Research in Management of Technology and Business Vol. 3 No. 1 (2022) 1049-1056

RMTB

Homepage: http://publisher.uthm.edu.my/periodicals/index.php/rmtb
e-ISSN : 2773-5044

Factors Influencing Adoption of Drip Fertigation System Among Farmers: A Review

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DOI: https://doi.org/10.30880/rmtb.2022.03.01.074
Received 31 March 2022; Accepted 30 April 2022; Available online 25 June 2022

Abstract: Integration of innovative irrigation systems and technologies is critical to improving crop water productivity and yields as global water levels fall and food demand rises. The drip fertigation system (DFS) is a resource conservation technology for agricultural production. Despite the numerous benefits of DFS, such as reduced water usage and increased crop productivity, DFS is still not widely used among farmers for farming practices. The purpose of this study was to conduct a detailed review to determine the factors that are hindering farmers from using drip fertigation system. The study revealed some key factors significantly contributing towards the adoption of drip fertigation system. Among these factors, water scarcity, availability of skilled operators or lack in technical skills, cost of installation and maintenance, subsidy from government, financial issues, and farmers' awareness regarding drip fertigation system were the most significant factors effecting the adoption of drip fertigation system. The study provides some implications for government as well drip fertigation system providers to focus on these factors that can enhance the adoption of drip fertigation system in the near future.

Keywords: Drip Fertigation System, Farmers, Adoption.

1. Introduction

Over the last decades, water use for crop production has increased twice as fast as population expansion around the world (FAO, Land *and* Water: Water Scarcity, 2015). According to a UN Water Scarcity Initiative research, by 2025, two-thirds of the earth's population could be living in water-stressed regions, with 1800 million people facing severe water scarcity. These territories include Mexico, Pakistan, South Africa, large sections of China and India, as well as the majority of countries in the Near East and North Africa (Khor *and* Feike, 2017). Water scarcity will have a significant impact on irrigation systems and, as a result, household income in these areas. Drip irrigation or fertigation is a method used in the face of water scarcity (Khor *and* Feike, 2017). When compared to typical irrigation

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technologies such as flood irrigation, it delivers water specifically to the root zone of the plants rather than the entire field, resulting in increased water use efficiency (Ayars *et al.*, 1999; Payero *et al.*, 2005). It also enables for the optimal timing of irrigation events based on the real crop water requirement (Laib *et al.*, 2018). The technology has been implemented in a number of developing countries across the globe, with encouraging results (Dittoh *et al.*, 2010; Karlberg *et al.*, 2007; Khor *and* Feike, 2017; Payero *et al.*, 2005). Drip irrigation, especially in water-scarce areas where agriculture and natural ecosystems compete for water, can help to ensure the ecological sustainability of agricultural production by increasing water usage efficiency and therefore lowering water consumption (Yacob *et al.*, 2019). However, environmental sustainability is simply one aspect of long-term growth. In order to secure the long-term ecological sustainability of irrigation practises, it is also necessary to ensure their economic sustainability.

Although this modern irrigation system is effective of reducing the problem of water scarcity, it is not being used at the level that is needed. Despite all of the advantages, farmers are still hesitant to use drip fertigation (Bakhsh *et al.*, 2020). There have been examples where fertigation systems have been implemented and then discontinued for various reasons, negatively impacting the fertigation adoption process. Despite some great achievements, the majority of farmers are still barely scraping by and are hesitant to promote fertigation further (Bakhsh *et al.*, 2020). This encourages academics and policymakers to research at the impediments to fertigation adoption and develop standards and guidelines to promote it so that small farmers can increase their crop production. This study, on the other hand, tried to uncover the primary barriers that stopped farmers from adopting or discontinuing the drip fertigation method, as well as the barriers that farmers experience in transitioning to such modern irrigation systems. The study also looked at the reasons for the non-adoption of drip fertigation systems by performing a thorough review of previous research. Besides, there are several factors impeding the fertigation practices which are discussed in the following sections. In addition, this study also outline the different terms used for such kind of irrigation practices.

2. Terms used for fertigation

Fertigation (fertilization + irrigation) dates back to the mid-nineteenth century, when crops were cultivated in water or sand cultures for basic soil nutrient studies (Davis *et al.*, 2009). These research used a number of soluble fertiliser mixtures, but the most widely used formula was Hoagland's solution, which was discovered by plant scientists at the University of California at Berkeley in the 1930s as part of nutria-culture experiments (Davis *et al.*, 2009). The initial structure of this mixture was modelled after that of a solution taken from high-productivity soils (Davis *et al.*, 2009). With the passage of time different terms used interchangeably as mentioned in Table 1.

