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EDITOR'S NOTE

The Central Bicol State University of Agriculture is so blessed in its quest to be a National Research University by improving the research capabilities of its faculty staff and students, coupled with the upgrading of its physical resources for research. The various support provided for research and innovation undertakings from both national and international funding agencies paved the way to develop highly and globally competitive researches generated benefiting its stakeholders. As such, the ACRIJ continues to share those knowledge with the research community. Moreover, with the university's internationalization efforts, global research partners were encouraged to share their researches through this journal.

For this issue, ACRIJ has been given a chance to feature research outputs from Bangladesh, Papua New Guinea, Vietnam, Indonesia, Egypt, and the Philippines. Fitting into its theme, "Sustainable Development and Environmental Protection," seven (7) papers were chosen. They focus mainly on pest control of spiralling whitefly, vetiver for slope protection, the anticancer activity of Royal jelly from *Apis mellifera*, nanoparticles for production of *Kochia indica*, management of *Morinda officinalis*, land acquisition and utilization, and a case study on the capacity strengthening of rural women. We are very thankful to the authors who entrusted their papers with ACRIJ.

The ACRIJ Staff is also thankful to the peer reviewers for maintaining the journal's quality through their shared expertise towards improving the papers. We are indebted to the following: Dr. Divina M. Amalin, Dr. Mark Ukwungwu †, Dr. Novizar Nazir, Dr. Manuel C. Palada, Dr. Julian F. Gonzalves, Dr. Ramon A. Razal, Dr. Ma. Cresilda M. Caning, Dr. Ravindra C. Joshi, Dr. Ramona Isabel S. Ramirez and Dr. Melchora V. Abonal. Thank you so much!

Appreciation is also extended to the Editorial Support Staff of the ACRIJ- Mr. Alvir Bausa, Prof. Julie Amara M. Bondilles, Dr. Mark Jaypee C. Gonzales, and Mr. Kennedy Beltran. The services of Rochell Petil is likewise appreciated. Sincere thanks to Dr. Ravindra C. Joshi (Consultant), Dr. Ramona Isabel S. Ramirez (VP for Research and Innovation), and Dr. Alberto N. Naperi (SUC President IV) for this extended designation as EIC of the journal.

The ACRIJ Editorial Board is grateful for the contributions of Dr. Mark Ukwungwu, one of the Associate Editors who peer-reviewed articles in this journal. May our condolences bring your family comfort and may our prayers ease the pain of his loss. Today and always, may loving memories bring your family peace, comfort and strength. Rest in peace, Dr. Mark.

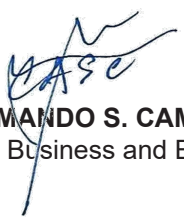
MARIA DULCE J. MOSTOLES, Ph.D.
Editor-in-chief

FROM THE DESK OF THE VICE PRESIDENT FOR BUSINESS AND EXTERNAL AFFAIRS

The COVID-19 pandemic has negatively affected all the vital sectors in our society, including the sectors where we belong, Agriculture and Education. While we currently live in uncertainty, only one thing is certain: we must continue to move forward in the academe. Our job is to seek answers that will help sustain or enhance our community and the world.

The CBSUA Office of Business and External Affairs extends its warm congratulations to the people behind this research journal, who made everything possible. Because of your exemplary hard work, the academe has been consistent in promoting and commercializing agriculture. With great commendations to the editor-in-chief for doing a great job collating these brilliant works and leading the team in all aspects of its creation. Despite the COVID-19 restrictions, every one of you persisted in providing us with new research and innovation.

I was ecstatic to learn that another completed AGRIKULTURA CBSUA Research and Innovation Journal was able to be published. I look forward to reading these works and seeing them be praised for their brilliance. May these inventive ideas become fruitful not only for CBSUA but also for the agricultural sector and the society to which we dedicate all our hard work and efforts. We look forward to more publications in the coming years! Congratulations to the team!



CESAR ARMANDO S. CAMBA, SR
Vice President for Business and External Affairs

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THE SPIRALLING WHITEFLY, *Aleurodicus dispersus* Russell (HEMIPTERA: ALEYRODIDAE): A PHILIPPINE PERSPECTIVE

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Abstract— Agriculture is among the most crucial sector in almost all countries around the world. It provides both income and employment opportunities among people ensuring food security and sustainability. However, an insect pest called spiralling whitefly, *Aleurodicus dispersus* Russell (Hemiptera:Aleyrodidae) threatens the agricultural industry. This pest is native to Caribbean Region and Central America and was first reported and described in Florida in 1965. From there on, it logistically spreads and invades many countries around the world. The spiralling whitefly is an intensively polyphagous pest with a wide range of host plants. It affects the plants by directly feeding on leaves competing with nutrients to the host. Indirect effects were also observed, such as producing honeydew and waxy substances that affect the host plants' overall physiological ability. Management strategies against the pest include releasing insect predators and parasitoids, removing infested leaves, installing light and sticky traps, selecting possible resistant crop varieties, using naturally occurring insecticides, and some synthetic control tactics. However, in the Philippines, very few studies have been conducted concerning the biology, ecology, and management of this polyphagous pest. Considering that the country is looking for a sustainable, healthier, and environmentally friendly pest management approach, research efforts should therefore give considerable attention to mitigate and prevent the possible impacts of this polyphagous insect pest in the future of the Philippine agricultural sector.

***Keywords*— Invasive pest, pest management, Philippines, polyphagous pest, spiralling whitefly**

INTRODUCTION

Spiralling whitefly, *Aleurodicus dispersus* Russell (Hemiptera: Aleyrodidae) is one of the most economically important insect pests in many horticultural and ornamental crops around the world (Kajita et al., 1991; Srinivasa, 2000; Oliviera et al., 2001; Chand et al., 2019). This pest is endemic in the Central America and Caribbean Region (Russell, 1965; Martin, 1987; Waterhouse and Norris, 1987). It was regarded as a highly polyphagous insect pest due to its extensive host range attacking many important agricultural and ornamental crops (Srinivasa, 2000; Stansly and Natwick, 2010). It was introduced in Canary Island and became an economically important insect pest in 1962 and was reported in Hawaii subsequently in 1978 (Paulson and Kumashiro, 1985). In 1981, the pest was reported in American Samoa and Guam (Firman, 1982), and a year after, the pest invaded the Philippines (Waterhouse and Norris, 1989).

The spiralling whitefly is an intensive polyphagous insect pest that attacks a wide range of host plants belonging to 295 genera and about 90 families of fruits, vegetables, and ornamental plants (Srinivasa, 2000; Gundappa et al., 2013). It damages the plant in two different ways. Directly, it feeds into the plant by inserting its stylet into the leaf tissues sucking up liquid nutrients therein, resulting in leaf drop off (Rashid et al., 2003). Indirectly, the pest secretes waxy substances on the leaf surfaces, which initiate the growth of sooty mold fungus (Purich et al., 1982; Chin et al., 2007). The pest is also vector plant viruses, affecting agricultural production (Nasruddin & Stocks, 2014). Yield reduction was recorded in Guava due to several months of continuous infestation reaching up to 80% (Wen et al., 1995) and in Cassava up to 53% (Geetha, 2000) in Taiwan and India, respectively.

Spiralling whitefly's intensive and logistic spread across many countries is mainly because of the ineffectiveness of synthetic control measures and inefficient non-chemical control tactics (Mani and Krishnamoorthy, 2002). Therefore, this insect pest presents a significant risk in the production and movement of agricultural products across nations (Lambkin, 1998). Since chemical control is impractical and uneconomic, alternative management approaches such as physical, cultural, and biological methods are continuously explored in countries where the pest has become economically significant (Waterhouse and Norris, 1987).

In the Philippines, since the first discovery of the pest in 1982 (Waterhouse and Norris, 1989), minimal attention and effort have been carried out concerning its status, biology, ecology, and management. Therefore, this paper critically analyzed the history and status of the pest in the world, including its management. This was done by examining various sources and published literatures both international and local about the spiralling whitefly. Despite the limited publications about spiralling whitefly in the Philippines, this paper aims to offer a better understanding of the biology and ecology of the pest. The paper also highlights our efforts in terms of its management, preventing this pest from becoming a serious threat in the Philippine agricultural sector.

Origin, Distribution and History of Introduction

Spiralling whitefly is native in Central America and Caribbean Islands but reported first in Florida in 1957 (Russell, 1965). Since then, the pest has successfully spread into many parts of the world, including South America, Africa, Australia, and some Pacific countries (Paulson and Kumashiro, 1985; Waterhouse and Norris, 1987; Akinlosotu et al., 1993). It was reported in Cook Island, Kiribati, Papua New Guinea, Majuro, and Fiji (Waterhouse and Norris, 1987). In Asian countries, on

the other hand, it was recorded in India at Kerala in 1993 (Palaniswami et al., 1995), and later to the rest of the Indian Peninsula (David & Regu, 1995). Unfortunately, there is no sufficient evidence yet to explain its mode of introduction in India, but it was hypothesized that the pest possibly came from Sri Lanka or Maldives (Raman et al., 2002). In Southeast Asia, through intensive field surveys and field observations in Java, Indonesia, the spiralling whitefly was recorded attacking 22 species belonging to 14 families of ornamental plants, fruit trees, and annual crops (Kajita et al., 1991; Yuliani et al., 2005).

Meanwhile, in the Philippines, the spiralling whitefly was first recorded in 1982 by Waterhouse and Norris (1989). The insect was reported as an emerging pest in 1987 in the province of Laguna and was believed to be introduced in the country through strong winds and typhoons (Medina, 1987). In the past few years, through an intensive survey, the pest was reported in the Island of Mindanao, Philippines, particularly in the SOCSARGEN region, and was observed attacking banana plants (Aguilar et al., 2014). Since then, there have been no subsequent studies on the status and distribution of spiralling whiteflies in the Philippines.

Taxonomy, Biology and Ecology of Spiralling Whitefly

The spiralling whitefly was first reported and described in Florida, USA, in 1957 by Russell (1965). The placement of this whitefly species is under the subfamily Aleurodicinae, which is among the three subfamilies under the family Aleyrodidae (Mound and Halsey, 1978). The spiralling whitefly was just among the 100 estimated species under this family (Russell, 1965). To distinguish this species from the other whiteflies, Russell (1965) further described the spiralling whitefly based on the pupal stage. The spiralling whitefly has compound and distinctive pores during this development stage, which is different from the other whitefly species. However, this would be a laborious way of identification and requires microscopic examination. Therefore, detailed taxonomic keys were provided based on some important characteristics of adults and puparia to differentiate spiralling whitefly from the other closely related species (Martin, 1987). On the other hand, no single attempt has been made concerning the taxonomic status of spiralling whiteflies in the Philippines.

Visually, this insect can be characterized by a small white-colored sucking insect closely related to mealybugs and aphids (Chin et al., 2007). The pest's life cycle consists of eggs, four stages of a nymph, and the adult (Chand et al., 2019). Eggs are yellow and elliptical, measuring about 0.3 mm long and singly laid underneath the leaves (Reddy, 2015). The eggs are laid with a short stalk or pedicel inserted into the tissues of the plant host during the process of oviposition (Waterhouse and Norris, 1989). It can be characterized by irregularly spiralling deposits of flocculent waxy structure. The first larval stage of the insect is called crawler and is mobile; however, can only travel short distances in search of feeding locations (Martin, 1987). The succeeding immature (2nd and 3rd) stages have an oval disc shape; about 0.5 to 0.65 mm long, soft-bodied instars, and can be observed as stationary while feeding on a fixed location. Waxy cottony secretions are more visible in these stages than in the 4th instar (Russell, 1965).

On the other hand, the pre-imago or the 4th instar stage is enclosed in a puparium that is about 1.6 mm long and has glass-like rods wax along the side of the body. The imago looks like a minute white-colored moth with a body length of about 2 mm in length (Martin, 1987; Banjo, 2010). The wings of the adults are plain white but may appear pale yellow with dark spots on the forewings (Chin et al., 2007). Spiralling

whiteflies' developmental biology was intensively studied in Nigeria on different cassava genotypes. The incubation period of eggs takes about 6-10 days; the first nymph takes 3-7 days, the second instar takes 4-7 days, the third instar takes 4-7 days, and the fourth instar takes 6-10 days (Banjo et al., 2003). In the Philippines, parthenogenesis was reported as the mode of reproduction by the pest. However, the average number of eggs laid by the mated and unmated males was similar at 67.7 eggs per adult female. Meanwhile, the percent hatchability of the pest in the Philippines reaches up to 88.3 percent (Medina, 1987).

Like any other tropical insect species, temperature and the amount of rainfall were the major climatic factors directly affecting the developmental period of spiralling whitefly regardless of the type of host (Banjo and Banjo, 2003). Lower temperature and heavy to occasional rainfall led to the partial reduction of the Whitefly population (Mani, 2010). Meanwhile, temperatures between 40-45 and 35-40 °C increased the mortality rates of immature and adults, respectively, while temperatures below 10 °C also resulted in higher mortality of the pest (Cherry, 1979; Waterhouse and Norris, 1987). In India, the pest was present throughout the year, with a peak population in March to June but gradually decreased between October to January (Mani & Krishnamoorthy, 2000; Gopi et al., 2001). Meanwhile, in Nigeria, moderate rainfall amount together with a high temperature in the month between April and May, which is also the start of the rainy season after the prolonged drought in December to January, definitely favors the population of spiralling whitefly to increase (Banjo and Banjo, 2003). However, in June and July, which is the wet season in Nigeria, the pest population gradually decreases because many of the eggs are washed out by intense rain with heavy winds (Banjo and Latunde Dada, 1999; Banjo et al., 2003; Asiwe et al., 2002). In the Philippines, the pest population dynamics was reported to be highly correlated with relative humidity, number of rainy days, and amount of rainfall but showed no correlation with temperature. Moreover, the number of natural enemies increases as the population of whitefly increases indicating a probable functional response (Medina, 1987). However, there is no available data regarding the seasonal abundance of the insect pest in the Philippines throughout the year.

Economic Importance

The spiralling whitefly's high reproductive capacity and dispersal rate in most of the invaded countries pose a significant threat to the agricultural industry around the world (Pacific Pest and Pathogen, 2016). The pest becomes economically crucial in two distinct ways. First, it directly feeds on the plant tissues posing a competition with the host for nutrients. The saps are composed of essential carbohydrates and other vital nutrients that are supposed to be utilized by the biochemical processes of the plants. As a result, plants compete with the insect pest causing premature leaf drop and decreasing the overall productivity of the host (Bryne et al., 1990). Secondly, the production of honeydew stimulates the growth of sooty molds, which affects the photosynthesis of the host plant (Puritch et al., 1982; Kumashiro et al., 1983). The growth of the fungus hinders the absorption of light, movement of water and gas exchange, leading to wilting symptoms of the leaves (Reddy, 2015). These two ultimately lead to the reduction of the yield from the infested crop.

Generally, almost all species of whiteflies can transmit plant diseases, specifically viral pathogens. Spiralling whitefly was reported to transmit Cassava Brown Streak Disease in Nigeria efficiently (Mware et al., 2009) and Pepper Yellow Leaf Curl Disease in Indonesia (Nasruddin and Stocks, 2014). The transmission of these diseases by the pest is believed to

be in a persistent manner, just like aphids, mainly when there is enough time to acquire the viral inoculum (Costa, 1969). In the Philippines, it was documented that the pest attacks 40 plants species belonging to 14 families. Specific plants preferred by the pest include *Psidium guajava*, *Euphorbia pulcherrima*, *Capsicum annuum*, and *Musa spp.* (Quimio and Cayetano, 1985; Medina, 1987).

Management Approaches

Spiralling whitefly was not believed an important insect pest from its native origin in Caribbean Region and Central America because the insect is assumed to be regulated by its natural enemies (Prathapan, 1996). However, whitefly management has been a great challenge today to most countries where the pest became economically crucial due to its polyphagous nature and wide host range (Chand et al., 2019). Thus, it was highly recommended that whiteflies be treated by integrating natural regulators, improving the functional response of natural enemies, and area-wide management programs (Chandel et al., 2010).

1.1. Biological Control Method

Biological control was considered one of the most important and safest management tactics and has been an effective component of integrated pest management worldwide (Chand et al., 2019). Since spiralling whitefly is an exotic insect pest in most countries, the introduction of biological control agents is necessary to have a better and sustainable management approach (Lopez et al., 1997). Introduction of natural enemies like aphelinids and coccinellids from the Caribbean Region to Hawaii and some of the Pacific countries showed promising results against the spiralling whitefly (Kumashiro et al., 1983; Paulson and Kumashiro, 1985; Waterhouse & Norris, 1989). Two aphelinid wasps *Encarsia haitensis* and *Encarsia guadaloupe vigigani* were also studied in Nigeria and Ghana against the pest (Neuenschwender, 1994). When the presence of spiralling whitefly was first observed in Benin, Africa, the wasps *E. haitiensis* and *E. guadeloupae* were reported to control the pest population in guava (D'Almeida et al., 1998). Successful control for spiralling whitefly was also reported in Australia when *E. haitiensis* was introduced in Queensland (Lambkin, 1998). Similarly, three aphelinid wasp species were introduced in Japan, namely *Eretmocerus mundus*, *Eretmocerus eremicus*, and *Encarsia formosa* against the pest (Sugiyama et al., 2011). The efficiency of these aphenlinid wasp species to parasitize spiralling whitefly nymphs was studied in India and reached 33.88 - 100% in different host plants (Beevi et al., 1999; Srinivasa et al., 1999; Beevi & Lyla, 2001). On the other hand, more than 40 native predators were reported against the spiralling whitefly in India, most of them are generalist, and only a few are species-specific (Ramani et al., 2002). In Southern Pacific mainly, pirate bugs, lacewings, big-eyed bugs, many coccinellid beetles, and a mite species were the common predators of spiralling whitefly (Messelink et al., 2008; Chand et al., 2019). Additionally, *Stenthonus spp.*, a species of small dark beetle, was reported in India to predate the nymph and pupa of the pest (Banjo, 2004). Meanwhile, entomopathogens have also appeared as a potential biological control agent against spiralling whitefly. Entomopathogenic fungi such as *Isaria farinosa* (formerly *Paecilomyces farinosus*), *B. bassiana*, *M. anisopliae*, *L. lecanii*, and *P. fumosoroseus* were found to be effective in reducing the population of the pest up to 100% in laboratory and field conditions (Mani et al., 2000; Boopathi et al., 2013; Boopathi et al., 2015a; Boopathi et al., 2015b). In the Philippines, 13 natural enemies were reported to regulate the population of spiralling whitefly in the province of Laguna. Among these, ten were considered

predators; 8 of these were beetles, and 2 were chrysopids, while the remaining 3 were hymenopteran parasitoids. The significant predators that showed a high predation rate were *Chrysopa splendida*, *Chrysopa basalii*, and *Clambus spp.* (Medina, 1987). However, there is a dearth of published reports on entomopathogens as biological control agents against the spiralling whitefly in the Philippines.

1.2. Cultural/Physical Method

The cultural pest management method is one of the classical techniques to manage insect pest population that affects agricultural industry (Hill, 1987). It is defined as the purposeful modification of crop production techniques to reduce the pest population or the damage caused by the pest. This method includes modifying the environment where the crop is established and enforcing the correct agronomic practices (Schellhorn et al., 2000). In combating the spiralling whitefly using the cultural method, the selection of plant varieties that are somewhat resistant against the pest was promising as a cultural management method. It was reported that some cassava genotypes in India showed compensatory ability even there is a high infestation of the whitefly (Banjo et al., 2004). Further, removing low-lying weeds during the wet season prevents the re-infestation of the pest since, during the wet season, infestation re-occurs when the environment is favorable (Banjo and Latunde-Dada, 1999). Use of clean planting materials and removal of infested leaves to rid the immobile immature and pupal stages may also be an environmentally friendly approach; however, it does not completely remove the presence of the pest but at least reduce their population (Geetha, 2000; Chand et al., 2019). On the other hand, installation of yellow sticky traps, light traps covered with Vaseline coating, and fluorescent light with castor oil effectively attract the adult population of the pest and can be placed both in greenhouse and field conditions (Srinivasan and Mohanasundaram, 1997; Mariam, 1999; Geetha, 2000; Barbedo, 2014). Unfortunately, there were no published articles on using this pest management method against spiralling whitefly in the Philippines.

1.3. Chemical Method

In countries where natural enemies and cultural management methods are not possible, a resort to chemical control is necessary to manage spiralling whitefly and is one of the options for most farmers. It is also recommended that when the pest population becomes severe, synthetic control may be used to prevent significant economic losses due to the attack of the pest (Asiwe et al., 2002). Commonly, synthetic insecticides such as Dimethoate 30 EC, Chlorpyriphos 20EC, Cypermethrin 10EC, Thiamethoxam 25WG, Diazinone 60EC, Chlorpyrifos 48EC, and Malathion 57EC were used against spiralling whitefly (Roy et al., 2014; Reddy, 2015; Khan, 2017; Khalil et al., 2019). Similarly, chemicals such as buprofezin, imidacloprid, pyridaben, and spiromesifen also showed promising results (Bi et al., 2002; Toscano and Bi, 2007). Insecticidal soap and detergents, on the other hand, have been reported to effectively control the spiralling whitefly and other insect pests in many countries (Puritch et al., 1982; Waterhouse and Norris, 1989; Butler et al., 1993; Laprade and Cerdas, 1998; Hall & Richardson, 2013; Boopathi et al., 2014). In the Philippines, there is a limited report concerning the application of chemical insecticides against the spiralling whitefly. It was stated that Chlorpyrifos, diazinon, malathion, and methomyl were the synthetic insecticides used against the pest infesting guava in Laguna, Philippines (Quimio and Cayetano, 1985). However, chemical control against the pest was uneconomic and impractical since it destroyed the abundance of natural enemies like insect parasitoids and predators in the

field (Kajita et al., 1991).

