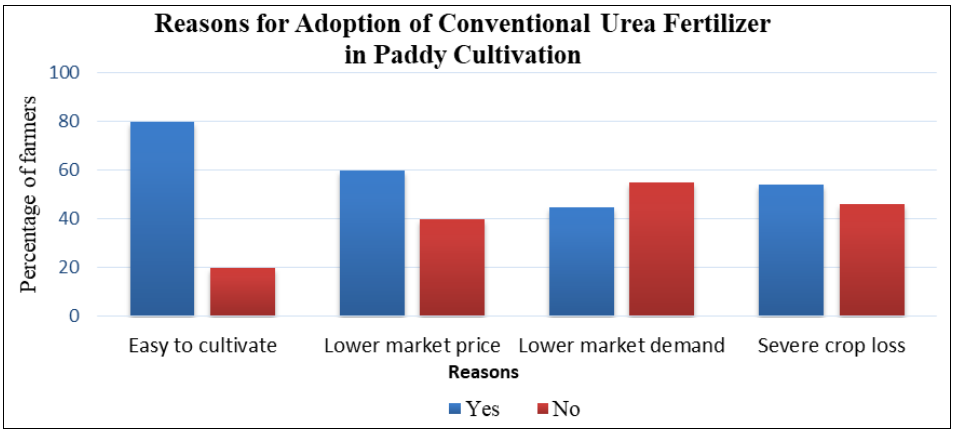

Fig 8: Details on Reasons for Adoption of Conventional Urea *Fertilizers* Usage on paddy cultivation in the study area

8. Extension services

The Fig.9showed that distribution of extension services provided for Nano Fertilizer usage on paddy cultivation in the study area. Study revealed that, 64 % of the respondents stated that the extension services were good in terms of conducting training programmes, young farmers' club activities and new technology demonstration programmes. It indicated that the majority of the extension services provided with respect to conventional farming practices and other usual extension programme. The needs of the increment of the extension services to the Nano based nitrogen usage must be promoted. Chi and Yamada (2002) indicated that novel technologies can be reached the farmers with the help of extension services through the technology transfer processes such as campaign programs and live demonstration.

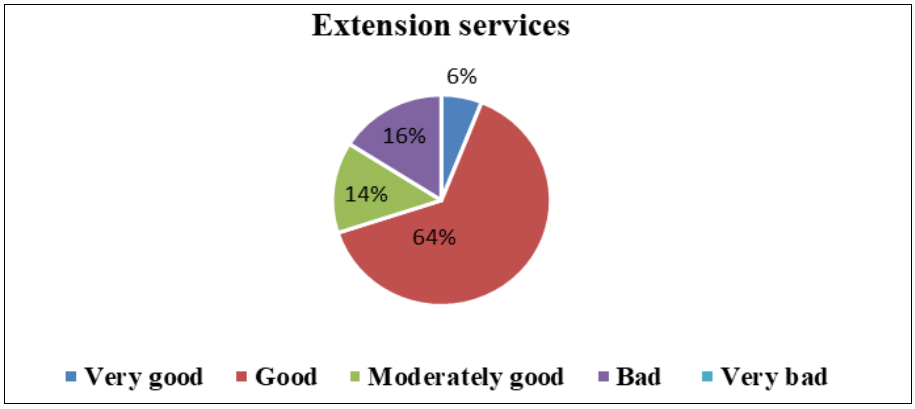

Fig 9: Extension Services provided for Nano Fertilizer usage on paddy cultivation in the study area

9. Reasons for preferring Nano based Nitrogen usage at field level

The Fig.10 showed that the respondents over 64% believed that Nano based nitrogen leads to higher yield but less than 10% said that the availability of Nano based nitrogen fertilizer is low. Significant increase in yields have been observed due to foliar application of Nano particles as fertilizer (Tarafdar *et al*., 2012) [30] where less than 5% of the respondents revealed that the fertilizer bound ability and handling is very low because the level of resistance to mechanical damage. Moreover, Chi and Yamada (2002) [9] stated that, factors such as age, education, income, family size, credit use and believes are positively related to adoption to new technology.

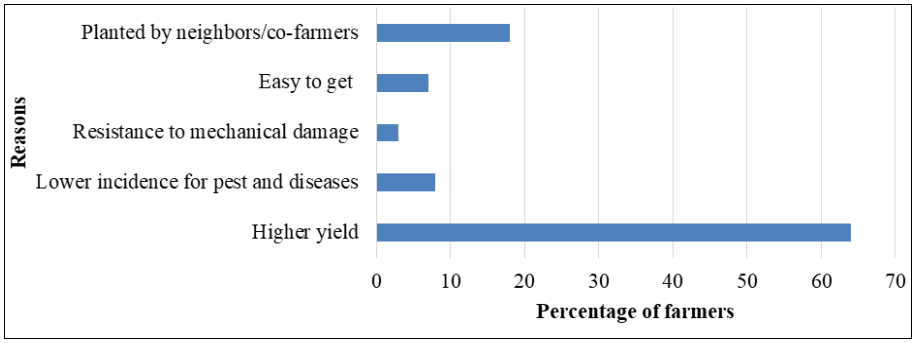

Fig 10: Details on reasons for preferring Nano based Nitrogen usage at field level at selected GN Divisions of selected DS divisions of Addalachenai and Nintavur of Ampara District.

10. Future perspective on Nano based nitrogen

All respondents who engaged with paddy cultivation demand the visible profit increment on the usage of Nano fertilizer over the conventional methods through the extension services. Further, farmers also stated that the availability of N-Nano fertilizer should be ensured for its easy accessibility and applicability with technical know-how and do-how for better paddy cultivation and enhanced production.

Conclusions

Nano fertilizer and Nano technology are the most important topic among the researchers. The experience from the nutrients management in paddy fields now become problematic in nature due to health concern and environmental degradation. Increase in total production cost have greater impact on family economy. The present study concluded that 40% of farmers have 6-10 years farming experience and 64% of farmers in this selected area had used extension services for conventional farming. Approximately 80% of the farmers said that, compared to current technologies, farming by conventional methods is easy. There were 64% of the farmers reported that N-Nano fertilizer usage will increase the level of production. However, limitation to the access to N-Nano Fertilizer was also pointed out by 64% of the farmers. Consequently, the farmers in this study area have a lower than 20% adaptation rate for usage of N-Nano fertilizer in paddy fields. Hence, this study found out that only 20% of the farmers adopting the usage of N-Nano fertilizer. Therefore, promotion campaigns through the extension services should be enhanced to increase the farmers' awareness on the usage of the N-Nano fertilizer applications in the paddy fields of the Ampara district, Sri Lanka.

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