Table 1: Terms used for fertigation

Terms used	References
Drip fertigation system	Benouniche *et al.* (2014); Chandran and Surendran, (2015); Chandran and Surendran, (2016); Khor and Feike, (2017); Narayanamoorthy *et al.* (2018); Yan *et al.* (2019); Yang *et al.* (2020); Dawit *et al.* (2020) and Borsato *et al.* (2019)
Fertigation	Ahmad *et al.* (2011) and Yuan *et al.* (2021)
High efficiency irrigation system	(Bakhsh *et al.*, 2020)
Drip method of irrigation	Devika *et al.* (2017); Laib *et al.* (2018) and Kaarthikeyan and Suresh, (2019)
Micro-irrigation	Dittoh *et al.* (2010)
Drip irrigation system	Joshi, (2011); Ortega-Reig *et al.* (2017); Greenland *et al.* (2018); Singh and Dangi, (2022) and Yazdanpanah *et al.* (2022)

As can be seen from the Table 1 different terms are used for the specific irrigation system. The widely used term is "drip fertigation system" that cover both the terms "drip" and "fertigation". Therefore, this study will use the term "drip fertigation system" onward in this paper.

3. Research Methodology

The Scopus database was used to access and download the relevant qualitative, quantitative and mixed method studies. This database has demonstrated to be the most appropriate for our research, allowing us to confirm the inclusion of representative drip fertigation studies. The terms used to carry out the search was "fertigation", "drip irrigation", "drip method of irrigation", "micro-irrigation", "drip fertigation system", "factors influencing", "determinants influencing", "adoption or acceptance", "farmers", "agripreneurs", and "agripreneurship". This decision was taken based on past research on the same topic. This term was looked up in the authors' titles and keywords. The period of study chosen was 2010 to 2022. At first the search for studies was limited to year 2016 and 2022 but very limited studies were found, hence, the year limit increased to 2010 and 2022. Research activity in this topic peaked during these years. Total 43 papers were read and among them 15 papers found relevant to the study. Microsoft excel sheet was used for data collection such as purpose of the study, author name and year, factors investigated, results, and findings from the papers.

4. Results and Discussion

In general, we observed a growing tendency in all of the variables studied, indicating the progression of this line of research. As can be seen from Figure 1 more than 60% of the total studies are conducted in the last six years. Our study reviewed the most relevant studies on the topic of determinants influencing the adoption of drip fertigation system. Consequently the authors found various factors as mentioned in Table 2 influencing the adoption of drip fertigation system. A full overview of all these factors is further discussed in the following sections.