1.4. Botanicals

Botanical insecticides have been considered to represent an alternative to chemical insecticides in protecting crops. Some major contributing factors for exploring such alternatives are health and environmental issues of using synthetic chemicals, uneconomic, impractical, and several reports of pest developing resistance (Kajita et al., 1991; Oliveira et al., 2001; Aktar et al., 2009; Chand et al., 2019). With these issues in mind, essential oils and plant-derived extracts were recently explored against a variety of insect pests that affect crops (Singh et al., 2012; Yang, 2010). It was reported that the mode of action of these biopesticides is mainly through contact action. These natural insecticides disrupt the natural functions of the cell, hinder the respiration process by blocking the entry point of air and inhibit growth and development (Bogran et al., 2006; Fogang et al., 2012; Subbalakhmi et al., 2012). Neem (*A. indica*) extract diluted in ethanol and acetone applied topically resulted in 100% mortality of spiralling whitefly (Alim et al., 2017). Neem oil has

Table 1. Summary on different management approaches against the spiralling whitefly.

Country/s	Method of Pest Management	Specific Management Technique	References
Hawaii	Biological	Introduction of Insect predators and Parasitoids	Kumashiro et al. (1983) Paulson and Kumashiro (1995) Waterhouse and Norris (1989)
Carribean Region	Biological	Native Parasitoids and Predators	Waterhouse and Norris (1989)
Nigeria	Biological	Introduction of insect parasitoids	Neuenschwender (1994)
Ghana	Biological	Introduction of insect parasitoids	Neuenschwender (1994)
Benin	Biological	Parasitoids	D'Almeida et al. (1998)
Australia	Biological	Utilization of insect parasitoids	Lambkin (1998)
Japan	Biological	Introduction of insect parasitoids	Sugiyama et al. (2011)
India	Biological, Cultural, Chemical and Botanical	Insect predators and Parasitoids, entomopathogens, removal of low lying weeds, application of synthetic chemicals, insecticidal soap and neem.	Beevi et al. (1999) Srinivasa et al. (1999) Mani et al. (2000) Beevi and Lyla (2001) Ramani et al. (2002) Boopathi et al. (2013) Boopathi, et al. (2015a) Boopathi, et al. (2015b) Khan (2017)
Philippines	Chemical and Biological	Application of synthetic insecticides and utilization of insect predators and parasitoids.	Quimio and Cayetano (1985) Medina (1987)
Southern Pacific	Biological and botanicals	Use of insect parasitoids, predators and medicinal plant extracts	Messelink et al. (2008) Chand et al. (2019) Chand et al. (2016)
Indonesia	Biological	Utilization of insect predators	Kajita et al. (1991)
Bangladesh	Chemical and bitanicals	Application of synthetic chemicals and plant extracts.	Khalil et al. (2019) Alim et al. (2017)
Costa Rica	Chemical	Application of diluted soap and detergents.	Laprades and Cerdas (1998)

also been effective against the pest in several countries (Ramani et al., 2002). Meanwhile, essential oils of some medicinal plants in the South Pacific, namely *Cananga odorata*, *Cymbopogon citratus*, *Murraya koenigii*, *Ocimum tenuiflorum* and *Euodia hortensis* showed excellent repellent and fumigant effects (Chand et al., 2016). There was a study in Bangladesh exploring eight species of plants extracted in ethanol and acetone against the pest (Alim et al., 2017). Unfortunately, there is still no published report in the Philippines until this date regarding the utilization of botanical insecticides against the spiralling whitefly.

Quarantine Regulations

Even if there are management strategies for spiralling whitefly in many countries globally, quarantine is still one of the most critical strategies for countries which the pest has not invaded until this date. Quarantine restrictions are significant in regulating the movement of infested plant materials together with insect pests (Karuppuchamy and Venugopal, 2016). The movement of plants and produce across borders requires specific regulations and inspection to ensure the products are free from insect infestation (Chin et al., 2007). In Queensland, plants should be inspected not more than 48 hours after arrival in the facility. Both sides of plant leaves must be inspected thoroughly by an authorized plant inspector. If accepted, the inspector will issue the authorization for the plants to enter the country. However, if the spiralling whitefly is detected, the plants will be automatically rejected, immediately removed from the area, treated with insecticides, and eventually discarded (Queensland Government, 2002). In the Philippines, a presidential decree 1433; otherwise known as the Plant Quarantine Decree, was enacted in 1978 that provides power to the Bureau of Plant Industry (BPI) in promulgating regulatory procedures to prevent the introduction, incursion, establishment, and the possible spread of different pests and diseases during movement of agricultural products across boundaries. The decree further provides plant quarantine rules and regulations that adhere to the UN's International Plant Protection Convention (IPCC) (Ani, 2017).

CONCLUSION AND RESEARCH PROSPECTS

The spiralling whitefly is indeed a serious insect pest of several crops in many countries around the world. The pest becomes a significant concern of most farmers due to its intensive host range. This is because the pest feeds directly on the leaves, removing nutrients from plants. The production of waxy substances and honeydew also cause indirect damage by interfering with photosynthesis. Many scientists reported the development of spiralling whitefly to be highly correlated with agrometeorological factors such as relative humidity, temperature, and rainfall. One of the concrete bases in any pest management is the data on the population dynamics of the concerned pest. Knowledge of these factors provides the exact time for a control measure to be applied. However, there is a dearth of researches concerning seasonal fluctuations of spiralling whitefly throughout the year in the Philippines, suggesting that more efforts on pest monitoring and detection are vital. Meanwhile, it was reported that this pest is a vector of numerous plant viruses that could be a potential for a disease outbreak in many crops. Thus, future research should also focus on the virus-vector interaction, including the pest's efficiency in transmitting such plant viruses.

As to the management of the pest, chemical control is still the option of many farmers. However, numerous records of biological control agents such as predators, parasitoids, and entomopathogenic fungi were all effective against the spiralling whitefly. Moreover, the bioefficacy of

botanical insecticides against the pest was also intensively explored in recent years. In the Philippines, however, only predators, parasitoids, and chemical control were studied. These limitations open the opportunity for future studies to explore entomopathogenic fungi and other entomopathogens as potential biological control agents against the spiralling whitefly. In addition, utilizing botanical insecticides against the spiralling whitefly is strongly advocated since there are dearth published efforts in the Philippines concerning natural insecticides for this insect pest. On the other hand, cultural methods have also been reported as a contributory factor for effective management against the pest. The use of this method must also be carried out in the country to utilize farm resources efficiently. Additionally, more recent evaluation on the efficiency of predators and parasitoids and the efficacy of newer synthetic insecticides with new mode of action is also recommended.

Due to environmental concerns and health issues, the non-chemical approaches as significant components of the integrated pest management program for spiralling whitefly must be given utmost priority in future works to have safer food products, a healthier environment, and prevent pest resistance. Although there are no reports of the spiralling whitefly outbreak in the Philippines since its first discovery in 1982, still it is important to monitor its occurrence and status to quickly respond to the pest before the outbreak scenario. Considering that this pest has a wide host range, it is undeniable that it would significantly affect Philippine Agriculture if given favorable conditions. Hence, mitigation and constant monitoring of its status are paramount to protecting the countries' agricultural industry.

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REFERENCES

Aguilar, C.H., Zapico, F.L., Namocatcat, J., Fortich, A., and Bojadores, R.M. 2014. International Conference on Intelligent Agriculture IPCBEE, 63, 22-27, IACSIT Press, Singapore.

Aktar, M.W., Sengupta, D. and Chowdhury, A. 2009. Impact of pesticides use in agriculture: their benefits and hazards. Interdisciplinary Toxicology, 2: 1-12.

Akinlosotu, T.A., Jackai, L.E.N., Ntonifor, N.N., Hassan, A.T., Agyakwa, C.W., Odebiyi, J.A., Akingbohungbe, A.E., Rossel, H.W. 1993. Spiralling whitefly *Aleurodicus dispersus* in Nigeria. FAO Plant Protection Bulletin 41, 127-129.

Alim, M.A., Song, J., Lim, U.A., Choi, J.J., Hossain, M.A. 2017. Bioassay of plant extracts against *Aleurodicus dispersus* (Hemiptera: Aleyrodidae). Florida Entomologist, 2, 350-357.

Ani, P.A.B. 2017. The Philippine plant quarantine laws: Review of policies protecting plant resources. Available at ap.fftc.org.tw/article/1237

Asiwe, J.A.N., Dixon, A.G.O., Jackal, L.E.N., Nukenine, E.N. 2002. Investigation on the the spread of the spiralling whitefly (*A. dispersus*, Russell) and field evaluation of elite cassava population for genetic resistance. A Research article in AJRTC 5 (1): 12-17.

Banjo, A.D. and Latunde-Dada, I.L. 1999. An assessment of host plant preference of the spiralling whitefly (*A. dispersus*) in Ago-Iwoye, Nigeria. J. Crop Res. 17(3): 390-394.

Banjo, A.D. and Banjo, F.M. 2003. Life history and the influences of agroclimatological factors on the spiralling whitefly (*A. dispersus* Russel) (Homoptera: Aleyrodidae) on some host plants of economic importance in South-Western Nigeria. J. Crop Res. 26(1):140-144.

Banjo, A.D., Hassan, A.T., Jackal, L.E.N., Dixon, A.G.O., Ekanayake, I.J. 2003. Developmental and Behavioural study of spiralling whitefly (*A. dispersus*) on three cassava (*Manihot esculenta* crantz) genotypes. Nigeria. J. Crop Res. 26(1): 145-149.

Banjo, A. 2010. A review of on *Aleurodicus dispersus* Russel (spiralling whitefly) [Hemiptera: Aleyrodidae] in Nigeria Journal of Entomology and Nematology, 2: 1-6.

Banjo, A.D., Hassan, A.T., Ekanayake, I.J., Dixon, A.G.O., Jackal, L.E.N. 2004. Effect of *Aleurodicus dispersus* Russel (Spiralling whitefly) on growth indices and yield of three genotypes of cassava (*Manihot esculenta* Crantz). J. Res. Crops. 5(2-3): 252-260.

Barbedo, J.G.A. 2014. Using digital image processing for counting whiteflies on soybean leaves. Journal of Asia-Pacific Entomology, 17: 685-694.

Beevi, S.P., Lyla, K.R. & Vidya, P. 1999. Report of Encarsia (Hymenoptera: Aphelinidae) on spiralling whitefly *Aleurodicus dispersus* Russell (Homoptera: Aleyrodidae). Insect Environment 5, 44.

Bi, J.L., Toscano, N.C., Ballmer, G.R. 2002. Greenhouse and field evaluation of six novel insecticides against the greenhouse whitefly *Trialeurodes vaporariorum* on strawberries. Crop Protection, 21: 49-55.

Boopathi, T., Karuppuchamy, P., Kalyanasundaram, M.P., Mohankumar, S. & Ravi, M. 2013. Pathogenicity, ovicidal action, and median lethal concentrations (LC50) of entomopathogenic fungi against Exotic Spiralling Whitefly, *Aleurodicus dispersus* Russell. Journal of Pathogens. 2013; 393787.

Boopathi, T., Karuppuchamy, P., Kalyanasundaram, Subbarayalu, M. & Ravi, M. 2014. Effects of botanicals, fish oil rosin soap and organic salt on eggs of Spiralling Whitefly, *Aleurodicus dispersus*. Indian Journal of Plant Protection, 42(1): 86-88.

Boopathi, T., Karuppuchamy, P., Kalyanasundaram, M., Subbarayalu, M., Ravi, M. & Singh, S.B. 2015a. Microbial control of the Exotic Spiralling whitefly (Hemiptera: Aleyrodidae) on eggplant with entomopathogenic fungi. African Journal of Microbiology Research, 9(1), 39-46.

Boopathi, T., Karuppuchamy, P., Kalyanasundaram, M., Subbarayalu, M., Ravi, M. & Singh, S.B. 2015b. Microbial control of the invasive Spiralling whitefly on cassava with entomopathogenic fungi. Brazilian Journal of Microbiology, 46(4), 1077-1085.

Borgan, C.E., Ludwig, S. & Metz, B. 2006. Using Oils as Pesticides. Texas AandM Agrilife Extension Service. E-419. Available electronically from *https://hdl.handle.neT/1969.1/86885*

Butler, G.D., Henneberry, T.J., Stansly, P.A., & Schuster, D.J. 1993.

Insecticidal effects of selected soaps, oils and detergents on the Sweet Potato Whitefly: (Homoptera: Aleyrodidae). Florida Entomologist, 76(1).

Chand, R.R., Jokhan, A.D. and Gopalan, R.D. 2016. Bioactivity of selected essential oil from medicinal plants found in Fiji against the Spiralling whiteflies. Advances in Horticultural Science, 30(3): 165-174.

Chand, R.R., Jokhan, A.D., Kelera, R. 2019. Spiralling whitefly and its management Practices in the South Pacific. A review. Advances in Horticultural Science, 33(1): 123-131.

Cherry, R.H. 1979. Temperature tolerance of three whitefly species found in Florida. Environ. Entomology, 8: 1150-1152.

Chin, D., Brown, H., Zhang, L., Neal, M., Thistleton, B. & Smith, S. 2007. Biology and Pest Management of Spiralling whitefly. Northern Territory Government Factsheet, Department of Primary Industry, Fisheries and Mines, Australia.

Costa, A.S. 1969. Whiteflies as vectors. In viruses vectors and Vegetation. In: Maramoruskh, K. (ed.) John Wiley and sons, New York. 111pp.

D'Almeida, Y.A., Lys, J.A., Neuenschwander, P., Aljuonu, O. 1998. Impact of two accidentally introduced *Encarsia* species (Hymenoptera: Aphelinidae) and other biotic and abiotic factors on the spiralling whitefly *Aleurodicus dispersus* Russell (Homoptera: Aleyrodidae) in Benin, West Africa. Biocontrol Science and Technology, 8(1): 163-173.

Firman, I.D. 1982. Plant protection news. Noumea, New Caledonia; South Pacific Commission, Information Circular No. 90, 8.

Fogang, H.P.D., Womeni, H.M., Piombo, J., Barouh, N. & Tapondjou, L.A. 2012. Bioefficacy of essential and vegetable oils of Zanthoxylum xanthoxyloides against *Acanthoscelides obtecus* (Say) (Coleoptera: Bruchidae). Journal of Food Protection, 75(3), 547-555.

Geetha, B. 2000. Biology and Management of Spiralling whitefly *Aleurodicus dispersus* Russell (Homoptera: Aleyrodidae). [PhD Thesis]. Available at Tamil Nadu Agricultural University Library, Coimbatore, India.

Gundappa, Kamala Jayanthi PD, Verghese A. 2013. Management of spiralling Whitefly, *Aleurodicus dispersus* (Russell) in guava, *Psidium guajava* L. Pest Management in Horticultural Ecosystems, 19(1):102-105.

Hall, D.G. and Richardson, M.L. 2013. Toxicity of insecticidal soaps to the Asian citrus psyllid and two of its natural enemies. Journal of Applied Entomology. 137(5).

Hill, S. 1987. Cultural Pest Control. American Journal of Alternative Agriculture, 2(04): 53-58.

Kajita, H., Samudra, I., and Naito, A. 1991. Discovery of Spiralling whitefly *Aleurodicus dispersus* Russell (Homoptera: Aleyrodidae) from Indonesia, with notes on its host plants and natural enemies. Applied Entomology and Zoology (3): 397-400.

Karuppuchamy, P. and Venugopal, S. 2016. Integrated pest management. In: Omkar (eds). Ecofriendly Pest Management for Food Security, 651-684, Elsevier Academic Press.

Khan, M.M.H. 2017. Bioefficacy of insecticides on the immature and and adult stages of Spiralling Whitefly on guava. Journal of Entomology and Zoology Studies. 5(5), 380- 384.

Kumashiro, B.R., Lai, P.Y.; Funasaki, G.Y., Teramoto, K.K. 1983. Efficacy of *Nephaspis amnicola* and *Encarsia haitiensis* in controlling *Aleurodicus dispersus* in Hawaii. Proceedings of the Hawaiian Entomological Society 24, 261-269.

Lambkin, T. 1998. Spiralling whitefly threat in Australia. Quarantine Bulletin no. 8. Department of Primary Industry, Brisbane, Queensland, Australia.

Laprade, S. & Cerdas, V.H. 1998. Management of the spiralling white fly (*Aleurodicus dispersus* Russell, Homoptera: Aleyrodidae) in banana (*Musa* AAA) using insecticides and oil. CORBANA, 22(48):89-94.

Lopez, V.F., Kairo, M.T.K., Carl, K.P. 1997. Strengthening of the Biological control programme against the spiralling Whitefly, *Aleurodicus dispersus*, in Togo. Curepe, Trinidad and Tobago; International Institute of Biological Control, Technical Report, p.70.

Mani, M. & Krishnamoorthy, A. 2000. Population dynamics of spiralling whitefly, *Aleurodicus dispersus* Russell (Aleyrodidae, Homoptera) and its natural enemies on guava in India. Entomon 25, 29-34.

Mani, M., Krishnamoorthy, A., Dinesh, M.S. 2000. Biological control studies on the spiralling whitefly, *Aleurodicus dispersus* Russell (Homoptera: Aleyrodidae). Abstracts, Entomocongress 2000 – Perspectives for the New Millennium, Trivandrum, 5-8 November 2000. Trivandrum, India; Association for Advancement of Entomology, pp.37-38.

Mani, M., Krishnamoorth, A. 2002. Classical biological Control of the spiralling whitefly, *Aleurodicus dispersus* Russell – An appraisal. – Int. J. Tropical Insect Sci., 22: 263-273.

Mani, M. 2010. Origin, introduction, distribution and management of the invasive spiralling Whitefly, *Aleurodicus dispersus* Russell in India. - Karnataka J. Agric. Sci., 23: 59-75.

Mariam, M. A. 1999. Biology and management of spiralling whitefly, *Aleurodicus dispersus* Russell (Homoptera: Aleyrodidae) on mulberry. M.Sc. (Ag) Thesis, Tamil Nadu Agricultural University Library, Coimbatore, India. p. 88.

Martin, J.H. 1987. An identification guide to common whitefly pest species of the world (Homoptera, Aleyrodidae). Tropical Pest Management, 33(4):298-322.

Messelink G.J., Maanen R.V., Van Steenpaal S.E.F. & Janssen, A. 2008. Biological control of thrips and whiteflies by a shared predator: Two pests are better than one. Biological Control, 44: 372-379.

Medina, C.P. 1987. Biology and ecology of the spiralling whitefly, *Aleurodicus dispersus* Russell (Homoptera: Aleyrodidae) and its natural enemies in the Philippines. [Thesis]. University of the Philippines, Los Banos, Laguna, Philippines.

Mound, L.A. & Halsey, S.H. 1978). Whitefly of the world: A systematic catalogue of the aleyrodidae (Hemiptera) with host plant and natural enemy data. John Wiley and Sons, Chicheser. UK, p.321.

Mware, B., Naria, R., Amata, R., Olubayo, F., Songs, J., Ateka, E. M. 2009. Efficiency of cassava brown streak virus transmission by two whitefly species in coastal Kenya. Journal of General and Molecular Virology, 1(4): 040-045.

Nasruddin, A. and Stocks, I.C. 2014. First report on economic injury due to Spiralling whitefly (Hemiptera: Aleyrodidae) on pepper in Indonesia. Florida Entomologist, 97(3): 1255-1259.

Neuenschwender, P. 1994. Spiralling whitefly, *Aleurodicus dispersus* Russel, a recent invader and new cassava pest. African Journal of Crop Science, 2(40): 419-421.

Oliveira. M., Henneberry, T., Anderson, P. 2001. History, current status, and collaborative research projects for *Bemisia tabaci*. Crop protection, 20: 709-723.

Pacific Pests and Pathogens. 2016. Spiralling whitefly [Fact Sheet]. Accessed July 20, 2021 from http://www.pestnet.org/fact_sheets/spiralling_whitefly_025.pdf.

Palaniswami, M.S., Pillai, K.S., Nair, R.R., Mohandas, C. 1995. A new cassava pest in India. Cassava Newsletter 19, 6-7.

Paulson, G.S. and Kumashiro, B.R. 1985. Hawaiian Aleyrodidae. Proceedings of the Hawaiian Entomological Society 25, 103-129.

Prathapan, K.D. 1996. Outbreak of the spiralling whitefly *Aleurodicus dispersus* Russell (Aleyrodidae: Homoptera) in Kerala. Insect Environment, 2, 36-38.

Puritch, G.S., Tonks, N.V., and Downey, P. 1982. Effect of a Commercial Insecticidal Soap on Greenhouse Whitefly (Hom: Aleyrod) and its Parasitoid, *Encarsia formosa* (Hym: Euloph). Journal of the Entomological Society of British Columbia, 79: 25-28.

Queensland Government. 2002. Inspection and treatment of plants for spiralling whitefly. Plant Health Control - Interstate Certification Assurance-35, 11-12.

Quimio, A. J. & Cayetano, C. Q. 1985. Control of whiteflies (*Aleurodicus dispersus*) on guava with diazinon, chlorpyrifos, malathion and methomyl (Conference paper). Accessed from https://agris.fao.org/agris-search/search.do?recordID=XB8540313

Ramani, S., Poorani, J., Bhumannavar, B. S. 2002. Spiralling whitefly, *Aleurodicus dispersus*, in India. Biocontrol News and Information, 23(2): 55-62.

Rashid, M. M., Hossain, M., Alam, M.Z., Ibrahim, M. & Bhuiyan, M.K.A. 2003. Seasonal Abundance and Control of Spiralling whitefly, *Aleurodicus dispersus* Russell on Guava. Pakistan Journal of Biological Sciences, 6 (24): 2050-2053.

Reddy, P.P. 2015. Cassava, *Manihot esculenta*. Plant Protection in Tropical Root and Tuber Crops, Springer India.

Roy, S. K., Ali, M.S., Mony, F.T.Z., Islam, S. & Abdul Matin, M. 2014. Chemical control of whitefly and aphid insect pests of french bean (*Phaseolus vulgaris* L.). Journal of Bioscience and Agriculture Research, 02(02).

Russell, L.M., 1965. A new species of *Aleurodicus* Douglas and two close relatives (Homoptera: Aleyrodidae). The Florida Entomologist, 48:47-55.

Schellhorn, N.A., Harmon, J.P., and Andow, D.A. 2000. Using cultural practices to enhance insect pest control by natural enemies. In: Rechcigl, J.A. and Rechcigl, N.A. (Ed.) Insect pest Mangement: Techniques for Environmental Protection, 147-170. Boca Raton, FL: Lewis

Singh, A., Khare, A., and Singh, A. 2012. Use of vegetable oils as biopesticide in grain protection: A review. Journal of Biofertilizers and Biopesticides, 3(1).

Srinivasa, M.V., Viraktamath, C.A., Reddy, C. 1999. A new parasitoid of the spiralling whitefly *Aleurodicus dispersus* Russell (Hemiptera: Aleyrodidae) in South India. Pest Management in Horticultural Ecosystems 5, 59-61.

Srinivasa, M.V. 2000. Host plants of the spiralling whitefly *Aleurodicus dispersus* Russell (Hemiptera: Aleyrodidae). Pest Management in Horticultural Ecosystems 6, 79-105.

Srinivasan, G., Mohanasundaram, M. 1997. A novel method to trap the spiralling whitefly, *Aleurodicus dispersus* Russell adults in the home gardens. Insect Environment, 3: 18.

Stansly, P.A. and Natwick, E.T. 2010. Integrated Systems for managing *Bemisia tabaci* in protected and Open field agriculture. (Chapter 1). In: Stansly, A.P., and E.S. Naranjo (eds.) Bemisia: Bionomics and Management of a Global Pest. Springer, Dordrecht, The Netherlands.

Sugiyama K., Katayama H., and Saito, T. 2011. Effect of insecticides on the mortalities of three whitefly parasitoid species, *Eretmocerus mundus*, *Eretmocerus eremicus* and *Encarsia formosa* (Hymenoptera: Aphelinidae). Applied Entomola and Zoology, 46: 311-317.

Subbalakhmi, L., Muthukrishnan, P., and Jeyaraman, S., 2012. Neem products and their agricultural applications. Journal of Biopesticides. 5, 72-76.

Toscano N.C., and Bi J.L. 2007. Efficacy of spiromesifen against greenhouse whitefly (Homoptera: aleyrodidae) on strawberry, HortScience, 42: 285-288.

Waterhouse D.F. and Norris K.R. 1987. Biological control: Pacific prospects. In: Waterhouse D.F., and K.R. Norris (eds.) Biological Control. ACFIA, Inkata Press, Melbourne, Australia, pp. 454.

Waterhouse, D.F. and Norris, K.R. 1989. Biological Control: Pacific Prospects – Supplement 1. Canberra, Australia; ACIAR, ACIAR Monograph No.12. 130 pp.

Wen, H. C., Tung, C. H. & Chen, C. N. 1995. Yield loss and control of Spiralling whitefly (*Aleurodicus dieprsus* Russell). Journal of Agricultural Research of China, 44: 147-156.

Yang, N.W. 2010. Effects of plant essential oils on immature and adult Sweet potato whitefly, *Bemisia tabaci* biotype B. Crop Protection, 29: 1200-1207.

Yuliani, P., Hidayat and Sartiami, D. 2005. Identification of whiteflies (Hemiptera: Aleyrodidae) from several host Plants and their population growth. Jurnal Entomologi Indonesia, 3(1): 41-49.

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THE ROLE OF VETIVER GRASS IN PROTECTING UNSTABLE SLOPES

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Abstract — Vetiver grass (*Chrysopogon spp.*) is characterised by creating a dense hedge that acts as a barrier against rainwater runoff. The barrier significantly reduces the runoff velocity that enables the sediment contents of the runoff to be deposited behind the hedge depending on the slope of the land that creates terraces over time. This case study aims to review the characteristics of the vetiver roots and evaluate its effectiveness in protecting unstable slopes. Field trials were conducted in selected mining areas in Papua New Guinea using quality planting materials and fertilizers for rapid growth and a very immense network of roots formed in the soil. Its root average tensile strength of 75 MPa or approximately 1/6th of mild steel, higher than several trees traditionally used for steep slope stabilization. Vetiver grass is tolerant to drought, saline soil, high and low temperature, thus it lives longer. The effectiveness of Vetiver System Technology is presented in this case study on very unstable sites in Papua New Guinea.

Keywords **— Vetiver grass, vetiver roots, slope stabilization**

INTRODUCTION

There are three well-known vetiver species: Indian vetiver (*Chrysopogon zizanioides*), African vetiver (*Chrysopogon nigritana*), and South East Asian vetiver (*Chrysopogon nemoralis*). In addition, there are five less known species: *Chrysopogon lawsonii* and *Chrysopogon gryllus* in northern India and three Australian native vetiver species: *Chrysopogon filipes*, *Chrysopogon elongata* and *Chrysopogon rigidus*.

The Indian vetiver species (*C. zizanioides*) is further distinguished in to South Indian and North Indian cultivars. Among these, South Indian vetiver *C. zizanioides* is the best known and globally most widespread species due to its essential oil production and use in thatching. Presently, the South Indian cultivar is cultivated for various applications in tropical and subtropical Africa, Asia, Americas, Oceania, and Mediterranean Europe. The North Indian cultivars is not commonly cultivated, and it only exist in swamps in the northern states of India.

Lavania (2008) of the Central Institute of Medicinal and Aromatic Plants in Lucknow, India stated that vetiver is native to India, where it is known to be used both for its fragrant oil and as traditional medicine since antiquity, and its hedges have been used for soil conservation of agricultural lands in India since centuries.

Throughout the tropical and sub-tropical wild states in India, vetiver occurs particularly in marshy land and along riverbanks. It has wide range of ecological distribution ranging from sandy coastal swamps to plains and foothills, and also on the hilltops up to elevations of 800m in the Kumaun hills of Uttar Pradesh. Two distinct morphological cultivars of vetiver are found to inhabit spatially separated geographic regions in India.

The two cultivars are distinctly different. The north Indian wild types flower profusely with high seed-setting and narrow leaves, roots produces superior quality laevorotatory oil (*ruh-khus* or *khus* oil). On the other hand, the south Indian cultivated types has low/non seed-setting and wider leaves, non/late flowering pattern, and produces lower quality of dextrorotatory root oil.

The South Indian *C. zizanioides* vetiver grass has deep penetrating tufted root system and a prolific clump of tillers above ground reaching the height of up to 2.5 meters, and the roots growing indeterminately reaching up to 3 meters in one year. Propagation can be done vegetatively through planting of tillers. Vetiver root complex has tuft of fibrous roots which grows vertically penetrating deep into the soil. However, this penetrating root system may have a diverse architectural pattern, ranging from limited spread to vertically penetrating. The main source of essential oil are the primary fibrous roots in contrast with the lateral hairy roots with little oil. However, these lateral hairy roots does help in the formation of root-web facilitating strong soil binding.

The objectives of this case study is to review the role of vertiver roots and evaluate the effectiveness of vetiver grass under different climatic conditions in Papua New Guinea in protecting unstable slopes.

Plant roots and their Interaction with Soil Medium

In the book Plant Roots: Growth, Activity, and Interaction with Soils, Gregory (2006) pointed out the importance of the following attributes of the root system and its interactions with the surrounding environment.

Mass and Length

Most of the vetiver roots are fine roots (≤2 mm diameter), but coarse roots make up by far the majority of the root biomas in

croplands and temperate grasslands. The fine roots constitute the primary pathway for water and nutrient uptake in many biomes.

Depth of Rooting

Factors which influences the depth of rooting are the genetic and environmental factors. The depth to which roots can grow has many implications for the hydrological balance and biogeochemical cycling of ecosystems. A maximum rooting depth of 253 woody and herbaceous species from the major terrestrial biomes were found to have a maximum rooting depth varying from 0.3m for some tundra species to 68m. Twenty-two species had roots that extended to 10m or more but 194 species had roots that were at least 2m deep.

Root Longevity and Turnover

High variability in the median lifespan of roots, ranging from a few weeks in some plants (annual crops like sweet potato and groundnut) to many months (sugar maple). In the grass family, thicker roots and high tissue density have also been associated with increased longevity. In nutrient-poor environments thicker roots with a longer lifespan may increase the residence time of nutrients in the plant, and provide an important means of nutrient conservation.

Lavania (2003) pointed out that the Vetiver Root System has diverse applications such as land/slope stabilization, bio-engineering, and environment specific cultivation.

Each application envisages specific a type of root system, hence search for an ideal Root Type for specific applications. For land/slope stabilization and other Bioengineering applications, its roots needs to be profusely branching, spreading type with the amount least essential oil.

VETIVER GRASS ROOTS

Botanical Organization of Vetiver Root System

The veritver roots are characterized to have a tufted vertically growing root system, primary roots are supported with secondary fibrous roots, juvenile primary/ secondary roots are solid with persistent cortex and little oil, mature thick roots are spongy with schizogenous cortex and have well developed phloem, phloem is the site of essential oil synthesis and storage, solid vascular cylinder provides tensile strength to roots, and schizogenous cortex facilitates root aeration suitable for submerged conditions. Presented in Figure 1 is the vetiver root system showing its diversity.

Fig. 1. The diversity of the vetiver root system.

Lavania (2019) also pointed out that most grasses have fibrous roots, which spread out from the underground part of the crown and hold the soil in a horizontal pattern. However, the vetiver root whether it is the main and secondary roots ot their fibrous ramification, penetrate vertically into the soil. In vetiver, the roots are biologically the most important and economically the most useful part of the plant. In addition to absorbing water and stabilizing soil moisture, vetiver roots reinforce the integrity of the soil structure.

Structural Dynamics of Vetiver Root

Vetiver roots are comprised of the tufted mass originating from the crown from

which shoots arise. In general, growth and behavior of roots is coupled closely to the growth and behavior of shoots. Twelve to eighteen months old vetiver plants has well-developed vascular cylinder and persistent cortex.

Yoon (1989), in an expert on bioengineering using vetiver for slope stabilization (cut and fill batters), described the vetiver root system as very deep and vigorous. With the use of quality planting materials and appropriate fertilizers, rapid growth was obtained and a very immense network of roots formed in the soil. These were clearly demonstrated by plant excavations in China, Malaysia, Thailand, Vietnam. Shown in Figure 2 is a one-year old vetiver roots in Thailand. In the Mediterranean climate of Spain, the roots reached down to 2.1m, after nine (9) months of growth. After I4 months in the field, the roots reached 2.6m depth, and this was despite going through a winter period when sub-zero temperatures killed the tops.

Fig. 2. One year old vetiver with 3.7m root in Thailand

Lifespan of Vetiver

As life span and size of its root system play a very important role in bioengineering, measures that encourage root growth and persistence, even at the expense of its shoot growth should be encouraged. Through a personal communication with Don Miller, as his review on the existence of vetiver in the South West Pacific Islands, he discovered some long lived vetiver plants in the region, which had been introduced earlier, that could be over 100 year old in New Caledonia.

Vetiver Root Responses to Varying Temperature

Although vetiver is a tropical plant, it is extremely tolerant to low temperature. In Australia, vetiver growth was not affected by severe frost at -14°C ground temperature, it survived for a short period at -22°C (-8°F) in northern China. In Georgia (USA), Vetiver survived in soil temperature of -10°C but not at -15°C.

Under phytotron conditions, on average, at temperature above 25°C, daily root growth of 3cm was recorded and at the soil temperature range of 15°C (day) and at 13°C (night), root growth continued at the rate of 12.6cm/day, indicating that vetiver grass was not dormant at this temperature. (Truong, 2003).

Physiological Adaptations of Vetiver under Drought

Under drought conditions, vetiver extends its roots until they reach the moist subsoil and beyond the water table. Significant physiological adaptations of its root must occur during this water stress period. Under artificial inducement it can be in excess of 11m as in Guatemala. At that depth, oxygen level in the soil is extremely low, to sustain this underground growth, vetiver has to rely on the oxygen supply

from the shoot through its phenomenal network of parenchyma (Wang, 2000)

Salt Tolerance of Vetiver Grass

As shown in the graphs below, the saline threshold of Monto vetiver is ECse = 8 dSm-1 (left) and soil ECse values of 10 and 20 dSm-1 would reduce yield by 10% and 50% respectively (right). These results indicate vetiver grass compares favorably with some of the most salt tolerant crop and pasture species grown in Australia as shown in the Figure 3 (Truong, 2003).

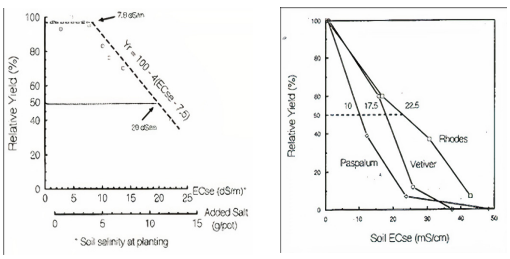

Fig. 3. Salt tolerance of vetiver grass.

Vetiver as a Bio-Engineering Tool

Hengchaovanich and Nilaweera (1998, 1999) reported that soil bioengineering is a recent technology using live materials, mainly vegetation, on its own or in integration with civil engineering works to solve problems relative to soil erosion and slope stabilization.

In the tropical and subtropical regions, the re-vegetation of slopes can be by means of hydroseeding of cover crops (for minor surface movement) or the use of fast-growing shrubs and trees for the mitigation of deep-seated erosion in the order of 20-150 cm depths. In the event of heavy and prolonged rainstorms, the tree or shrub roots are able to grip and bind the soils needed to prevent the deep-seated surface slips. This is because roots or “inclusions” impart apparent cohesion (cr) similar to “soil nailing” or “soil doweling” in the reinforced soil principle, thus increasing the safety factors of slopes permeated with roots vis-à-vis no-roots scenario.

Inherent drawbacks among trees and shrubs due to their too slow to establish to become effective. Even fast-growing species will take about 2-3 years to become established and are in danger of being uprooted during heavy storms, typhoons or cyclones. Although vetiver is a grass, it possess tree-like feature thus becomes a good alternative to trees or shrubs for bioengineering applications.

In 2000, the International Erosion Control Association published an article featuring vetiver grass as a bio-engineering tool due to its unique characteristics: a) vetiver grows upright, forming a dense hedge within 3-4 months, resulting in the reduction of rainfall runoff velocity and formation of an effective sediment filter; b) a vigorous, massive and dense subterranean root system that reaches vertically 2-5 m depth depending on soil types; c) the roots are very strong compared to other hardwood species as shown in Table below, having an average tensile strength of 75 MPa or approximately 1/6th of mild steel.

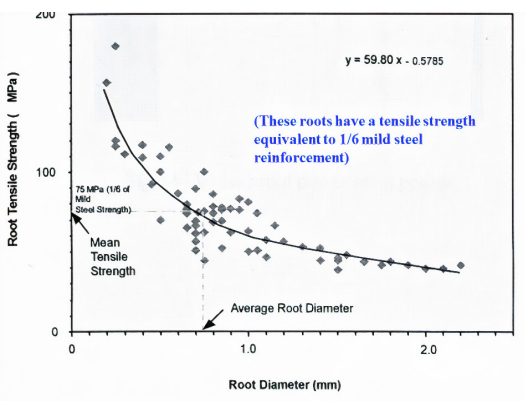

Fig. 4. Tensile strength of vetiver roots.

Effectiveness of Vetiver Grass in Steep Slopes Stabilisation, a Case Study in Tabubil, Papua New Guinea

The Fubilan Mine Pit and Kiunga Port facility are linked up by the Mill-Tabubil-Kiunga road corridor that stretches out for approximately 158km. This road corridor is critical to the business as it facilitates the movement of materials necessary for the operations of the Mining Limited Company at Papua New Guinea. Furthermore, it is essential for the service of Copper and Pyrite Concentration Pipes, Power Pylon and water supply pipes as they are located alongside the road corridor. The existence of geotechnical hazards along the road corridor and around the mine poses significant threats to the stability of the roads, service lines, infrastructures and ultimately the business. Geotechnical hazards are erodible slopes and road batters along road corridor of the mill-mine access roads that are prone to failure. Hence, regular geotechnical visual inspections and survey monitoring of these identified geotechnical hazards are carried out to ensure the stability of the road and other business infrastructures are maintained to allow for consistent traffic flow for normal business operations. Therefore, survey prisms are installed at selected active geotechnical hazard sites which are considered to be active having moderate to high risk with the potential to have an impact on the roads, service lines and other infrastructures.

The Problem

The geographical setting of Mining Limited at Papua New Guinea makes it vulnerable to natural disasters. It is mountainous and hilly with torrential monsoon rains. Landslides, is one of the frequent natural disasters commonly causing severe damage, thus constituting a severe threat to human life, infrastructure and mine production. Excessive water is the common cause that triggered major landslide in Tabubil. The current climate change effects will continue to result in more frequent and intensive storm events, and the landslide disasters will become increasingly more severe for the highway and this access roads which is the lifeline of Mining Limited at Papua New Guinea.

Eagle Vetiver Systems Ltd. as a consulting contractor with the Roads and Civil Engineering team carried out a joint visit of the geo-hazard sites and identified, accessed and evaluated the procedures, and thereafter implemented the Vetiver System Technology (VST) for the re-vegetation and stabilization of slopes as identified to be hazardous.

As per observation, the geology of the entire slopes comprises silty clay to silty loam clay soil structures that was weathering and/or has completely weathered due to accumulation of excess water by the high rainfall (averaging 8,000mm annually) activities, which was resulting in occasional landslips.

Site Inspection of the Slopes

Eagle Vetiver Systems Limited's qualitative assessment classified the road into five categories during the site inspection. The categorization were done basically to categorize each hazard site for ease of management in terms of prioritizing which slopes needed urgent remedial works to prevent slope failures. The purpose of the characterization was to distinguish between slopes that are highly likely to pose a risk to the road, the people, and the damage it will cause to the infrastructure.

Native vegetation on the slopes was minimal, consisting mostly of shrubs and creeping grasses. All have shallow rooting structures and, if disturbed by human activities, will poses risk. Therefore, it was highly recommended that vetiver grass be planted as a primary grass, which will encourage other grasses to grow between

vetiver rows.

Field Trial

Field trials were conducted at two sites on road embankments for slope protection with vetiver on two different geohazard sites along the Kiunga/Tabubil highway to evaluate the effectiveness of vetiver grass under Papua New Guinea climatic conditions. Slope stability analysis from our planting showed that the growth of vetiver grass increased the factor of safety hence, reducing slope movement significantly. The slope stability analysis was done by way of monthly survey prism movement monitoring. Iron prisms were placed randomly across the slope face and movement data compilation were collected to analyze the elevation movement trend.

Site 1

This site at KM99 was identified to be potentially an unstable area with landslides on both sides of the road. This slope had conventional engineering structures constructed but with little success with ongoing slope movements hence affecting the road from time to time.

Fig. 5. View of the slope planted with Vetiver Grass (Site 2).

As shown in Figure 5, this site has a maximum length of 150m and maximum width of 39m. The slope gradient has a main scarp around 190%, the head about 40% and the minor scarp around 60% on the right and 50% on the left. From the foot to the toe was 15%. The soil was mainly fine-textured, with a mixer of grey sand stone siting on completely weathered hard clay. Due to recent site preparation for the vetiver grass planting, there was no vegetation. The main scarp was unstable and there was potential for a failure that would cause material to fall, however it will be moderate. vetiver grass was also planted to minimize and to stabilize the slip area.

Slope gradient as indicated in red circle is 214% and about 62m² in surface area, but it was identified to be stable, so planting of vetiver grass was not needed. On the other hand, the zone of accumulation was sitting on riverine gravel and sand stone remains from the landslip, 3 rows of vetiver were planted at 7.5 meters between rows to control soil erosion at the toe. When Vetiver was planted on compacted riverine, growth was slow initially. However, when top soil was applied at the base of the grass to provide plant nutrient, plant growth improved remarkedly.

Site 2

This site at KM98 was unstable due to landslides. The total slip face area was 2616.1m², with minimum width of 27.0m and maximum length was 74.8m. It has a 15% gradient on the left, with the middle being 14% and the right with 20% gradient.

The right flank was noted to be stable. Traverse cracks and radial cracks were evident on the foot and toe of the slope and poses risk of further slumping. Underground water was also seeping out from adjacent pool of water, drains were constructed to drain out the sitting water in the pool.

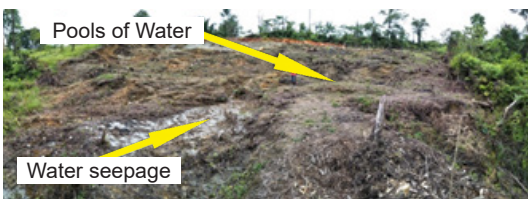

Fig. 6. View of slope from the toe (Site 2).