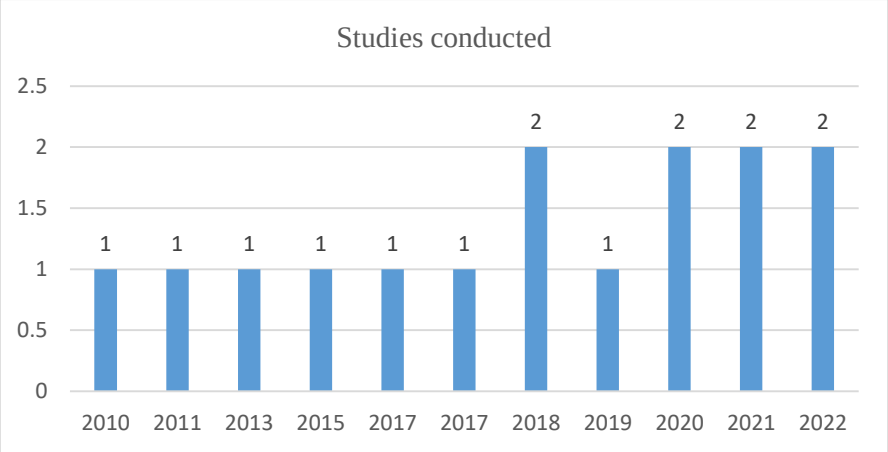

Figure 1: Studies conducted from year 2010 until 2022

Table 2: Factors influencing the adoption of drip fertigation system

Author and year	Factors
Kumar and Palanisami (2010)	• Scarcity of water
Ahmad *et al.* (2011)	• Awareness
Joshi (2013)	• Lack of information and knowledge about usage of drip irrigation, and the higher cost of installation.
Chandran and Surendran (2015)	• Subsidy, water scarcity, and high cost of the system.
Chandran and Surendran (2016)	• Socioeconomic characteristics such as age, education, experience and land holding size. Besides, the reported constraints experienced by farmers include rainfall, clogging of drippers, high initial cost, and difficulty in getting subsidy.
Khor and Feike (2017)	• Water scarcity
Greenland *et al.* (2018)	• Perceived costs, as well as installation and maintenance challenges.
Laib *et al.* (2018)	• Distribution uniformity and water stress levels
Kaarthikeyan and Suresh (2019)	• Financial constraints, water scarcity, no subsidy from the government, damages by the animals, high maintenance cost, and lack in technical skills.
Yang *et al.* (2020)	• Farmers' age, education, farm size, perceived helpfulness of their social network, farmers' planting experience, off-farm work, skillfulness of contact person and conformity to others.
Bakhsh *et al.* (2020)	• Availability of skilled operator, frequent contacts with professionals, level of awareness, education and training of farmers, financial issues, intensive supervision, small land holdings, and absentee land owners
Hasan *et al.* (2021)	• Social norms, grants and workshops
Yuan *et al.* (2021)	• Income, labor force, farmers' information processing ability and information acquisition channels.
Singh and Dangi (2022)	• Use of strainer filter to control physical impurities, use of fertigation with DIS, acid treatment for cleaning the system, use of emitters per plant, use of 5 ppm chlorine to avoid algae and bacteria and removal of emitters at the time of every ploughing.
Yazdanpanah *et al.* (2022)	• Farmer's' socio-economic characteristics, social capital, and technology characteristics.

4.1 Scarcity of water

Over the last century, water use for crop production is increasing twice as quickly as population expansion around the world (FAO, Land *and* Water: Water Scarcity, 2015). Therefore, drip fertigation system is presented that is a method used in the face of water scarcity. Several studies conducted regarding water consumption in drip fertigation system have found water as a main factor influencing the adoption of drip fertigation system. According to studies conducted by Kaarthikeyan and Suresh (2019) and Khor and Feike (2017), drip fertigation increases farmers' production but has a statistically minor impact on gross margin. Khor and Feike (2017) also found that the effect of drip fertigation on net income is highly beneficial only for farmers who have reduced water availability limitation, as indicated by their water use, using regression analysis. With the region's water scarcity predicted to worsen in the future, farmers are likely to find drip fertigation less profitable and thus less sustainable. As a result, the authors argue that, particularly in areas where water is scarce, the adoption of drip

fertigation systems must be accompanied by parallel improvements in water infrastructure to assure water availability at all times.

4.2 Farming Experience

There was also a substantial difference in the adoption index of farmers across various categories of farming experience. According to the authors, the average drip irrigation adoption index of younger farmers is higher than that of farmers with more experienced (Chandran *and* Surendran, 2016). This suggests that young farmers are much more interested in new technologies. Furthermore, according to Yang *et al.* (2020), farmers' experience has little bearing on the adoption of drip fertigation systems. This finding appears to be in contrast to earlier research on farmers' adoption of new technologies (Chandran *and* Surendran, 2016; Liu *et al.*, 2019). In their study, Liu *et al.* (2019) show that older farmers are less likely to adopt new agricultural technologies, such as drip fertigation, due to their preference for traditional farming practices.

4.3 Availability of skilled operators or lack in technical skills

Another key element influencing farmers' decisions to use drip fertigation was the ability to afford skilled labors or operators (Bakhsh *et al.*, 2020). Drip fertigation adoptation rate was significantly higher among farmers with permanent trained labor on their farms (Bakhsh *et al.*, 2020). This could explain why farmers that could afford to hire trained labor or operators to operate the system at a higher wage were more willing to do so. As a result, the availability of labours or operators with technical understanding could be another essential component in increasing the drip fertigation system adoption process. (Bakhsh *et al*., 2020).

4.4 Land holding size

Farmers' adoption of drip fertigation is also influenced by the size of their land holdings. Between the maximum size group and the others, there is a considerable variation in adoption index. Drip fertigation adoption is influenced by land holding size because big farms have lower initial investment costs because components such as the head unit, filter, tank, and pumpset are common (Chandran *and* Surendran, 2016).

4.5 Cost

Another significant factor was the initial cost towards drip fertigation systems mentioned by Pandy *et al.* (2016) that one of the primary barriers for a farmer to adopt drip fertigation is the high initial cost, which is followed by the maintenance cost. In addition, Chandran and Surendran (2016) revealed that none of the farmers in the two districts of tropical Kerala, India are practicing fertigation through drip irrigation. They believed that the costs of a drip fertigation system was prohibitively expensive. Many farmers are not employing the drip fertigation method despite its many benefits due to financial restraints, and if the cost can be reduced, the adoption rate will be higher. Further, Kaarthikeyan and Suresh (2019) and Greenland *et al.* (2018) stated that the high initial cost is the main factor for farmers not adopting drip irrigation because marginal and small farmers have extremely limited land holdings and so cannot afford the drip irrigation system.