Bamboos that were planted on the slope a few months back were removed and

replanted at the toe of the slope to increase shear strength. Some small trees growing in the middle were also cut back to avoid the trees from over shading the vetiver at initial growing stages. Figures 6, 7 and 8 show the site before, during and after planting.

Assessment of the trial plantings

Site 2 planting has shown very encouraging results, as reported by Nolin Munia (2018). They were reported to be a success with the site having fully grown vetiver hedges. Active movements of the slope (both downward movement and cumulative elevation trend) have significantly reduced over time with minimal movements picked up during monitoring as shown in the following pictures. The reduction in slope movements have indicated that with time and root growth of the vetiver grass, slope stability has significantly improved.

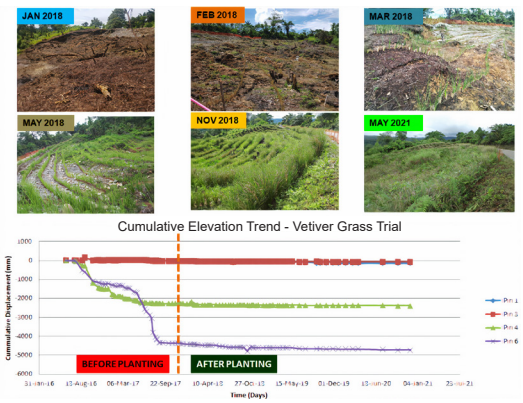

Fig. 7. The growing stages of the trial planting on KM98.

Figure 7 above is a pictorial representation of the growing stages from planting through to full hedge establishment, with the graph below the pictures showing the cumulative elevation trend of the slope before planting of the vetiver grass and the result two and half years after the planting of vetiver grass.

Fertilizer was not applied to this site, however top soil from nearby was applied to the base of the plant to provide the much needed plant nutrient during the initial growth stages.

The following figures are the growth stages of the trial planting on Site 1, a very challenging site as vetiver grass was planted on compacted road base material. Application of fertilizer was not done as a control however, humus soil from nearby was collected and placed under the stems to provide plant nutrients and moisture to encourage plant growth.

Fig. 8. Vetiver growth in March 2018.

Fig. 9. Vetiver growth in November 2018.

Vetiver growth on this site was slow at the establishment stages as shown in this picture as vetiver was planted on compacted road base material with no topsoil for plant nutrient, however with deep penetrative root growth and uptake of plant nutrient plant growth improved a lot with excellent hedge establishment.

Fig. 10. Vetiver growth in May 2020.

The slope with fully established vetiver hedgerows in 2020 (Figure 10) and regrowth of native vegetation after slope being fully stabilized (Figure 11).

Fig. 11. Vetiver growth in May 2021.

SUMMARY

Of the two trial sites, the trial planting at Site 2 appeared to be more effective in stabilizing the failed slope due to the excellent growth of vetiver. Contributing factors for the excellent growth of vetiver was due to good sub-surface soil conditions with adequate soil moisture as it was planted at the beginning of the rainy season complimented with readily available plant food nutrient.

During the visit in 2018, the planting on Site 1, plants appeared to be growing slowly and withering during the long dry periods. Contributing factors that affected the vetiver from growing well were due to poor ground conditions. There is a need to apply N and P fertilizers in planting holes before planting and after planting to encourage and stimulate plant growth during establishment phase.

The success of the trial plantings on both these sites has resulted in rolling out of vetiver planting program on all its vulnerable geohazard sites along the road corridor of the mine-mill access road and the highway. The long term goal of the slope stabilization trial using vetiver grass is also to allow regrowth of native vegetation after the failed slopes have been fully stabilized within four to five years of planting vetiver grass.

REFERENCES

Gregory, P.J. 2006. Plant Roots: Their growth, activity and interaction with soils. Blackwell Publishing Ltd.

Hengchaovanich, D. and Nilaweera, N.S. 1998. An assessment of strength properties of vetiver grass roots in relation to slope stabilization. Proc. First Int. Vetiver Conf. (ICV-1) Chiang Rai, Thailand.

Hengchaovanich, D. 1999. Fifteen years of bioengineering in the wet tropics from A (*Acacia auriculiformis*) to V (*Vetiveria zizanioides*). Proc. Ground and Water Bioengineering for Erosion Control and Slope Stabilization, Manila, Philippines.

Lavania, S. 2003. Vetiver Root System: Search for the Ideotype. Proc. Third Int. Vetiver Conf. (ICV-3) Guangzhou, China.

Lavania, S. 2019. Vetiver grass model and phenomics of root system architecture. J. Indian Bot. Soc. vol 98, pages 176-182.

Lavania, U.C. 2008. Vetiver in India. Proc. Vetiver system for environmental protection and Natural disaster management Cochin, India, 21-23 February 2008.

Truong, P. 2003. Vetiver System for Water Quality Improvement. Proc. Third Int. Vetiver Conf), October 2003, Guangzhou, China.

Wang, Y.W. 2000. The root extension rate of vetiver under different temperature treatments. Proc. Second Int. Vetiver Conf. (ICV-2) Thailand.

Yoon, P. K. 1989. A Look-see Vetiver grass in Malaysia. First progress Report. TVNI Archive.

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ANTICANCER ACTIVITY OF ROYAL JELLY *Apis mellifera* AGAINST WIDR CELL LINE AND HELA CELL LINE

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Abstract — Cervical cancer is the most common cause of women's death after breast cancer in Indonesia, meanwhile colon cancer is the second leading cause of death from cancer among adults. One of the efforts for cancer treatment is to consume natural compounds such as Royal jelly, which has been reported to have anticancer activity. Recent studies also indicated Royal jelly action against breast cancer cell line MCF-7 1 mg/mL and colon cancer cell line CaCo-2 0.5 mg/mL. This research aimed to determine cancer cell inhibition activity by Royal jelly toward cervical cell line HeLa, colon cell line WiDr and normal cell line Chang. The total phenol test, cell culture, WiDr cell preparation, Royal jelly treatments and MTT cytotoxic tests were carried out. Results showed that Royal jelly has higher inhibition activity against HeLa cell line than WiDr cell line. Royal jelly inhibited HeLa cell proliferation 36.425% and WiDr cell line 16.625% at 125 µg/mL.

Keywords **— Royal jelly, antioxidant, widr and hela cell lines**

INTRODUCTION

Colon cancer is a cancer that grows and develops in the colon or rectum which causes weight loss, changes in cancer structure and bowel function in digestion, and fatigue which results in decreased productivity (Karim and Huso, 2013). Colon cancer risk factors are related to lifestyle, age and genetic disorders (Yeatman, 2001). According to Haggar and Boushey (2009), colon cancer sufferers in 2005 were 108,100 individuals and in 2008 increased to 148,900 diagnoses. Approximately 49,900 patients die in the United States from colon cancer. The metastatic nature of colon cancer causes this disease to only have a survival rate of less than 5 years at stage 4 (<10%) (Yu et al., 2015).

Cervical cancer is a malignant neoplasm of cervical cells. Cervical cancer generally affects women and is caused by infection with the Human Papillomavirus (HPV) (Jadon and Joshi, 2012). Human Papillomavirus is a DNA virus that infects the basal epithelium such as skin and mucosa causing cervical cancer (Cuts et al., 2007). According to Sreedevi et al. (2015), the incidence of cervical cancer mostly occurs in developing countries (86%). Every year, about 122,844 women are diagnosed with cervical cancer and 67,477 (54.5%) die. The incidence of colon cancer in Indonesia is the third most common type of cancer in Indonesia with 100 cases diagnosed from 100,000 Indonesians in 2006 (Ministry of Health, 2006). The incidence of cervical cancer in Indonesia is around 0.8% with 98.062 patients diagnosed, and the highest prevalence occurs in the Riau Islands Province, North Maluku and DI Yogyakarta (Ministry of Health, 2015).

At least patients who receive medical treatment for cancer in Indonesia is still relatively expensive, so it is necessary to develop affordable cancer therapies for cancer patients, especially from the lower middle class. Chemotherapy is the administration of chemical compounds to reduce and inhibit the proliferation of cancer cells, but this method has side effects such as weakness, nausea, hair loss, dry skin, and drastic weight loss and can damage the formation of normal cells around it. Anticancer herbal drugs that have been approved by the FDA include vinca alkaloids, taxane, podolpilotoxin and camptothekin (Safarzadeh et al., 2014).

Royal jelly has been known to have biological benefits such as antioxidant, neurotopic, hypocholesterolemic, anti-aging, antibiotic, anti-inflammatory, anti-immunodulator, and antitumor (Karadeniz, 2011). Royal jelly contains long chain fatty acids, namely 10-hydroxy-2-decanoic acid which acts as an antitumor (Townsend et al.,1960). Antitumor effect plays a role in the process of cancer cell proliferation. According to Barnutiu et al., (2011), other active components of Royal jelly are low protein fraction (major Royal jelly fraction), namely MRJP 1-MRJP 6, vitamins (L-ascorbate, vitamin D, vitamin E, vitamin B complex), royalisin, apisimin, and albumin.

There has been no research that uses Royal jelly as a substance that inhibits the proliferation of colon cancer cells and cervical cancer cells. Therefore, this study aimed to examine the cytotoxic potential of *Apis mellifera* Royal jelly on cervical cancer cells (HeLa) and colon cancer cells (WiDr) and liver cells (Chang) as normal control cells. This research is expected to provide data on the antiproliferative activity of Royal jelly against sustainable cancer cells for the development of anticancer drugs in the future.

MATERIALS AND METHODS

Materials

The ingredients used in this study were *Apis mellifera* Royal jelly from a beekeeping farm in Wonogiri, Central Java and commercial Royal jelly brand Spring Leaf

Australia¸ sterile distilled water, NaCl 10% w/v, sodium bicarbonate 7.5% w/v, FeCl3 reagent, Merck *Folin Ciocalteu* reagent, dimethyl sulfoxide (DMSO) CTCC® 4-X™ Merck, methanol 99% Merck, diphenyl-2-picrylhydrazyl (DPPH) 0.4 mM Sigma Aldrich, L-ascorbic acid Sigma Aldrich, cancer cells colon (WiDr, ATCC®-CCL™ 218), HeLa cancer cells (HeLa, ATCC®-CCL-2™) and normal liver cells (Chang, ATCC®-CCL™ 13) were obtained from the American Type Culture Collection, doxorubicin Kalbe as positive control, Fetal Bovine Serum (FBS) Gibco, Roswells Park Memorial Institute (RPMI) medium 1640 Gibco, Dulbecco's Modified Eagle (D-MEM) Gibco medium, penicillin-streptomycin, 3-(4,5 dimethylthiazole-2-yl)- 2,5-diphenyl tetrazolium bromide (MTT) Sigma Aldrich, 2-(N-morpholino)-ethanosulphonic acid buffer Sigma Aldrich, 10% trypsin Gibco, 60% ethanol, Axygen T-300 Scientific white tips pipette, Axygen TR-222-Y Scientific yellow tips pipette, Stardec blue tips pipette, Whatman parafilm, Kinpak plastic wrap, and Ansell gloves.

Methods

In this study, the total phenol test was carried out using the *Folin Ciocalteu* method (Vongsak et al. 2013) and the anticancer activity of Royal jelly using the MTT method in the study (CCRC 2000). Royal jelly was tested in vitro against normal liver cells (Chang, ATCC®-CCL™ 13), colon cancer cells (WiDr, ATCC®-CCL™ 218), and cervical cancer cells (HeLa, ATCC®-CCL- 2™). The inhibitory activity and the percentage of the number of cells before and after treatment of cancer cells against Royal jelly showed anticancer activity.

Preparation of Royal jelly Stock Solution (Bramasta 2013 Modification)

Royal jelly was dissolved in various types of solvents, namely distilled water, RPMI medium and D-MEM according to the test to be carried out. Ten (10) mg of Royal jelly was dissolved in 5 mL of solvent, then a sonicator was carried out for 10 minutes until the sample was completely dissolved and then 5 mL of solvent was added to a total volume of 10 mL with a stock solution concentration of 1000 g/mL. The 1000 g/mL Royal jelly solution was then diluted 10 mL to a final concentration of 50 g/mL which would be used for various tests such as total phenolic, and MTT.

Determination of Total Phenolics (Vongsak et al., 2013)

Determination of total phenolic Royal jelly was carried out by modifying the method of Vongsak et al. (2012). A total of 200 L of Royal jelly solution from a stock solution of 100 g/mL Royal jelly, added 500 g/mL *Folin Ciocalteu* reagent 10% v/v, and added 300 g/mL sodium bicarbonate 7.5% w/v to a final concentration of 0 g/mL , 4 g/mL, 8 g/mL, 12 g/mL, 16 g/mL, and 20 g/mL in test tubes. The test tube was read at room temperature (22 °C ± 1 °C) for 30 minutes. The absorbance of the sample was calculated at a wavelength of 760 nm with distilled water blank. Total phenol is expressed in milligrams equivalent of gallic acid. The standard curve used was gallic acid 0 g/mL, 4 g/mL, 8 g/mL, 12 g/mL, 16 g/mL, and 20 g/mL.

Cell Culture (Haryanti and Katno, 2011)

The sustainable cells of Widr, HeLa and Chang are a collection of the Microbiology and Immunology Laboratory of the Center for Primate Studies, LPPM, Bogor Agricultural University. Cell cultures were grown in RPMI 1640 Gibco growth medium containing 10% v/v FBS and 1% v/v Gibco penicillin-streptomycin. Meanwhile, for Chang and HeLa cells, Gibco's D-MEM growth medium was used.

WiDr Cell Preparation (Filipic et al., 2015 Modification)

Widr cells were taken from the nitrogen

tank and thawed in a water bath at 37 °C. The ampoules were sprayed using 70% ethanol and put in a laminar air flow. The ampoule was opened and the Widr cells were transferred to a sterile conical tube containing RPMI 1640 medium. The cell suspension was centrifuged at 1000 g for 3 minutes. New RPMI 1640 medium was added to the cell suspension and centrifuged for 5 minutes. WiDr cell suspension was added with 1 mL of medium containing 10% FBS and resuspended slowly until homogeneous. WiDr cells were added to a small tissue culture flask and incubated in a 37 °C CO2 incubator. WiDr culture medium was replaced after 24 hours and grown until the cell population reached 80% (80% cofluent). WiDr cells that had reached 80% population were washed with 3.5 mL of PBS 2 times and 300 µL of Trypsin-EDTA and then incubated for 3 minutes in a CO2 incubator. Five (5) mL of the culture medium was added and the cells were resuspended to separate from the flask wall. WiDr cells were counted using a hemacytometer. A similar way of working was also carried out for Chang cells and HeLa cells by changing the RPMI 1640 Gibco medium to D-MEM Gibco medium.

Royal jelly Treatment (Filipic et al. 2015 Modification)

Cell cultures from cell preparations were incubated for 24 hours then the old medium was discarded, then continued with Royal jelly treatment. The solutions tested were medium and Royal jelly solution. The stock of Royal jelly is 10 mg in 50 µL of DMSO and then 950 µL of RPMI is added. The solution was diluted by adding RPMI to obtain final concentrations (125 µg/mL, 250 µg/mL, and 375 µg/mL) on microplates. The microplate well contains cells from cell culture, 100 µL of Royal jelly solution was added as a treatment and 100 µL of medium was added as a negative control. The treatment mixture in the microplate was incubated for 48 hours in a 5% CO2 incubator at 37 °C. For positive control, doxorubicin was used. A similar way of working was also carried out for Chang cells and HeLa cells by changing the RPMI 1640 Gibco medium to D-MEM Gibco medium.

MTT Cytotoxic Test (CCRC 2000)

The results of the 48-hour cell incubation from the previous method were added to the 5 mg/mL tetrazolium salt solution as much as 10 µL per well. The mixed color is yellow. Incubate the microplate for 4 hours in a 5% CO2 incubator at 37 °C. After incubation and formazan crystals formed, the Royal jelly solution was discarded. Formazan crystals were dissolved in 100 µL of 96% ethanol in each well. The color of the solution became purple. The absorbance value was measured on a microplate reader at a wavelength of 595 nm. All treatments were carried out in triples. The data obtained from the proliferation test with MTT is the absorbance value of each well which is converted to % inhibition.

RESULTS AND DISCUSSION

Royal jelly samples used came from 2 different places, namely Royal jelly from Wonogiri, Central Java and Melbourne, Australia. Determination of the total phenol content of Royal jelly using gallic acid standard (Figure 1). The concentration of gallic acid on the average absorbance data at a wavelength of 760 nm produces a linear standard line equation of y = 0.032x + 0.016 with a regression value (R2) of 0.960. Total phenol Royal jelly is expressed in milligrams gallic acid equivalent per milligram Royal jelly (mg GAE/mg). The total phenol of Wonogiri Royal jelly is greater than that of Australian Spring Leaf commercial Royal jelly. The total phenol content of Royal jelly found in the Wonogiri Royal jelly sample was 116.06 mg GAE/mg ± 0.03 (as much as 1 mg of Royal jelly was equivalent to 116.06 mg of gallic acid, while Australian Royal jelly had a total phenol of 54.81 GAE/mg ± 0.58 mg (as much as 1 mg of Royal jelly is equivalent to 54.81 mg of gallic acid).

Anticancer testing began with the cytotoxicity test of Royal jelly on normal cells using the MTT method. This test aims to determine the selectivity of Royal jelly against normal cells. According to Wang et al. (2010), formazan color intensity correlated with the number of living cells. The normal cells used are Chang cells. According to Otang et al. (2014), Chang cells were derived from normal liver tissue obtained from a boy of Chinese descent, and isolated in 1954. Chang cells were used to model cellular cytotoxicity activity.

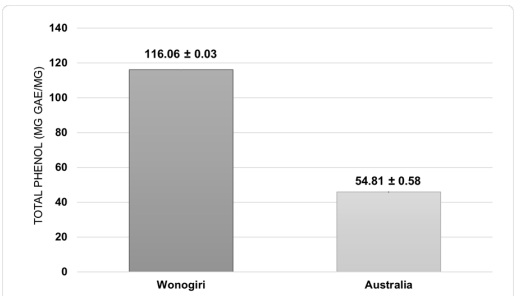

Fig. 1. Phenol content of Royal jelly from Wonogiri and Australia.

The effect of Royal jelly on normal Chang cells was expressed in % proliferation (Figure 2). The percentage of proliferation indicated an increase in the number of cells after adding Royal jelly for 48 hours of incubation. The results of the percentage of cell proliferation of Chang against Royal jelly showed an increase in the percentage of proliferation with an increase in the concentration of the solution. The addition of Royal jelly resulted in an increase in the number of cells. The highest % proliferation was found at a concentration of 375 µg/mL at 42.30% ± 13.01 while the lowest % proliferation was at a concentration of 125 µg/mL at 12.12% ± 8.75 and for a concentration of 250 µg/mL at 21.90% ± 6.80.

The effect of Royal jelly on Chang cells was expressed by % proliferation (Figure 2). Increasing the concentration of Royal jelly did not inhibit Chang's normal cell growth. Increasing the concentration will further increase the number of normal cell populations in the microplate. Therefore, Royal jelly is non-toxic to normal cells and induces new cell growth.

The results of the induction of Chang's cell proliferation by Royal jelly in this study are in accordance with the research conducted by Kamakura et al. (2001) which states that the active protein substance of Royal jelly can trigger the proliferation of mouse hepatocytes and increase the formation of blood albumin. Hattori et al. (2007) reported the activity of neurogenesis or the formation of nerve cells by Royal jelly against nerve stem progenitor cells in fibroblast growth factor (FGF-2) medium. Royal jelly can also trigger the differentiation and proliferation of brain nerve cell progenitors into neurons, astrocytes, and oligodendrocytes. Royal jelly can also trigger the growth of MC3T3-E1 cells and bone osteoblasts of mice induced by Royal jelly for 9 weeks (Narita et al., 2014).

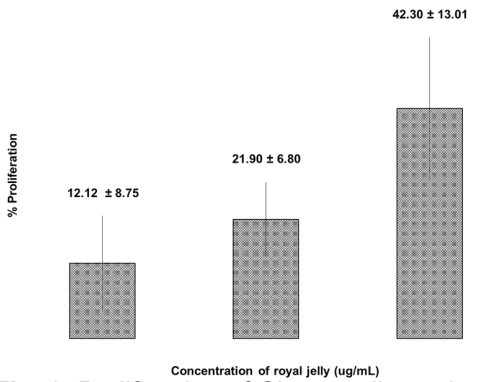

Fig. 2. Proliferation of Chang cells against Royal jelly at various concentrations (µg/mL).

The effect of Royal jelly on WiDr colon cancer cells was expressed in % inhibition (Figure 3). The percentage of inhibition indicated a decrease in the number of cells after the addition of Royal jelly with a certain concentration. The results of % inhibition of WiDr cells decreased with the increase in the concentration of Royal jelly solution. The highest percentage decrease in the number

of WiDr cells was found at a concentration of 125 µg/mL at 16.65% ± 4.80 while the lowest % inhibition was at a concentration of 375 µg/mL at 11.51% ± 5.31. The effect of Royal jelly on HeLa cervical cancer cells was also expressed in % inhibition (Figure 3). The percentage decrease in the number of HeLa cells after being treated with Royal jelly at various concentrations decreased along with the increase in concentration, such as WiDr cells. The result of the highest % inhibition of HeLa cells was at a concentration of 125 µg/mL at 36.42% ± 7.90, while the lowest was at a concentration of 375 µg/mL at 31.03% ± 2.70.

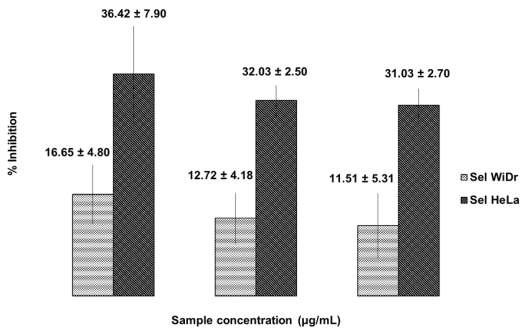

Fig. 3. Percentage of Royal jelly inhibition against WiDr cells ( ) and HeLa cells ( ) at 3 different concentrations.

A positive control of doxorubicin was used on WiDr cells and HeLa cells. Controls were used to compare the anticancer activity of Royal jelly against WiDr cells and HeLa cells. The results of % inhibition of doxorubicin positive control (Figure 4) showed that HeLa cells were more sensitive to doxorubicin than WiDr cells. Doxorubicin killed more HeLa cells than WiDr cells at the same concentration.

The effect of doxorubicin on WiDr cells showed an increase in % inhibitory activity (Figure 4). The concentrations used were 1 µg/mL, 3 µg/mL, and 6 µg/mL. The highest % inhibition result was at a concentration of 6 g/mL of 91.92% ± 0.76 while the lowest was at a concentration of 1 µg/mL of 73.65% ± 4.00. Positive control concentration of 1 g/mL was able to kill >50% WiDr cells. The positive control effect of doxorubicin on HeLa cells also showed an increase in % inhibition with increasing concentration (Figure 4). The highest % inhibition result was 93.60% ± 1.38 at a concentration of 6 µg/mL, while the lowest was 81.68% ± 2.40 at a concentration of 1 µg/mL. The use of low concentrations of doxorubicin has been able to reduce the HeLa cell population >50%. Based on the % inhibition data in Figure 4, doxorubicin kills HeLa cancer cells more than WiDr cells. This is because at a concentration of 1 g/mL, doxorubicin was able to kill HeLa cells >80% compared to 70% WiDr cells.

The positive control used in this study was doxorubicin. The drug is a commercial drug for chemotherapy. Chemotherapy is a systematic therapy by giving synthetic drugs to inhibit the growth of cancer cells (Jong, 2002). Doxorubicin is an anthracycline antibiotic that has antineoplastic activity, isolated from Streptomyces peucetius var. caesius (NCI, 2009). The mechanism of doxorubicin in killing cancer cells is binding to DNA and interfering with topoisomerase II activity involved in DNA repair reactions, formation of free radicals that disrupt cellular membranes, DNA and proteins (Thorn et al. 2011), and the formation of excess

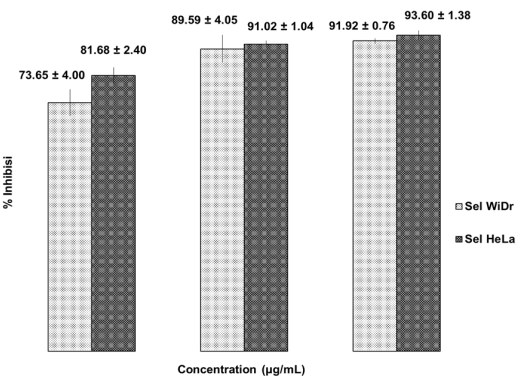

Fig. 4. Percentage of doxorubicin inhibition against WiDr cells ( ) and HeLa cells ( ) at 3 different concentrations

ceramides. Exogenous ceramides can induce cancer cell death through apoptosis (Yang et al. 2014).

Chang's cell morphology (Figure 5), WiDr cells (Figure 6), and HeLa cells (Figure 7) showed different shapes and numbers. The number of Chang cells after Royal jelly treatment appeared to increase, and live cells were adherent. The morphology of HeLa cells and WiDr cells that have shown an inhibitory effect is characterized by abnormal cell shape compared to normal cells. Abnormal cell shape such as irregular and separated from living cell colonies.

The morphology of Chang cells, WiDr cells, and HeLa cells were observed under a microscope with a magnification of 1430 x 640. Observations were made twice, namely before and after incubation of cells using Royal jelly. Chang and HeLa cells are elongated with tapering ends, while WiDr cells tend to be rounded. The results of observations of Chang's cells under a microscope showed an increase in the number of cells before and after Royal jelly treatment (Figure 5). The number of cells at a concentration of 0 g/mL was 46.5 x 104 cells/100 L, while the number of cells at a concentration of 125 g/mL, 250 g/mL and 375 g/mL respectively were 53.9 x 104 cells/100 L, 56.7 x 104 cells/100 L, and 66.16 x 104 cells/100 L.

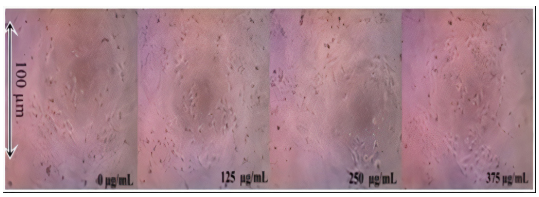

Fig. 5. Morphology of Chang cells at various concentrations of Royal jelly.

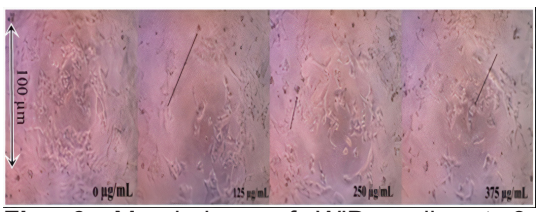

Fig. 6. Morphology of WiDr cells at 3 variations of Royal jelly concentrations.

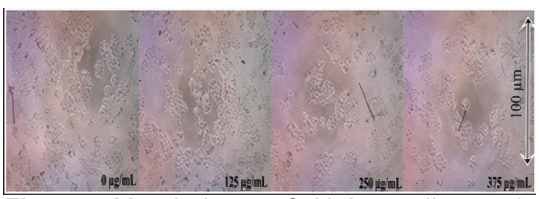

Fig. 7. Morphology of HeLa cells at 3 variations of Royal jelly concentrations.

Observations of WiDr cells under a microscope showed changes in cell morphology (Figure 6). Changes between concentrations of 0 g/mL as control cells and treatment (125 µg/mL, 250 µg/mL and 375 µg/mL) were abnormal cell shape after Royal jelly treatment, such as irregular cell shape, and dead cells separated from cell colonies. life. The number of WiDr cells at a concentration of 0 g/mL was 71 x 104 cells/100 L, while the number of WiDr cells at a treatment concentration of 125 g/mL, 250 g/mL and 375 g/mL was 59.18 x 104 cells/100 L, 61.20 x 104 cells/100 L, and 63.12 x 104 cells/100 L. Observation of WiDr cells on doxorubicin (Figure 8) showed that the number of dead cells was higher than that of Royal jelly samples. Microscopic observations of WiDr cells before and after Royal jelly treatment showed changes in cell morphology, such as in WiDr cells in the form of abnormal cell shapes (Figure 8).

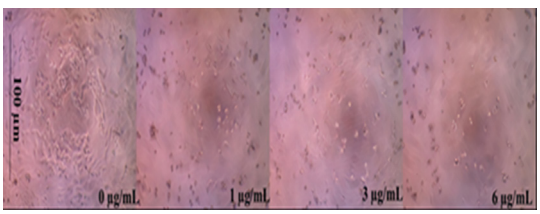

Fig. 8. WiDr cells against Doxorubicin.

Abnormal cell shape is indicated by black arrows. The number of HeLa cells at a concentration of 0 g/mL was 48 x 104 cells/100 L, while the number of HeLa cells at various concentrations used in this study were 30.52 104 cells/100 L, 32.62 104 cells/100 L, and 33.05 104 cells/ 100 L. Observation of HeLa cells against

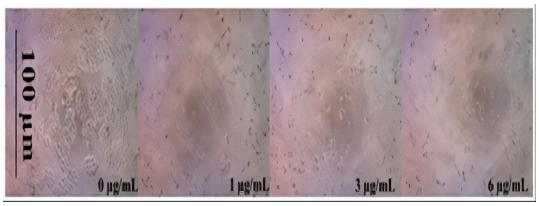

Fig. 9. HeLa cells against Doxorubicin.

doxorubicin (Figure 9) showed higher inhibitory activity than Royal jelly, irregular cell morphology and lower live cell colonies than dead cells.

The anticancer activity of Royal jelly was tested on colon cancer cells and cervical cancer cells. Colon and cervical cancer cells used were WiDr (ATCC®-CCL™ 218) and HeLa (ATCC®-CCL-2™) cells. WiDr cells were derived from primary rectosigmoid colon adenocarcinoma from a 78-year-old woman in 1971 (Kusuma et al., 2010). WiDr cells are colon cancer cells originating from epithelial tissue with adherent properties that are resistant to chemotherapeutic agents and COX-2 overexpression (Haryanti and Katno, 2011). HeLa cells are human cervical cancer epithelial cells isolated in 1915 from a 31-year-old woman named Henrietta Lacks (Masters, 2002). The anticancer activity of Royal jelly is expressed in % inhibition of WiDr and HeLa which is the percentage of inhibition of cells by Royal jelly.

Data on % inhibition of WiDr cells and HeLa cells showed a decrease in the percentage of inhibition with increasing concentrations of Royal jelly. The decrease in the percentage of inhibition could be due to the content of bioactive compounds such as phenolic compounds and fatty acids found in different Royal jelly at high and low concentrations, and the level of solubility of Royal jelly bioactive compounds with distilled water and cell medium used during the study. HeLa cells are more sensitive to Royal jelly. This was indicated by the higher % inhibition of HeLa cells than WiDr cells at the same concentration (125 µg/mL).

The result of % inhibition of Royal jelly against HeLa cells was 36.425% while WiDr cells were 13.830%, but this value was still lower than doxorubicin of 81.680% for HeLa cells and 73.643% for WiDr cells. HeLa cells were more sensitive to doxorubicin and Royal jelly. The low antiproliferative activity of Royal jelly is in accordance with the study of Filipic et al. (2015). The antiproliferative activity of Royal jelly against CaCo-2 colon cancer cells tends to be low at a concentration of 0.5 mg/mL (Filipic et al., 2015). Royal jelly can also inhibit the growth of MCF-7 breast cancer cells at a concentration of 1 mg/mL (Nakaya et al., 2007).

The mechanism of the proliferation of Chang cells and inhibition of the growth of HeLa cells and Chang cells were not investigated in this study, so the exact mechanism is not yet known. Factors that affect the growth of normal liver cells (hepatocytes) are epidermal growth factor (FPE), insulin, glucagon, hepatocyte growth factor (FPH), pyruvate, lactate, and nicotinamide. According to Kamakura et al. (2001), the fraction of Royal jelly protein (major Royal jelly protein) 57 kDa is an active component of Royal jelly that can increase DNA synthesis and hepatocyte proliferation. The 57 kDa Royal jelly protein fraction has a cytokine factor effect on hepatocytes, and triggers the production of autocrine growth factors such as TGF-GF and fibroblast growth factor to activate intracellular signal transduction and trigger DNA synthesis and albumin production. Meanwhile, the 350 kDA Royal jelly protein fraction functions to maintain the number of hepatocytes so that normal cell growth can be controlled (Fujii et al.,1996).

Another bioactive component of Royal jelly that can inhibit the growth of cancer cells is 10-hydroxy-2-decanoate (10-HAD) which is only found in Royal jelly. According to Li et al. (2013), the mechanism of 10-HAD activity against cancer cells is inhibiting angiogenesis, as a modulator of estrogen receptors and inhibiting cell proliferation at

the S and G2 stages, as well as inducing macrophage activity and increasing the production of antitumor cytokines (tumor necrosis factor) for apoptosis. The activity of 10-HAD is also involved in modulating oxidative stress by decreasing lipid peroxidation and induction of apoptosis (Filipic et al., 2015).

CONCLUSIONS

The highest total phenol Royal jelly was obtained by the Wonogiri Royal jelly sample of 116.06 mg GAE/mg ± 0.03 Royal jelly was non-toxic to normal Chang cells by increasing normal cell proliferation by 42.30% ± 13.01 at a concentration of 375 µg/mL. The anticancer potential of Royal jelly in HeLa cells and WiDr cells at a concentration of 125 µg/mL with inhibitory percentages of 36.42% ± 7.90 and 16.65% ± 4.80 in HeLa cells.

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REFERENCES

Ainsworth, E.A., Gillespie, K.M. 2008. Estimation of total phenolic content and other oxidation substrates in plant tissue using Folin-Ciocalteu reagent. Nature. 2(4): 875-877.

Barnutiu, L.I., Marginitias, A., Dezmiriean, D.S., Mihai C.M., Bobis, O. 2011. Chemical composition and antimicrobial activity of Royal jelly—a review. An Sci Biotec. 44(2):67-72.

Berridge, M.V., Tan, A.S. 1993. Characterization of the cellular reduction of 3-(4,5-dimetiltiazol-2-yl)-2,5-difenil tetrazolium bromida (MTT): subcellular localization, substrate dependence, and involvement of mitochondrial electron transport in MTT reduction. Arcv Biochem Biophy. 303(2):474-482.

Blainski, A., Lopes, G.C., Mello, J.C.P. 2013. Application and analysis of the folin ciocalteu method for the determination of total phenolic contenct from *Limonium Brasiliense* L. Molecules. 18:6852-6865. doi:10.3390/molecules19066852

Bramasta, B.A. 2013. Uji pengaruh Royal jelly terhadap efek tonik madu dari spesies lebah (*Apis mellifera*) pada mencit putih jantan galur Swiss Webster [skripsi]. Universitas Muhammadiyah Surakarta: Surakarta. 1-14.

Cancer Chemoprevention Research Center. [CCRC] 2000. Prosedur Tetap Uji Sitotoksis Metode MTT. Yogyarakarta (ID): Fakultas Farmasi Universitas Gajah Mada.

Cuts, F.T., Goldie, S., Castellsague, X., Sanjose, S., Garneet, G., Edmunds, W.J., Claeys, P., Goldenthal, K.L., Harper, D.M., Markowitz, L. 2007. Human papillomavirus and HPV vaccines: a review. WHO bulletin. 85(9):719-726.

Ceksteryte, V., Kurtinaitiene, B., Venskutonis, P.R., Pukalkas, A., Kazernaviciute, R., Balzekas, J. 2016. Evaluation of antioxidant activity and flavonoid composition in differently preserved

bee products. Czech J Food Sci.34(2):133-142.

Dai, J., Mumper, R.J. 2010. Plant phenolics extraction, analysis, dan their antioxidant and anticancer properties. Molecules. 15:7313-7352.

Daneshfar, A., Ghaziaskar, H.S., Homayoun, N. 2008. Solubility of gallic acid in methanol, ethanol, water and ethyl acetate. J Chem Eng Data. 53:776-778.

Filipic, B., Gradisnik, L., Rihar, K., Soos, E., Pereyra, A., Potokar, P. 2015. The influence of Royal jelly and human interferon alpha-HUIFN-N3 on proliferation, glutathione level, and lipid peroxidation in human colorectal adenocarcinoma cells. Arh Hug Rada Toksikol. 66:269-274.

Fujii, M., Yonekura, M., Higuchi, T., Morimitsu, K., Yoshino, I., Mukai, S., Aoki, T., Fukunaga, T., Inoue, Y., Sato, M., and Kanaeda, J. 1996. Effect 350 kDa glycoprotein in Royal jelly on primary culture of rat hepatocytes. Food Sci Technol Int. 2:223-225.

Haggar, F.A., and Boushey, R.P. 2009. Colorectal cancer epidemiology: incidence, mortality, survival, and risk factors. Clin Colon Rect Sur. 22(4):191-197.

Haryanti, S. and Katno. 2011. Aktivitas sitoktoksik *Ocimum sanctum* L pada sel kanker kolon WiDr. Perhipba 1 0(5):1-6.

Hattori, N., Nomoto, J., Fukumitsu, H., Mishima, S., and Furukawa, S. 2007. Royal jelly and its unique fatty acid, 10-hidroxy-trans-2-decanoic acid, promote neurogenesis by neural stem/ progenitor cell *in vitro*. Biomed Res. 5:261-266.

Jadon, G. and Joshi, K.S. 2012. Cervical cancer: a review article. J Biomed Pharm Res. 1(1):1-4.

Jayamani, J., and Shanmugam, G. 2014. Gallic acid, one of the components in many plant tissue, is a potential inhibitor for insulin amyloid fibril formation. Euro J Med Chem. 85:352-358.

Jong Wim de. 2002. *Kanker, apakah itu? Pengobatan, Harapan Hidup, dan Dukungan Keluarga*. Heedjan AS, penerjemah; Juwono L, editor. Jakarta (ID): Penerbit Arcan. Terjemahan dari: Kanker, wat heet?! Medische Informatie over De Ziekten(N), de Behandeling en de Prognose.

Kamakura, M., Sueonobu, N., and Fukushima, M. 2001. Fifty-seven-kDa protein in Royal jelly enchances proliferation of primary cultured rat hepatocytes and increases albumin production in the absence of serum. Biochem Biophys Res Comm. 282: 865-874.

Karim, B.O. and Huso, D.L. 2013. Mouse models for colorectal cancer review. Am J Cancer Res. 3(3):240-250.

Karadeniz, M. 2011. Royal jelly modulates oxidative stress and apoptosis in liver and kidneys of rats treated with cisplatin. J Biomed. 12(2):344-348.

Kolayli, S., Sahin, H., Can, Z., Yildiz, O., Malkoc, M., Asadov, A. 2015. A member of complementary medicinal food: Anatolian royal jellies, their chemical compositions and

antioxidant properties. J Ev Compl Alt Med. 3(1):1-6.

Kusuma, A.W., Nurulita, N.A., Hartanti, D. 2010. Efek sitotoksik dan antiproliferatif kuersetin pada sel kanker kolon WiDr. Pharmacy. 7(3):107-122.

Liu, J.R., Yang Yuan, Shi Li Shan, Peng Chi Chung. 2008. Antioxidant properties of Royal jelly associated with larval age and time of harvest. J Agric Food Chem. 56:11447-11452.

Li Xing, Huang C, Xue Y. 2013. Contribution of lipid in honeybee *Apis mellifera* Royal jelly to health. J Med Food. 16(2):96-102.

Masters, J.R. 2002. HeLa cells 50 years on: the good, the bad and the ugly. Nature Rev. 2:316-319.

Meda, A., Lamien, C.E., Romito, M., Millogo, J., Nacoulma, O.G. 2015. Determination of total phenolic, flavonoid, and proline contents in Burkina Fasan honey, as well as their radical scavenging activity. Food Chem.91:571-577.

Ministry of Health. 2006. *Situasi Penyakit Kanker di Indonesia*. Buletin Jendela Data dan Informasi Kesehatan. Jakarta (ID): Kementrian Kesehatan Republik Indonesia.

Ministry of Health. 2015. *InfoDatin: Stop Kanker!*. Buletin Jendela Data dan Informasi Kesehatan. Jakarta (ID): Kementrian Kesehatan Republik Indonesia.

Nabas, Z., Haddadin, M.S., Haddadin, J., Nazer, I.K. 2014. Chemical composition of Royal jelly and effects of symbiotic with two different locally isolated probiotic strains on antioxidant activites. Pol J Food Nutr Sci.64(3):171-180.

Nakaya, M., Onda, H., Sasaki, K., Yukiyoshi, A., Tachibana, H., Yamada, K. 2007. Effect of Royal jelly on bisphenol A induces proliferation of human breast cancer cells. Biosci Biotechnol Biochem. 71(1)-253-255.

Narita, Y., Nomura, J., Ohta, S., Inoh, Y., Suzuki, K.M., Araki, Y., Okada, S., Matsumoto, I., Isohama, Y., Abe, K., Miyata, T., Mishima, S. 2006. Royal jelly stimulates bone formation: physiologic and nutrigenomic studies with mice and cell lines. Biosci Biotechnol Biochem. 70(10):2508-2514.

National Cancer Institute. 2009. Doxorubicin hydrochloride. [terhubung berkala]. Diakes 22 Agustus 2016.

Otang, W.M., Grierson, D.S., Ndip, R.N. 2014. Cytotoxicity of three South African medicinal plants using the chang liver cell line. J Tradit Complement Altren Med. 11(2):324-329.

Pavel, C.I., Marghitas, L.A., Dezmirean, D.S., Tomos, L.I., Bonta, V., Sapcaliu, A., Buttstedt, A. 2014. Comparison between local and commercial Royal jelly use of antioxidant activity and 10-hidroxy-2-decanoic acid as quality parameter. J Agric Apic Res. 53(1):116-123.

Safarzadeh, E., Shotobani, S.S., Baradaran, B. 2014. Herbal medicine as inducers of apoptosis in cancer treatment. Adv Pharm Bull. 4(1):421-427.

Sreedevi, A., Javed, R., Dinesh, A. 2015. Epidemiology of cervical cancer with special focus in India. Int J Women Hlth. 7:405-414.

Townsend, G.F., Morgan, J.F., Tolnai, S. 1960. Studies on the in vitro antitumor activity of fatty acids 10-hidroxy-2-decenoic acid from Royal jelly. Cancer Res. 20: 503-510.

Thorn, C.F., Oshiro, C., Marsh, S., Boussard, T.H., McLeod, H., Klein, T.E., Altman, R.B. 2011. Doxorubicin pathways: pharmacodynamics and adverse effects. Pharm Genomic. 21(7):440-446.