4.6 Inadequate subsidy

The Agriculture Department's subsidy has not been a significant role in the development of drip fertigation systems. The authors also stated that during negotiations with Agriculture Department personnel, it was discovered that various issues exist with relation to the subsidy component of the Department's drip irrigation system (Chandran *and* Surendran, 2016). In addition, Kaarthikeyan and Suresh (2019) stated that challenges in obtaining government subsidy for drip fertigation play a crucial role in drip fertigation system adoption.

4.7 Social norms

Social norm or subjective norm is another vital factor of drip fertigation adoption. As identified by Hasan *et al.* (2021) that farmers who were early adopters of drip fertigation were less concerned with what other farmers thought, which demonstrates that social norms may be more relevant to adoption across the wider farmer community but are less of a consideration for early adopters of practice change.

4.8 Awareness

Al-Shadiadeh, (2011) stated that farmers tended not to be aware or have low levels of awareness with respect to drip fertigation which further lower the adoption of drip fertigation system. In addition, Bakhsh *et al.* (2020) mentioned that the major constraints regarding non-adoption was lack of awareness. Further, Bakhsh *et al.* (2020) declared there is a dire need for creating awareness among the farming community. It is a need of the time to train and educate farmers regarding drip fertigation system so that dissemination and adoption of drip fertigation can be ensured on sustainable basis (Bakhsh *et al.*, 2020).

4.9 Financial issues (Financial constraints)

Having financial problems means being unable to pay debts over the short or long term. Financial issues are major concerns in farming on a lower or larger scale (Bakhsh *et al.*, 2020). Study conducted by Kaarthikeyan and Suresh (2019) found that the reasons for the farmers to not adopt drip irrigation was the financial constraints. In addition, Bakhsh *et al.* (2020) mentioned that the major constraints regarding non-adoption of drip fertigation system were financial issues. Further, Bakhsh *et al.* (2020) revealed that the financial issue for non-adopters contributed in the non-adoption whereas adopters also claimed this issue as increased cost of production when they changed their cropping pattern from conventional crops to vegetables. Similarly, study conducted by Yazdanpanah *et al.* (2022) regarding non-adopters of drip fertigation system and the result reveals that the financial issue is the strongest factor to hinder the adoption of drip fertigation system.

4.10 Other factors

Apart from the abovementioned factors having significant influence on the adoption of drip fertigation system. There are some other factors that also influence the adoption of drip fertigation system for example socioeconomic characteristics such as age, education, experience and land holding size. In addition, clogging of drippers, damages by the animals, farm size, perceived helpfulness of their social network, farmers' planting experience, off-farm work, skillfulness of contact person and conformity to others, intensive supervision, absentee land owners, income, labor force, farmers' information processing ability and information acquisition channels are the influential factors that have effects on the adoption of drip fertigation system.

5. Conclusion

This paper was conducted with the aim to investigate the influential factors or determinants influencing the adoption of drip fertigation system. During the study the authors found that several terms are used interchangeably for the fertigation. This study adopted the term "drip fertigation system" which is widely used by previous study and most familiar to know. The authors found several factors that either hinder the adoption of drip fertigation system or have significant effects towards the adoption drip fertigation system. Moreover, scarcity of water was the most influential factor that hinder the adoption of drip fertigation by farmers. Water is the main source and a need for irrigation and farming. Areas with less water or having dependency on rain water and surface irrigation the farmers at that specific area have not adopted the drip fertigation system for irrigation and farming. The second most influential factor is availability of skilled operators or lack in technical skills. Some studies mentioned

that farmers have either have scarce availability for skilled operators to operate the drip fertigation system or have deficiency in technical skills for drip fertigation.

The third important factor that influence the adoption of drip fertigation was "cost". High initial cost is one of the main constraint for farmers to adopt the drip fertigation then followed by maintenance cost. Despite many advantages in the drip fertigation system farmers are not adopting the system because of financial constraints and if the cost can be subsidized the adoption rate will be higher. Further, financial issues were for non-adopters contributed in the non-adoption whereas adopters also claimed this issue as increased cost of production when they changed their cropping pattern from conventional crops to vegetables. In addition, subsidies from government was a prominent factor that hinder the adoption of drip fertigation system. If government provide subsidies the adoption of drip fertigation will be higher. In addition, awareness regarding drip fertigation is also a significant factor as some farmers tended not to be aware or have low levels of awareness with respect to drip fertigation which further lower the adoption of drip fertigation system.

Acknowledgement

The authors would like to extend their gratitude to Universiti Tun Hussein Onn Malaysia for financial support under the TIER 1 research grant Vot Q022. All those who contributed direct or indirectly are thanked.

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