Vongsak, B., Sithisarn, P., Mangmool, S., Thongparditchote, S., Wongkrajang , Y., Gritsanapan, W. 2013. Maximing total phenolics, total flavonoids contents and antioxidant activity of *Moringa oleifera* leaf extract by the appropriate extraction method. Inds Crop Prod. 44: 566-571.

Wang, P., Henning, S.M., Heber, D. 2010. Limitations of MTT and MTS-based assays for measurement of antiproliferative activity of green tea polyphenols. Plos ONE. 5(4):1-10.

Yeatman, T.J. 2001. Colon Cancer Encyclopedia of Life Sciences. New York (US): Nature.

Yang Fan, Teves, S.S., Kemp, C.J., Henikoff, S. 2014. Doxorubicin, DNA torsion and chromatin dynamics. Biochem Biophys Act. 22(2):84-89.

Yu, J., Wu, W.K., Li, X., He Ju, Li, X., Simon, S.M., Yu, C., Gao, Z., Yang, J., Wang, Q., Joanna, T., Nathalie, W. 2015. Novel recurrently mutated gens and a prognostic mutation signature in colorectal cancer. Gut. 64(4):636-645.

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NANOPARTICLES FOR SUSTAINABLE PRODUCTION OF *Kochia indica* IRRIGATED WITH LOW QUALITY WATER

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Abstract — Green revolution had led to the increased consumption of chemical fertilizers which resulted in the higher productivity and caused environmental hazards. Nutrient use efficiency of conventional fertilizers is very low. To overcome all these drawbacks in a better way, nanotechnology can be a ray of hope. Nano fertilizer is an important tool in agriculture to improve crop growth, yield and quality parameters with increased nutrient use efficiency. Careful and judicious use of nanotechnology can ensure help in maximizing plant productivity especially in new reclaimed salt affected sandy soil which usually suffer from abiotic stress (drought and salinity). Nanoparticles have potential to improve growth and yield of plant under this circumstances. This paper studied the effect of ZnO nanoparticles on *Kochia indica* grown under saline conditions. To realize the previous tasks, a field trial was conducted at the Model Farm of the National Research Centre, El Tour, South Sinai to test the impact of foliar application with ZnO (20, 40 and 60 ppm) in addition to control treatment on some growth characters, photosynthetic pigments content, crude protein content, crude fiber, ash and some physiological aspects as well as nutrients content of *K. indica*. The results show that foliar application of ZnO nanoparticle improved growth, pigment content, crude protein, and crude fiber. The best results were obtained under foliar application with 40 ppm ZnO nanoparticle treatment. Thus, this concludes that zinc nanoparticles can improve productivity of *K. indica* in salt affected soils.

***Keywords — Kochia indica*, Zn nanoparticles, growth, physiological aspects, saline habitats**

INTRODUCTION

Soil salinity is one of the worst environmental problem around the world which affects arid and semi-arid regions. In general, it could be increased in irrigated lands because of poor drainage, bad irrigation system, low rainfall and high transpiration rate. It was stated that approximately 20% of irrigated land is affected by salts, which nearly about 1000 million hectare of land (Munns and Tester, 2008). Salinity tolerance is defined as the capability of plants to grow under salt stress evironment (Munns et al., 2002). Another essential factor of salt tolerance mechanisms is the ability of plant cells to regulate osmotically and to accumulate organic solutes (i.e. proteins, sugar, amino acids, etc.).

Kochia as a halophytic plant receiving attention by many researchers as it could be a very good opportunity as fodder or forage crop, it's a good plant for soil bioremediation in dry regions. many scientists reported that *kochia* is a promising forage crop for salt-affected environment (Youssef et al., 2009).

Recent agricultural managements associated with the green revolution have greatly increased the global food supply. They have also had an inadvertent, detrimental impact on the environment and on ecosystem services, highlighting the need for more sustainable agricultural methods (Tillman et al., 2002). It is well documented that excessive and inappropriate use of fertilizers has improved nutrients and toxins in both ground and surface waters, incurring health and water purification costs, and decreasing fishery. Agricultural practices that degrade soil quality contribute to eutrophication of aquatic habitats and may necessitate the expense of increased fertilization, irrigation, and energy to maintain productivity on degraded soils, they also kill beneficial insects and other wildlife (Presley et al., 2004) and Mukhopadhyay (2005). Intensive tillage, irrigation, and fertilizer dressing have also caused more extensive damage to the carbon profile in soils than early agrarian practices did (Knorr et al., 2005).

Recently, there has been a rapid growth of interest in the field of nanoscience and nanotechnology because of the realization that nano-sized materials are more effective in a multitude of agricultural technology (Nair et al., 2010).

Nanotechnology deals with the production and utilization of substances with nanoscale dimension. Nanoscale dimension provides nanoparticles a large surface area to volume ratio and thus very specific properties (Agarwal et al., 2017). Attempts to apply nanotechnology in agriculture began with the growing realization that conventional farming technologies would neither be able to increase productivity any further nor recover damaged ecosystems. Nanotechnology is an emerging technology, which can lead to a new revolution in every branch of science (Abbasifar et al., 2020). Research in this field has gained momentum especially in the recent years by providing innovative solutions in different scientific fields (Rico et al., 2011). Nanotechnology deals with nanoparticles that are atomic or molecular aggregates characterized by size less than 100 nm. These are actually modified form of basic elements derived by altering their atomic as well as molecular properties of elements (Kato, 2011). Zinc oxide is an inorganic compound with the molecular formula ZnO. It appears as a white powder and is nearly insoluble in water (Kokina et al., 2020). In this regard, Raliya and Tarafdar (2013) stated that, ZnO NPs in lower concentration increased seed germination in wheat. They recorded improved plant biomass, root and shoot length, chlorophyll and protein synthesis and other growth parameters *Cyamopsis tetragonoloba* when exposed to ZnO NPs. Moreover, Burman et al., (2013) reported that foliar application of ZnO NP at 1.5 mg/L concentration increased biomass in

chickpea as compared to normal ZnSO4.

The objective of this experiment was to test the effect of some nano-concentration of ZnO treatments on growth, photosynthetic pigments content, crude content as well as some physiological aspects of *K. indica*.

MATERIALS AND METHODS

A field experiment was carried out at the Model Farm of National Research Centre, El Tour, South Sinai to study the impact of foliar application of ZnO nanoparticles (control, 20, 40 and 60 ppm) on some growth characters, photosynthetic pigments content, crude protein content and some physiological aspects as well as nutrients content of *K. indica*. Zinc oxide (ZnO) NPs about 18 nm sizes were synthesized by mixing 10 ml of sodium hydroxide (NaOH) solution (4mM) to 0.1 ml of 0.5 M solution of 1- thioglycerol and to 10 ml of 10-3 M solution of zinc acetate (Dhobale et al., 2008). The synthesized ZnO NPs were dried in oven, suspended in water and then used for treatment.

K. indica seedlings were transplanted at the 15th May 2020 and grown under drip irrigation system with salt affected water (EC: 8.7 dSm-1), water analysis of Abo Kalam Well are presented in Table 1. Each experiment included four (4) treatments. RCBD was used in this experiment with 1.5 x 1 m distance between plants having a total of 2800 plants/field. Mechanical and chemical analyses of the soil were carried out by using the standard method described by Klute (1986) shown in Table 2. Each plant was fertilized with 50 g calcium superphosphate (15.5% P2O5) and 30 g potassium sulphate (48.0 % K2O) and 60 g urea (46.5% N) mixed with 500 g green manures (compost). Foliar application with ZnO nanoparticles was applied 30 days from transplantation and 30 days later. Three replicates from vegetative samples for each treatment were taken at 2nd Sep 2015 to determine some growth characters such as plant height, number of branches, number of leaves, dry weight of leaves, dry weight of whole plant and leaf area as well photosynthetic pigments content as Von Wettstein (1957).Then samples were washed, dried thoroughly, then dried at 70° C to constant weight in an aerated oven to determine, proline (µg/g) according to Bates et al. (1979), osmotic potential were obtained from the corresponding values of cell sap concentration tables given by Gusev (1960) as well as values of succulence (ratio of fresh weight/dry weight) according to Tiku (1979). Soluble carbohydrates content determined by the method described by Dubois et al., (1956). The contents of sodium and potassium were determined in the digested material using Jenway flame photometer as described by Eppendrof and Hing (1970). K/Na ratio was also calculated for each treatment. crude fiber and ash were determined by standard analytical methods after A.O.A.C. (2010). Nitrogen was determined with micro Kjeldhal's apparatus according to the method described by A.O.A.C. (2010). Crude protein was calculated by multiplying nitrogen contents by 5.75.The obtained data were subjected to statistical analysis of variance described by Snedecor and Cochran (1982).

Table 1. Water analysis of Abo Kalam well, El Tour, South Sinai.

pH		7.49
EC dS^{-1}		8.71
Soluble cations Meq/L	K^+	0.52
	Na^+	69.23
	Mg^{++}	11.92
	Ca^{++}	21.64
Soluble anions Meq/L	SO4--	26.61
	Cl-	74.20
	HCO3-	2.44
	CO--	-

Table 2. Mechanical and chemical analyses of the soil.

Depth		00 – 30 cm	30 – 60 cm
Soil texture		Sandy soil	Sandy soil
pH		8.1	8.43
EC dS^{-1}		15.1	4.52
Soluble cations Meq/L	K^{+}	0.4	0.24
	Na^{+}	112.0	27.02
	Mg^{++}	28.8	5.53
	Ca^{++}	60.5	12.51
Soluble anions Meq/L	SO4--	61.0	10.64
	Cl-	139.0	31.04
	HCO3-	2.7	3.63
	CO--	-	-

RESULTS AND DISCUSSION

Effect of Foliar Application with Nanoparticles ZnO on some Growth Characters of *K. indica*

Data in Table 3 show that all foliar treatments significantly affected the studied growth characters. The highest values for plant height, number of branches, leaf area, dry weight of shoot, dry weight of root as well as shoot / root ratio were recorded in plants sprayed with 40 ppm ZnO. Similar results were obtained by (Franklin et al., 2007). Nanofertilizers have important role in physiological and biochemical processes of crops by increasing the availability of nutrients, which help in enhancing metabolic processes and promoting meristematic activities causing higher apical growth and photosynthetic area. It was documented by some research studies, where foliar spraying of nanoformulations of NPK and micronutrients mixture increased the plant height and number of branches in black gram as indicated by Marimuthu and Surendran (2015). and also Abdel-Aziz et al., (2018) found that nano NPK increased the growth of leaves in wheat, which was obtained by enhanced availability of nutrients by easy penetration of nano formulation of NPK through stomata of leaves via gas uptake. In this concern, Prasad et al. (2012) stated that zinc oxide have potential to boost the yield and growth of crops. Likewise, Naderi and Abedi (2012) stated that the increase in vegetative growth in plant could be due to basic role of Zn in protecting and maintaining structural stability of cell membranes. Cakmak (2000) added that Zn can be used in protein synthesis, membrane function, cell elongation as well as tolerance to environmental stresses. Prasad et al. (2012) suggested that ZnO nanoparticles are absorbed by plants to a larger extent as compared to ZnSO4. They also observed beneficial effects of nanoparticles in promoting plant growth, development and yield in peanut at lower doses, but at higher concentrations ZnO nanoparticles were detrimental just as the bulk nutrients. Mahajan et al. (2011) stated that, ZnONPs promoted the root and shoot length, and root and shoot biomass.

Table 3. Effect of foliar application withnanoparticles ZnO on some growth characters of *K. indica*.

Treatments	Plant height (cm)	Number of branches / plant	Leaf area (cm^2)	Shoot dry weight (g)	Root dry weight (g)	Shoot / root ratio
Control	95.68	31.57	95.36	157.60	44.98	3.50
ZnO 20 ppm	101.54	35.25	100.87	179.57	47.65	3.77
ZnO 40 ppm	115.36	42.30	121.30	201.35	50.58	3.98
ZnO 60 ppm	108.39	39.65	112.60	185.94	48.65	3.82
LSD 5%	6.36	2.03	7.15	8.98	2.44	0.15

Effect of Foliar Application with Nanoparticles ZnO on Photosynthetic Pigments of *K. indica*

Data in Figure 1 revealed that foliar application with nanoparticles ZnO, positively affected photosynthetic pigments content, with superiority to 40 ppm concentration over all the other treatments. Results are in a harmony with those of Prasad et al. (2012) who reported a higher content of chlorophyll (1.97 mg g−1 rt.wt) in peanut leaves by foliar application of ZnO NPs at 1000 mg L−1 (25 nm) compared to ZnSO4. Similar results were obtained by Franklin et al. (2007). Such increase in photosynthetic pigments content in the leaves of plants may be attributed to the enhancing effect of ZnO nanoparticles on chlorophyll accumulation through the useful importance of Zn on plant growth. In this regard, Raliya and Tarafdar (2013) reported that ZnONPs induced a significant improvement in chlorophyll synthesis. In this regard, Siddiqui et al. (2014) stated that SiO2NPs can improve photosynthetic rate by improving activity of carbonic anhydrase and synthesis of photosynthetic pigments. Moreover, the exogenous application of TiO2NPs improves net photosynthetic rate, conductance to water, and transpiration rate in plants (Qi et al., 2013). According to Govorov and Carmeli (2007), metal nanoparticles can induce the efficiency of chemical energy production in photosynthetic systems.

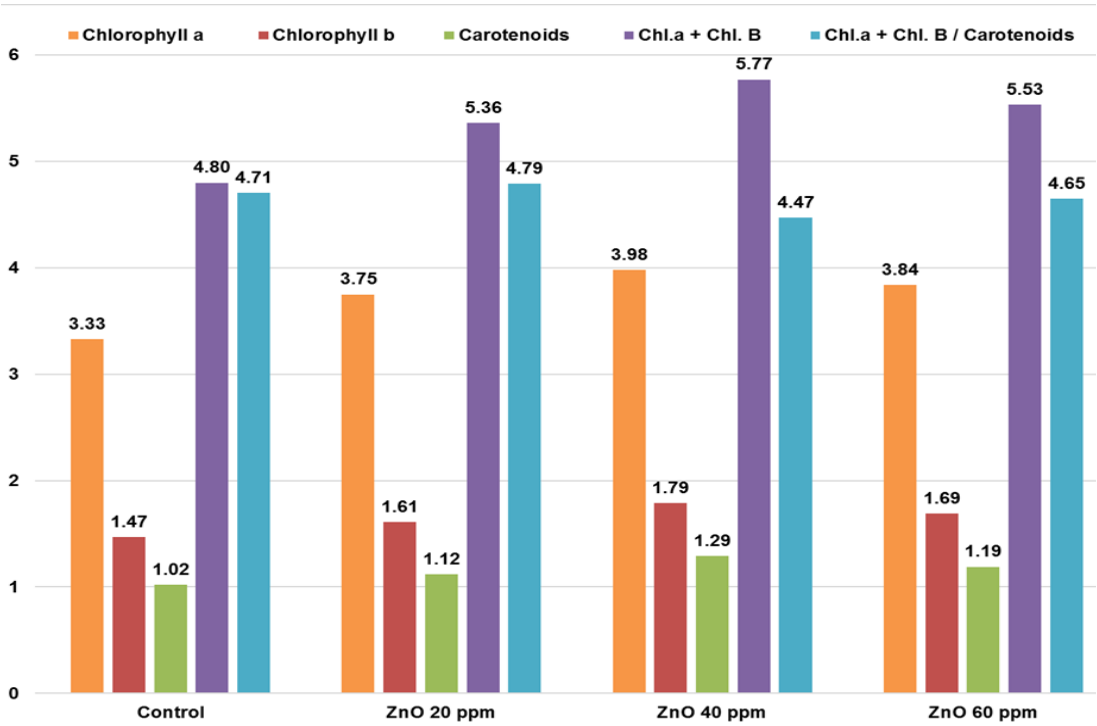

Fig. 1. Effect of foliar application with nanoparticles ZnO on photosynthetic pigments content of *K. indica* (LSD 5% = 0.19).

Effect of Foliar Application with Nanoparticles ZnO on some Physiological Aspects of *K. indica*

Table 4 shows the effect of different treatments on some physiological aspects of *Kochia indica*. It is clear that all foliar treatments significantly affected all the studied characters as compared with control treatment. It is also clear from the table that foliar application with 40 ppm ZnO nanoparticles recorded the highest values for Osmotic potential, Proline content and soluble carbohydrates % as well as succulence values, crude protein content and crude fiber in the plant leaves. On the other hand, the highest values for ash % were recorded under 60 ppm ZnO treatment. Similar results were obtained by Afshar et al. (2014) and El-Metwally et al. (2018). There was a remarkable increase in the physiological and biochemical parameters of crops with the application of nanofertilizers. In this regard, Helaly et al. (2014) stated that, ZnO NPs induced proline synthesis, and improved tolerance to abiotic stress. In another study, Nano-chelate zinc fertilizer application proved to enhance the activity of peroxidase, catalase, and polyphenol oxidase enzymes in cotton and soybean crops which increases the shoot and root growth (Rezaei and Abbasi, 2014). Moreover, Prasad et al. (2012) found that the application of fertilizer in nanoform is completely controlled and has led to an increase protein content in peanut. Furthurmore, Foliar application of nano-forms of iron and zinc fertilizers increased, and crude protein and soluble carbohydrate concentration in forage corn over chemical forms of fertilizers, (Sharifi et al., 2016). They added that, zinc fertilizers increased soluble carbohydrate concentration, probably due to involvement of zinc in photosynthesis, chlorophyll synthesis, starch formation and enzyme carbonic anhydrase, accelerating carbohydrate.

Effect of Foliar Application with Nanoparticles ZnO on Nutrients Content of *K. indica*

Data in Table 5 show that, foliar application with ZnO nanoparticles, significantly affected content of N, P, K, Na, and Zn as well as K/Na value as compared with control treatment. However, plants sprayed with 40 ppm ZnO recorded the highest values of N, P and K as well as K/Na while plants sprayed with tap water (control) recorded higher contents of Na. On the other hand, plants sprayed with 60 ppm ZnO recorded the highest values of Zn. Such results were confirmed by the findings of Bahrnanyar and Ranjbar (2008). Zinc plays a positive role in root development, it helps plants absorb important nutrients, especially nitrogen responsible for protein

Table 4. Effect of foliar application with nanoparticles ZnO on some physiological aspects of *K. indica*.

Treatments	Osmotic potential values	Proline content µg/g dry wt.	Soluble carbohydrates %	Succulence	Crude protein %	Crude fiber %	Ash %
Control	7.06	344.58	45.98	3.19	7.68	21.35	27.68
ZnO 20 ppm	7.25	365.87	47.02	3.57	8.02	20.37	28.65
ZnO 40 ppm	8.02	402.36	48.23	3.75	8.87	22.02	28.87
ZnO 60 ppm	7.68	388.25	47.85	3.67	8.47	21.36	29.03
LSD 5%	0.41	18.25	2.81	0.15	0.44	NS	NS

Table 5. Effect of foliar application with nanoparticles ZnO on nutrients content of *K. indica*.

Treatments	N %	P %	K %	Na %	K/Na	Zn ppm
Control	1.34	0.51	0.98	1.02	0.96	15.36
ZnO 20 ppm	1.39	0.55	1.03	0.96	1.07	16.58
ZnO 40 ppm	1.54	0.68	1.25	0.91	1.42	17.25
ZnO 60 ppm	1.47	0.60	1.12	0.88	1.23	17.99
LSD 5%	0.08	0.04	0.07	0.06	0.07	0.72

synthesis (El-Metwally et al., 2018). such increase could be attributed to the synergistic effect between N and Zn which might be due to increase enzymatic activity by Zn application (Keram et al., 2012).

Foliar application of nano-forms of iron and zinc fertilizers increased, phosphorus concentration in forage corn over chemical forms of fertilizers, (Sharifi et al., 2016).

CONCLUSION

Nano-fertilizers may be more effective than regular fertilizers in improving plant nutrition, enhancing nutrition use efficiency, and protecting plants from environmental stress. The results suggest safe use of ZnNPs in the agricultural fields with further suitable modifications. Results showed that *K. indica* is highly salt tolerant halophyte, foliar application with 40 ZnO nanoparticles enhanced all studied growth characters as well as photosynthetic pigments content and crude protein as well as the physiological aspects of the plant. We can conclude that zinc nanoparticles can improve plant growth in salt affected environment.

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REFERENCES

Abbasifar, A., Shahrabadi, F., ValizadehKaji, B. 2020. Effects of green synthesized zinc and copper nano-fertilizers on the morphological and biochemical attributes of basil plant. J. Plant Nutr. 43, 1104–1118.

Abdel-Aziz, H.M.M., Hasaneen, M.N.A. and Aya, M.O. 2018. . Foliar application of nano chitosan NPK fertilizer improves the yield of wheat plants grown on two different soils. The Egyptian J Experimental Biol. (Botany), 14(1): 63-72.

A.O.A.C. 2010. Official Method of Analysis 15th Association Official Analytical chemists, Washington, D.C. (U.S.A.).

Afshar, I., Haghighi, A.R. and Shirazi, M. 2014. Comparison the effect of spraying different amount of ano zinc oxide on wheat. International J. Plt. , Anim. and Envtl Sci, 4 (3): 688-693.

Agarwal, H., Kumar, S.V. and Rajeshkumar, S. 2017. A review on green synthesis of zinc oxide nanoparticles – An eco-friendly approach. Resource - Efficient Technologies 3: 406-413.

Bahrnanyar, M.A. and Ranjbar, G.A. 2008. The role of potassium in improving

growth indicesand increasing amount of grain nutrient elements of wheat cultivars. J. Applied Sci. 8 (7): 1280-1285.

Bates, L.S., Waldrem, R.P. and Tear, L.D. 1979. Rapid determination of proline for water stress studies. Plant and Soil, 39: 205 – 207.

Burman U, Saini and Praveen-Kumar, M. 2013. Effect of zinc oxide nanoparticles on growth and antioxidant system of chickpea seedlings, Toxicol Environ Chem., 95(4): 605–612.

Cakmak, I. 2000. Possible Roles of Zinc in Protecting Plant Cells from Damage by Reactive Oxygen Species. New Phytologist 146: 185-205.

Dhobale Sandip, Trupti Thite, C.V., Laware, S. L., Rode, C.V., Soumya, J., Koppikar, Ruchika-Kaul Ghanekar, and Kale, S.N. 2008. Zinc oxide nanoparticles as novel alpha-amylase inhibitors. J. Applied Physics 104, 9490.

Dubois, M., Gilles, K.A., Hamilton, J., Rebes, R. and Smith, F. 1956. Colorimetric method for determination of sugar and related substances. Anal. Chem. 28: 350.

El-Metwally, I.M., Doaa, M.R., Abo-Basha and Abd El-Aziz, M.E. 2018. Response of peanut plants to different foliar applications of nano- iron, manganese and zinc under sandy soil conditions. Middle East J. Applied Sci. 8(2): 474-482.

Eppendrof, N. and Hing, G.1970. Interaction manual of flame photometer B 700-E. Measuring method, Description of the apparatus and Instructions for use.

Franklin, N.M., Rogers, N.J., Apte, S.C., Batley, G.E., Gadd, G.E. and Casey, P.S. 2007. Comparative toxicity of nanoparticulate ZnO, bulk ZnO, and ZnCl2 to a freshwater microalga (*Pseudokirchneriella subcapitata*): the importance of particle solubility. Envtl. Sci. and Tech. 41 (24): 8484–8490.

Govorov, A.O., and Carmeli, I. 2007. Hybrid structures composed of photosynthetic system and metal nanoparticles: plasmon enhancement effect. Nano Lett. 7(3):620–625.

Gusev, N.A. 1960. Some Methods for Studying Plant Water Relations, Akad. of Sciences Nauke U.S.S.R., Leningrad.

Helaly, M.N., El-Metwally, M.A., El-Hoseiny, H., Omar, S.A. and El-Sheery, N.I. 2014. Effect of nanoparticles on biological contamination of in vitro cultures and organogenic regeneration of banana. Aust. J. Crop Sci. 8: 612–624.

Kato, H. 2011. In vitro assays: tracking nanoparticles inside cells. Nature Nanotechnology 6 (3): 139–140.

Keram, K.S., Sharma, B.L. and Sawarkar, S. D. 2012. Impact of Zn application on yield, Quality, Nutrients uptake and Soil fertility in a medium deep black soil (Vertisol). International J. Sci., Envt. and Tech. 1(5):563 – 571.

Klute, A. 1986. Methods of Soil Analysis. 2nd ed. Part 1: Physical and mineralogical methods. Part 2 : Chemical and Microbiological

properties. Madifon, Wesconsin, USA.

Knorr, W., Prentice, I.C., House, J.I. and Holland, E.A. 2005. Long-term sensitivity of soil carbon turnover to warming. Nature 433:298–302.

Kokina, I., Plaksenkova, I., Jermal, Onoka, M., Petrova, A. 2010. Impact of iron oxide nanoparticles on yellow medick (*Medicago falcata* L.) plants. J. Plant Interact. 15: 1–7.

Marimuthu, S. and Surendran, U. 2015. Effect of nutrients and plant growth regulators on growth and yield of black gram in sandy loam soils of Cauvery new delta zone, India. Cogent Food and Agriculture, 1(1): 1010415.

Mahajan, P., Dhoke, S.K. and Khanna, A.S. 2011. Effect of nano-ZnO particle suspension on growth of mung (*Vigna radiata*) and gram (*Cicer arietinum*) seedlings using plant agar method. J. Nanotechnol, 2011:1–7.

Mukhopadhyay, S.S. 2005. Weathering of soil minerals and distribution of elements: pedochemical aspects. Clay Res., 24:183–199.

Munns, R., Husain, S. Rivelli, A., Richard, A., James, A.G., Lindsay, M. Lagudah, E., Schachtman, D., Ray, A. and Hare, R. 2002. Avenues for increasing salt tolerance of crops, and the role of physiologically based selection traits. Plant and Soil 247: 93–105.

Munns, R., and Tester, M. 2008. Mechanisms of salinity tolerance. Ann. Rev. Plant Biol. 59: 651-681.

Naderi, M.R. and Abedi, A. 2012. Application of nanotechnology in agriculture and refinement of environmental pollutants. J. Nanotechnology 11(1):18- 26.

Nair, R., Varghese, S.H., Nair, B.G., Maekawa, T., Yoshida, Y. and Kumar, D.S. 2010. Nanoparticulate material delivery to plants. Plant. Sci. 179: 154–163.

Presley, D.R., Ransom, M.D., Kluitenberg, G.J. and Finnell, P.R. 2004. Effect of thirty years of irrigation on the genesis and morphology of two semi-arid soils in Kansas. Soil Sci Soc Am J., 68:1916–1926.

Prasad, T.N., Sudhakar, P. and Sreenivasuluetal, Y. 2012. Effect of nanoscale zinc oxide particles on the germination, growth and yield of peanut. J. Plant Nutrition, 35 (6): 905–927.

Qi, M., Liu, Y. and Li, T. 2013. Nano-TiO2 improve the photosynthesis of tomato leaves under mild heat stress. Biol Trace Elem Res. 156(1–3): 323–328.

Raliya, R. and Tarafdar, J.C. 2013. ZnO nanoparticle biosynthesis and its effect on phosphorous-mobilizing enzyme secretion and gum contents in cluster bean (*Cyamopsis tetragonoloba* L.). Agric Res. 2: 48–57.

Rezaei, M. and Abbasi, H. 2014. Foliar application of nanochelate and non-nanochelate of zinc on plant resistance physiological processes in cotton (*Gossipium hirsutum* L.). Iranian J. Plt. Physio. 4(4): 1137-1144.

Rico, C.M., Majumdar, S., Duarte-Gardea, M., Peralta-Videa, J.R. and

Gardea-Torresdey, J.L. 2011. Interaction of nanoparticles with edible plants and their possible implications in the food chain. J. Agricultural and Food Chem. 59 (8): 3485–3498.

Sharifi, R., Mohammadi, K. and Rokhzadi, A. 2016. Effect of seed priming and foliar application with micronutrients on quality of forage corn (*Zea mays*). Envtl and Exptl. Bio. 14: 151-156.

Siddiqui, M.H., Al-Whaibi, M.H., Faisal, M., Al Sahli, A.A. 2014. Nano-silicon dioxide mitigates the adverse effects of salt stress on *Cucurbita pepo* L. Environ Toxicol Chem. 33(11): 2429– 2437.

Snedecor, G.W. and Cochran, W.G. 1982. Statistical Methods. 7th ed. Iowa State Univ. press Iowa, USA.

Tiku, G.L. 1979. Ecophysiological aspects of halophyte zonation. Plant and Soil, 43 : 355.

Tillman, D., Cassman, K.G., Matson, P.A., Naylor, R., Polasky, S. 2002. Agricultural sustainability and intensive production practices. Nature 418:671–677.

Von Wettstein, D. 1957. Chlorophyll latalfaktoren und der submikroskopische formuechsel der plastidenn. Exper. Cell Res. 12 : 327 – 433.

Youssef, A.M. 2009. Salt Tolerance Mechanisms in Some Halophytes from Saudi Arabia and Egypt. Res. J. Agric. and Biol. Sci., 5(3): 191-206.

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PROPAGATION AND FERTILIZER FOR *Morinda officinalis* How. CULTIVATED IN BAC GIANG PROVINCE, VIETNAM

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Abstract — *Morinda officinalis* How. is widely used as traditional medicinal plant with high pharmacological value. A big gap in the market for medicinal herbs in Vietnam emerged due to overexploitation and high demand for medicinal herbs. Covid-19 further boosted demand to develop medicinal plants to meet the domestic demand. There were limitations on applying fertilizers for medicinal plants in cultivation. In this study, the impact of propagation and different fertilizer applications for *M. officinalis* cultivation in Bac Giang Province were investigated. Data on ground diameter, height, root weight, and yield were collected after 18 and 54 months. The results showed that propagation could provide high yield and maintain good chracteristics of mother trees. *M. officinalis* grew well and provided high yield when it was applied with manure, mixture fertilizers and microbial fertilizers. The results of the study can be used for cultivating *M. officinalis* in large scale in support of the pharmaceutical industry having enough materials as well as improving livelihood of local people.

Keywords — **Bac Giang Province, Vietnam, fertilizer, *Morinda officinalis*, propagation**

INTRODUCTION

Morinda officinalis How. (Family: Rubuiaceae) is considered as a medicinal plant as its roots have been used for various purposes (Huong et al., 2020, Zhai et al., 2020). The root extract of *M. officinalis* was used to enhance immune function in the treatment of impotence, menstrual disorders, diabetes and dermatitis (Zhang et al., 2018). In Viet Nam, *M. officinalis* is also listed as an endangered species (Nguyen Tap and Nguyen Chieu, 2007).

Due to past unsustainable practice, the resource of medical plants in Vietnam has been depleted and some plants are endangered or have become extinct. The big gap in the market for medicinal herbs in Vietnam emerged due to exploitation and high demand for medicinal herbs. COVID-19 further boosted demand to develop medicinal plants to meet the domestic demand (Caspani, 2020).

Cultivation of medicinal plants has been limited and there was blind application of fertilizers to *M. officinalis* to provide theoretical support in cultivation. Zhu et al. (2020) studied the effects of fertilizers on yield and quality of *Panax notoginseng* in Yunnan Province, China and found that supplementation of organic and medium and trace element fertilizers would help to increase root weight per plants.

To date there has been no formalized studies examining propagation techniques and fertilizer application rates for *M. officinalis*. Therefore, this study was conducted to investigate the impact of propagation and different fertilizer applications on *M. officinalis* in Bac Giang Province.

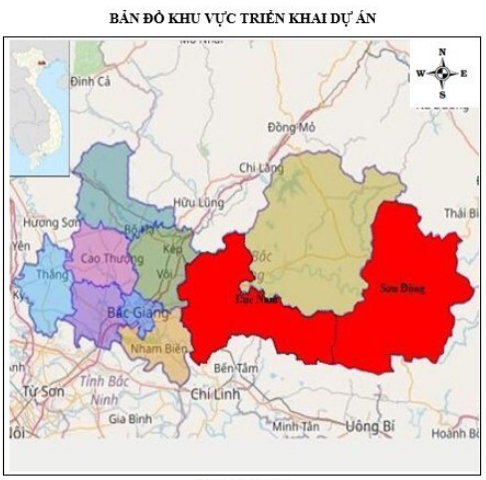

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Fig.1. Location of cultivation *Morinda officinalis* How. in Bac Giang Province.

MATERIALS AND METHODS

Impact of Propagation on the Growth and Yields of *M. officinalis*

The experiment had 2 treatments including CT1: used seeds of *M. officinalis* and CT2: used stem cutting for propagation. In CT1, seeds were collected from the mature trees, over 3 years old with ripened fruits in red color. In CT2, stem cutting plants were collected from the mother trees, 2-3 years old. Stem cutting materials were soaked with Indol Butylic Acid (IBA) in concentration of 1500ppm (Quang et al., 2020). Experiments were conducted using the completely randomized design with 3 replicates, each measured 62.5 m² with 50 plants/replication/treatment. Materials in both treatments used the same variety (BK8). Experiments was conducted from April 2014 to October 2018.

Experiments were done in the land after harvesting hybrid Acaciar in the Nghia Phuong commune, Luc Nam district, Bac Giang Province, Vietnam (Figure 1). Soil was dug and turned 50cm deep by machine. The hole size was 40 x 40 x 30cm, distance 1 m x 1.25m (8.000 plants/ha). Basal fertilizer for each hole included 0.1 kg NPK (5:10:3). Fertilizer application, land preparation and hole cover were completed before planting in 20 days. In the CT1, plants for cultivation had height 20-25 cm, 4-5 leaves, 5-10cm root length, healthy, not curved or cut shoot. In the CT2, plants for cultivation had height 15-20 cm, 4-5 leaves, 5-10 cm root length, healthy, not curved or cut shoot (after 4 months).

Impact of Fertilizers on the Growth and Yields of *M. officinalis* root

The experiments had four (4) treatments namely:

CT1: Basal fertilizers inluded 0.1kg NPK (5:10:3)/plant with additional fertilizer application in the 2nd, 3rd year, two times per year, each 1kg NPK (5:10:3)/plant.

CT2: Basal fertilizers included 1kg manure + 0.1kg NPK (5:10:3)/plant, additional fertilizer were applied in the 1st year once at 0.1kg NPK (5 :10 :3)/ plant; applying additional fertilizers were applied in the 2nd year, twice each time at 0.5kg manure + 0.1kg NPK (5:10:3)/plant; additional fertilizer were applied in the 3rd year, twice each time at 0.1 kg NPK (5:10:3)/ plant each time.

CT3: Basal fertilizers included 1kg manure + 0.05kg mixture of fertilizer/plant, additional fertilizers were applied the 1st year, once at 0.05kg mixture of fertilizer/ plant additional fertilizers were applied in the 2nd year, twice each time at 0.5kg manure + 0.05kg mixture of fertilizer/plant each time; additional fertilizer in the 3rd year was applied twice, each time at 0.05kg mixture fertilizers/plant each time. Mixed fertilizers included 288 kg NPK (5:10:3) + 80 kg $P_2 0_5$ + 32 kg $K_2 0$. Buffalo manure was collected one year prior to application.

CT4: Basal fertilizers included (1kg manure + 0.05kg mixture fertilizers + 0.1kg microbial fertilizers/plant; additional fertilizers were applied in the 1st year, once at (0.05kg mixture fertilizers + 0.1 kg microbial fertilizers)/plant; additional fertilizers were applied in the 2nd year, twice, each time at (0.5kg manure + 0.05 kg mixture fertilizers + 0.1kg microbial fertilizers)/plant each time; additional fertilizers was applied in the 3rd year, twice, each time at (0.05 kg mixture fertilizers + 0.1kg microbial fertilizers)/plant each time.

Location and design of experiments were similar with the propagation study. In both experiments, data were collected on the survival ratio (sr = alive plants/ total plants x 100%), ground diameter, height, the numbers of leaf pair and the numbers of the third brands, root weight and root yields [ry = average root weight (kg)/plot area x ($10000m^2$)].

Data were analyzed by using SPSS Version 12.0.

RESULTS AND DISCUSSION

Comparing propagation to seedling after 18 months, the following we observed:

In the propagation by stem cutting experiment had a survival ratio was 88.5%, ground diameter was 6.2mm, there were 68.1 pairs/plant and 42.7 third branches/ plant. By contrast, in the seeding experiment, survival ratio was 82.5%, ground diameter was 4.6mm, the numbers of leaf pair was 48.5 pairs/plant and the numbers of the third branches was 25.5/plant. After 54 months, root yields of *M. officinalis* in the propagation experiment reached 4.8 tons ha^{-1} whereas seedling yielded 3.7 tons ha^{-1} (Table 1).

Table 1. Growth of *M. officinalis* plants by cultivating seeds and propagation after 18 months.

Treatment	Survival rate (%)	Ground diameter (mm)	Height (cm)	Numbers of pair of Leaves (a pair)	The third branch numbers (branches)
By propagation	88,5	6,2	255,1	68,1	42,7
By seeds	82,5	4,6	270,2	48,5	25,5
Fpr	*0,024*	*0,003*	*0,081*	*0,004*	*0,000*
Lsd 0.05	*4,3*	*0,14*	*22,4*	*11,6*	*0,99*

Comparing propagation and seed experiments, it can be concluded that using propagation of *M. officinalis* can lead to faster growth in physiological indicators of the mother trees than using seeds. More importantly, propagation leads to statistically higher root yields. After 18 months, survival ratio of *M. officinalis* in the 4 treaments using fertilizers ranged from 84.7% – 94.6%, highest number in CT4 (94.6%) and lowest number in CT1 (84.7%) (Table 2).

Table 2. Impact of fertilizers to the growth of *M. officinalis.*

Treatment	Survival rate (%)	Measurement factors after 18 months		
		Ground diameter (mm)	Numbers of pair leaves (a pair)	Numbers of the third branches (branches)
CT1	84.7	5.2	57.6	24.0
CT2	92.4	5.8	77.3	27.3
CT3	94.1	6.8	83.1	30.3
CT4	94.6	8.5	109.7	41.2
Fpr	*0.000*	*0.000*	*0.000*	*0.002*
LSD0.05	*2.68*	*0.29*	*8.79*	*5.6*

Similarly, measurement factors in CT4 were higher significantly than in other experiments such as ground diameters (8.5mm), the numbers of pairs leaves (109.7 pairs/plant), the numbers of the third branches (41.2 branches/plant) whereas in the other experiments, ground diameter ranged from 5.2 – 6.8mm, the numbers of pair leaves 57.6-83.1 pairs/plant and the numbers of the third branches 24.0/plant (Table 3).

Table 3. Yield of *M. officinalis* roots by cultivating seeds and propagation after 54 months.

Treatment	Root weight (g/plant)	Root yield (ton/ha)
By propagation	680,5	4,8
By seeds	567,1	3,7
Fpr	*0,002*	*0,001*
Lsd 0.05	*4,1*	*0,24*

After 54 months, highest root yield of *M. officinalis* gained 5.2 tons/ha in CT4 and lowest yield was in CT1 (3.5 tons/ha) (Table 4).

Table 4. Yields of *M. officinalis* How roots after 54 months applying fertilizers.

Treatment	Root weight (g/plant)	Root yield (ton/ha)
CT1	776.5	3.5
CT2	927.3	4.3
CT3	1.01.7	4.8
CT4	1.169.0	5.2
Fpr	*0.003*	*0.000*
LSD0.05	*137.78*	*0.24*

M. officinalis would grew well after applying manure, mixture fertilizers (NPK + phosphate + potassium + microbial fertilizers) as supported by Quang et al. (2020) in their propagation technique of *M. officinalis.*

M. officinalis is a species develops and produces roots so it needs high noncohesive and highly fertile soils. In the growing stage and rooty development stage, potassium fertilizers should be added. Zhu et al. (2020) obtained similar results where organic and trace element were added on P. notoginseng.

A limitation of study was to assume that *M. officinalis* grew well without pest and disease and trialed in Bac Giang Province, the native area of this species.

CONCLUSIONS

Cutting stem propagation of *M. officinalis* would provide statistically higher growth and yield.

Supplementation of manure, mixture fertilizers and microbial fertilizers for *M. officinalis* How in the basal application and later stages would enhance h yield.

This study indirectly inferred that *M. officinalis* required noncohesive and fertile soils. Fertilizers should be added in the developing stages of *M. officinalis*.

M. officinalis plantation should be expanded to help improve the livelihood of local residents.

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REFERENCES

Huong, T.T., Mong, N.T.K., Loc, L.T., Co, N.T.Q., Tuan, T.T. 2020. Study of adventitious root formation derived from node of *Morinda officinalis* How cultured in vitro. J. Sci. Tech. and Food , 20(2): 72-79 https://123docz.net/document/7012471-study-of-adventitious-root-formation-derived-from-node-of-morinda-officinalis-how-cultured-in-vitro.htm

Nguyen Tap, Nguyen Chieu. 2007. *Morinda officinalis* How. Labor Public House. Ha Noi. (Vietnamese).

Quang, K.N., Thom, N.M., Hai, V.D. 2020. Study on propagation techniques of *Morinda officinal* How in Bac Giang, Vietnam Journal of Forest Science. 4: 3-13. http://vafs.gov.vn/en/2020/11/vietnam-journal-of-forest-science-number-4-2020/

Zhai, H.J., Ye, G.H., Xue, J.J., Yu, J.H., Zhang, Y.Y., Zhang H. 2020. Two new naphthoate derivatives from *Morinda officinalis* How. Journal Asian Natural Products Research. 22 (11), 1018-1023. https://doi.org/10.1080/10286020.2019.1670648

Zhang, J.H., Xin, H.L., Xu, Y.M., Shen, Y., He, Y.Q., Yeh, H., Lin, B., Song, H.T., Yang, H.Y., Qin L.P., Zhang, Q.Y., Du, J. 2018. *Morinda officinalis* How. – A comprehensive review of traditional uses, phytochemistry and pharmacology. Journal of Ethnopharmacology 213: 230- 255. DOI: 10.1016/j.jep.2017.10.028

Zhu, Y., Chen, J., Long, G., Zhu, T., Zhu, S. 2020. Effect of organic and medium and trace element fertilizers on yield and quality of *Panax notoginseng*. Medicinal Plants 11(3): 55-59.

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LAND ACQUISITION, OWNERSHIP AND UTILIZATION IN 19TH CENTURY ALBAY

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Abstract — This preliminary study seeks to provide a working knowledge of how agricultural land was acquired, owned, and utilized in the Province of Albay during the middle to latter parts of the nineteenth century. Using land ownership and notarial records from the National Archives of the Philippines, this paper argues that lands planted mainly to rice and abaca were being purchased and acquired by men and women from different racial and socioeconomic classes in Philippine society as early as the 1860s. A careful examination of these documents reveals, however, that the acquisition of such holdings became increasingly concentrated in the hands of the male elite who obtained these via direct purchases, debt defaults, and applications to the State. Simple quantitative and qualitative examinations of these land documents also show the variety of land measures used by Albayenos to determine the sizes of their properties, the high value of abaca lands near seaports, the increasing dimensions of farmlands that were farther from these facilities, and the use of land by Albayenos for both commercial (abaca) and subsistence (rice, coconut) purposes. It is hoped that this study would encourage further research in the ownership, acquisition, and utilization of land during the Spanish period in the Philippines using archival documents.

Keywords **— Land use, land ownership, land acquisition, agricultural land**

INTRODUCTION

Land is a valuable, versatile, and attractive resource that people would like acquire. Developed or otherwise, urban and rural real property could yield material or economic benefits when sold as a commodity. On the other hand, its surface is a potential platform for profit and rent-seeking activities such as factory, shopping center or housing facility (Serote, 2004). Landowners could also take advantage of the fertility of agricultural parcels as a direct input for raising crops or livestock for personal consumption or a market commodity. Natural resources like minerals or timber (Serote, 2004) extracted from the soil can be subjected to further processing and eventual consumption. In this respect, land plays a crucial role to a society's development and serves an integral part in a people's way of life.

Early Filipinos, on the other hand, did not see land in this manner. Prior to Western contact to the middle part of the 18th century when the Philippines was under Spanish rule, the lack of a market for agricultural produce (Benitez, 1916), Spanish dependence on the Manila-centered Galleon Trade (Foreman, 1905), and the disinterest of colonial rulers to pursue agricultural pursuits meant that land was initially seen as a source of daily subsistence and tribute in colonial society (Rodriguez, 1998; Cushner, 1971). It was only during the late eighteenth and nineteenth centuries when the Philippines was opened to world commerce that its agricultural cash crops for export like sugarcane and abaca became sought after in the world market (Larkin 1972; Lynch 1988; Corpuz, 1997). Following this event, which led to the institution of a monetized economy, land emerged as a valuable and sought-after commodity (Bankoff, 1996) and a means for acquiring and solidifying economic and social status (Corpuz. 1997).

Landowning native elite and mestizo families were encouraged by Manila-based trading houses to go into the large-scale cultivation of cash crops that included tobacco, indigo, and coffee and purchase more and more land (Mallat, 1983; Corpuz, 1965; Corpuz, 1997). Some provinces soon became known for the crops its inhabitants produced. The localities of Central Luzon and Southern Tagalog and the island of Negros became the main source of sugar cane (Foreman, 1905; Larkin, 1972). Batangas, Laguna, and Cavite became known for its coffee, and Albay became a major source of abaca (Foreman, 1905).

This sudden and intense demand for agricultural land led to the titling of parcels of earth, their measurement, and valuation. Land also have became an object disposition, sale, and acquisition in different parts of the Philippine colony. Studies by Larkin (1972), Bauzon (1974), Owen (1984), Lynch (1988), Huetz de Lemps (1998), Camagay (1995), and Lagman (2020), among others, have discussed how agricultural and urban properties became the object of transactions both fair and foul in different settlements in the Philippines. Owen, in particular, deals with the growing importance of abaca lands in the Bicol Region's uplands as a source of wealth and systematic economic activity and the persistent importance of rice fields in the lowlands for alimentary purposes.

However, there has not been a study, that has sought to examine in detail the kind of agricultural land transactions, land uses, and other facts pertaining to the ownership, acquisition, disposition, and utilization of land resources among Bicolanos, particularly those in the province of Albay, during the late nineteenth century when land became so important that legal documents began to be employed to ensure an individual's possession and benefits from such assets.

This study examines land documents in the form of land titles and notarial records to shed light on the kind of demographic, spatial, resource use, and monetary

information that can be documented and analyzed in land acquisition, ownership, utilization-based sources pertaining to late nineteenth century Albay that are found at the National Archives of the Philippines. In particular, this research sought to answer the following questions:

1. Who and what were the characteristics of individuals involved in land-related transactions such as social class, race, gender, occupation?
2. In what ways were agricultural lands in Albay owned, acquired, and disposed of?
3. What were the sizes of private agricultural lands in Albay, what land measures were used to determine their metes and bounds, and what were their common market values?
4. What were the kinds of agricultural lands that were commoditized in the said province?
5. In what ways do the contents of such land transactions reflect the culture and values of Albayenos as their economy transitions to one with a more capitalistic nature?

MATERIALS AND METHODS

Social historians seek to tell the stories and everyday lives of people from past societies who are rarely given importance (Zunz, 1985; Burke, 2002; Sharpe, 1991). Their specific experiences that have been influenced by wider processes like effects of international trade, colonialism (Warren 2000; Warren 2003) could demonstrate particular patterns and trends (Burke, 2002) that are worthy of mention.

For this study, archival research of notarial records pertaining to transactions dealing with land in late nineteenth century Albay required the collection of data regarding such dealings in notarial records and land titles in the National Archives of the Philippines called the Protocolos de Albay and the Terrenos de Albay, respectively. Such documents, which were produced between the 1860s and 1890s, are all hand-written records in Spanish that were not collected annually and whose numbers vary from year to year. Save for the individuals involved and the property that was the object of a transaction, information in these documents is also not consistent and seem to change over time. Given that the study began with no idea as to the information and amount of material available for description and analysis, the following steps were undertaken in the data collection part of the research:

1. As there were different years wherein notarized records of land transactions were available, and since some years had documents that were unreadable, the researcher selected 1864, 1870, 1873, 1880, 1887, 1890, and 1895 as the years wherein information were to be gathered;
2. For consistency, all towns or pueblos that were the sites of land transactions were included in the database, even if such localities are no longer part of present-day Albay Province;
3. Notes were taken for the following information: a) the individual/s involved in the land transaction, b) the type of transaction, and c) description, location, size, land use, and value of the property;
4. All collected data were then inputted in Microsoft Excel to create a database of all transactions. A thorough analysis of the data led to the creation of additional columns that better describe the information regarding the concerned individuals and commoditized land. The additional columns include, among others, if the transactions were conducted among persons of equal status based on the titles they carried (Y/N), the conversion of land areas to hectares, another for additional remarks to account for unique cases; and

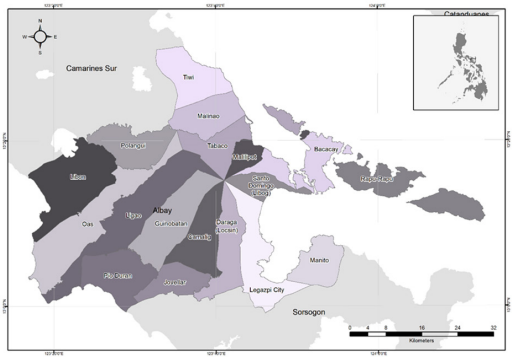

Fig. 1. Map on the Present-Day Province of the Albay.[i]

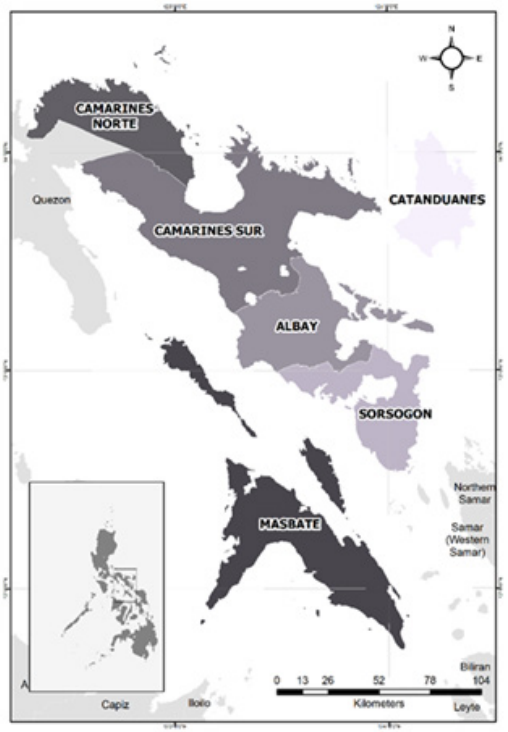

Fig. 2. Map of the present-day provinces of the Bicol Region.
(Based on archival sources, Albay Province in the late 1800s included the current provinces of Catanduanes, Sorsogon, and Masbate.)

5. Once completed, the database was then utilized and managed to identify patterns such as existence of land consolidators, buyers and sellers of land who were not locals, geographic distribution of transactions, and variations in the size and measures of agricultural properties depending on the place and time period.

Table 1. A sample of the database generated based on information gathered from the Terrenos and Protocolos de Albay documents.

TOWN	TRANSACTION TYPE	EQUALS	SELLER	M/F	ELITE	RACE
CAGSAWA	FORMALIZATION	NA				
BACACAY	PACTO DE RETROVENTA	YES	BRAULIA BASALLA	F	N	
LIGAO	PACTO DE RETROVENTA	NO	MANUELA DE LOS SANTOS	F	N	
	SALE	YES	JUAN LUCERO	M	N	
BACACAY	FORMALIZATION	NA				
TABACO	PACTO DE RETROVENTA	YES	MARIANO BUENAFE	M	Y	
BACACAY	PACTO DE RETROVENTA	YES	JUAN BERCES	M	N	
	SALE	NO	FRANCISCA FELICIANO	F	N	
	FORMALIZATION	NA				
BACACAY	SALE	YES	RAYMUNDO BARQUIN	M	N	
	SALE	YES	JUAN DE LA PENA	M	Y	
TABACO	PACTO DE RETROVENTA	NO	ACORDIA BORLAGDAN	F	N	
	SALE	YES	MARIANO CONSOL	M	N	
GUINOBATAN	FORMALIZATION	NA				
LIGAO	SALE	YES	CLEMENTE QUIRA	M	N	INDIO
	SALE	YES	MARZARIA DURAN	F	N	INDIO
LIGAO	SALE	YES	JUAN TICAGAN	M	N	INDIO
CAMALIG	SALE	NO	MATEO MARQUES	M	N	INDIO
	SALE	NO	MARIA MARCELLA	F	N	INDIO
PANDAN	PACTO DE RETROVENTA	NO	AGATON DE LA ROSA AND VICENTE ANGELES	MM	N	INDIO
PANDAN	PACTO DE RETROVENTA	NO	CASIMIRO YLANAN	M	N	INDIO
PANDAN	PACTO DE RETROVENTA	NO	_ SANCHES AND MAXIMO RIVERA	MM	N	INDIO
OAS	SALE	N	FERNANDO REFRACESON	M	N	
CAGSAWA	SALE	YES	MANUEL DINO	M	Y	
OAS	SALE	YES	MANUEL REALISTA	M	Y	
LIGAO	SALE	YES	DAMASO QUINTERIO	M	N	INDIO
MALINAO	SALE	NO	JUANA CONS	F	N	
MALINAO	SALE	NO	ANACLETO CARULLO	M	N	
MALINAO	SALE	NO	MATIAS BRAUS	M	N	
MALINAO	SALE	NO	LUCIO AND FELICIANO CERRANO	MM	N	
MALINAO	SALE	NO	CIRIACO CELESTIAL	M	N	INDIO
MALINAO	SALE	YES	MARIANO CASALLA	M	Y	
CAMALIG	SALE	NO	PEDRO GUIRIBA	M	N	INDIO
GUINOBATAN	SALE	YES	ANTONIO SANCHES	M	Y	ESPAÑOL
LIGAO	SALE	NO	PEDRO FEDERICO	M	N	

RESULTS AND DISCUSSION

Transactors' Social Class

Ninety-eight of 113 cases had sellers whose social class was identified. Thirty-seven (39%) of those individuals who sold their properties were members of the elite as signified by their honorific title of "Don" or "Doña" preceding their names, while 61% of those cases had individuals who had no titles and, thus, were common people.

Ninety-six percent of all recorded land transactions indicated the owner or buyer of the concerned property. There were 77 cases wherein the purchasers or owners of agricultural lands were members of the elite; this translates to roughly seven out of every ten dealings (71%). Only 29% of recorded buyers or possessors of agricultural lands, such as Manuel Gallegos (Terrenos de Albay, 266-70) and Apolinario Bruncano (Protocolos de Albay SDS-21302) were untitled individuals.

The data, while not conclusive, show a trend purchasers and possessors of farmlands were likely to be upper class individuals and those who put up their parcels for sale tended to be people from the lower classes. For the years 1864 and 1870, 6 out of every 10 landholders were titled individuals. By the years 1880, 1890, and 1895, 82% of all owners of agricultural properties that were notarized were upper class individuals. When a common person sold his properties, in only one out of every three dealings (32%) would it involve a buyer without a title. Conversely, 2/3 (68%) of the time, such a transaction would involve a purchaser of property from the upper class.

How about the proportion of acquirers of land coming from the upper class? In 1864, five of 13 land-related notarial records (38%) were persons who carried honorific titles. By 1870, this increases to 76% or more than three out of every four land contracts. In the 13 gathered records from 1890 and 1895, 11 or 85% of the buyers or individuals who formalized their ownership of farmlands were all Dons. This included Don Benito Onandia (Protocolos de Albay Bundle 1032-A, and Don Mariano Mape (Protocolos de Albay SDS-21416). The data, while not conclusive, proffers a trend wherein the rich are slowly consolidating ownership of agricultural lands. Thus, the data, however crude, reveals a possible manifestation of elite capture of a particular resource.

Gender

Of 89 land sales, in only 12 of those cases (14%) were the seller of the property a woman. These include Francisca Feliciano in 1864 (Terrenos de Albay 1864), an india named Marzaria Duran in 1870 (Protocolos de Albay SDS-21194), and Doña Maria Quinal in 1887 (Protocolos de Albay SDS-21302). A female, however, tended to be less likely to buy land as only Basilia Borjal (Terrenos de Albay 1864), Milatra Imperial and Martina Canco (Protocolos de Albay SDS-21302) were recorded as acquirers of land (3% of all land sales). The data demonstrates that women were three times more likely to be a seller than a buyer of land. Moreover, a woman was rarely an owner of agricultural land as females were involved in only 16% of all agricultural property contracts.

Occupation and Race

It is unfortunate that the land transactions that were examined did not yield much information regarding the occupations and races of the individuals involved. Out of the 113 documents that wherein notes were taken, we only have information on the livelihoods of only six sellers and three buyers. Of the six persons who sold their land parcels, five were farmers. Juan Rico and Tomas Lindio were growers based in Ligao who sold their abaca lands to a fellow agriculturalist named Don Mariano Mape in 1890 (Protocolos de Albay SDS-21416). Five years later, a 70-year-

old farmer named Don Juan Vegerano may have been too old to manage his more than 70-hectare abaca land (abacales) when he decided to sell the said property to another fellow cultivator named Don Jaime Serra (Protocolos de Albay SDS-21416). The only exception among the sellers was a woman named Arcadia Garcia of Libog (present-day Sto. Domingo) who sold three and a half hectares of abaca land to a businessman (negociante) named Don Martin Contabitarte in 1895. Ms. Garcia's occupation was listed as property-owner [proprietario] (Protocolos de Albay Bundle 1032-A).

The amount of recorded data with respect to the race of the persons involved in notarized land-related documents, while better than occupations, was also quite scant. Of the 17 people who sold or pawned their agricultural assets, 14 were indios or natives of the colony, two were Spaniards (Español), and one was of Chinese descent (Chino). On the other hand, out of 22 transactions that were notarized wherein the racial profile of the buyer or owner of the land concerned was noted, nine were Chinese, only five were indios, and two were Spaniards.

The documents that were examined indicate that sellers of land were likely to be natives of the Philippines, while their buyers belonged to groups that had more money such as the Chinese and the Spaniards. It should be noted that the significant number of Chinese doing business in a particular place served as a proxy indicator of the quality of the economy of a particular area (Casiño, 1976), and Albay province in the late 1800s was considered a prosperous first-class province. It was also noted by John Foreman, a British national who spent much time in the Philippines during the last decades of Spanish rule, that the Chinese were known to be active buyers of abaca lands (Foreman, 1905). The latter contention is reflected in purchases of abacales made by men such as Uy Toco, Tan Quico, and Martin Garcia in 1887 (Protocolos de Albay SDS-21302). Similar to Garcia, acquirers of agricultural land such as Sebastain Ynchausti (Terrenos de Manila 1864) and Eugenio Gonzales (Protocolos de Manila SDS-21302) were Christianized Chinese who already carried Hispanic names. This practice of using Christian names among the Chinese was likely an attempt by such migrants to adapt and integrate with their new lives in a new place.

The categorization of inhabitants of the Philippines based on race (i.e., Español, mestizo, Chino, Indio) is grounded on the legal code, jurisprudence, and methods of governance of the Spaniards in the Philippines (Larkin, 1972; Bankoff, 1996). Simply put, one's race determined one's rights and privileges in society (Madrid, 2021). Clearly, those of pure Spanish ancestry had more benefits, yet those Spaniards born in Spain were called Español peninsular and were considered of a higher class than those only born in the Philippines [Español Filipino or Insular] (Madrid, 2021). It is for this reason that Don Juan Marcella (Protocolos de Albay SDS-21416) and Juan Azada (Protocolos de Albay SDS-21515) were classified as Español, while it had to be made clear that Joaquin de Roco was merely an Español Filipino (Protocolos de Albay Bundle 963).

Notarized Land Transactions
Types of Land Dealings

The simplest and most direct land matter involved the legitimization of a person's ownership of a real property. This is undertaken when an individual notarizes several papers to stake his claim to a piece of land that is signed by a notary public. While such a document is not in any way a land title, a notarized record is one of the means by which an owner makes formal his hold over the said physical asset. There are five such documents that were uncovered, all of which were undertaken by men. In

1864, all such transactions involved the ownership of lands whose use was not clearly defined. Sebastian Ynchausti had a document stating that he had possession of two undefined plots of land, one of which was in the town of Cagsawa (Terrenos de Manila 1864), while Basilio and Eustaquio Barrameda made it known that they owned farmland in the pueblo of Bacacay (Terrenos de Manila 1864). Over time, such claims of landownership involved valuable abaca plots. In 1870, Guinobatan resident Juan Pasibio was the owner of 400 topones of abaca land that was valued at ₱1000 (Protocolos de Albay SDS-21194). Eladio Ognaga and Fermin Abuites also claimed possession of similar abaca fields in the towns of Malinao and Ligao, respectively, in 1895 (Protocolos de Albay Bundle 1032-A).

Another straightforward transaction was sale of agricultural land that involves a willing seller and an interested buyer. Such sales accounted for nearly four out

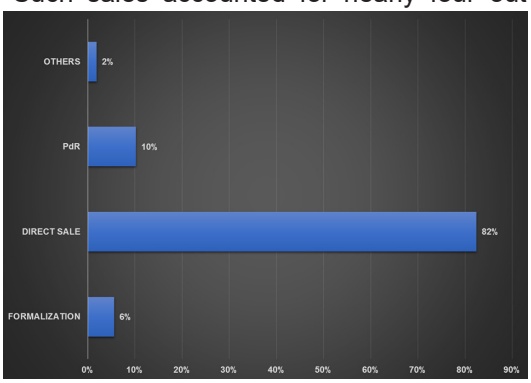

Fig. 3. Percentage share of methods of land ownership by type.

of every five (79%) dealings. For instance, in 1864, Raymundo Barquin agreed to give up his 1.4 hectares of abaca crop land to Calixto Bejarano for ₱27. There must have been some haggling involved as Bejarano also paid Barquin an unspecified amount of rice (Protocolos de Albay 1864). Sixteen years later, Don Tiburcio Lajata sold his abacal that was located in Sorsogon to Don Marcelino Jornaluz (Protocolos de Albay SDS-21302). Moreover, in 1890, Ciriaco Grajo sold his rice land that was situated in present-day Magallanes, Sorsogon to Don Aniceto Judit for ₱44.40.

These land sales underscore how agricultural parcels have become valuable commodities in the market. Their value as wealth-generating assets is further emphasized by an increasing number of individuals who bought multiple parcels as well as those who consolidated their ownership of land in a particular area. An example of an individual who actively acquired agricultural land was an indio named Don Eulalio Brotamonte. While he was a resident of Tabaco, in 1870 he purchased farmlands found in the nearby town of Malinao from Juana Cons, Anacleto Carullo, Matias Braus, as well as Lucio and Feliciano Cerrano (Protocolos de Albay SDS-21194). Ten years later, Mr. Brotamonte again acquired land in Malinao from Florencio Teocson, who was an absentee landowner as he was based in the province of Camarines Sur (Protocolos de Albay SDS-21302). Malinao seemed to have been a preferred area for the purchase of agricultural lands as Don Gaspar Palomar also bought developed farmlands from Ciriaco Celestial and Mariano Casalla (Protocolos de Albay SDS-21194).

Another example of a person who acquired so much land in a short time was Don Antonio Muñoz. In 1887, Muñoz was able to purchase 10 parcels from both upper class and untitled individuals. These properties were composed mainly of abaca lands as well as a few plots that were planted to rice and coconuts (Protocolos de Albay Bundle 1000-A).

Interested individuals in the 1800s had another way to acquire agricultural land. This was to loan money at exorbitant rates to individuals who used their agricultural lands as collateral. The term used for this means of acquisition is deuda con hipoteca or “debt with mortgage” (Bauzon, 1974). Also called pacto de retroventa, this practice

emerged in prosperous agricultural towns in the middle 1700s, wherein failure of the mortgaged to buy back the collateralized property mean the money lender got to formally own the land in question (Corpuz, 1997; Larkin, 1972).

Nearly one out of every 10 notarized land dealings (9.2%) involved an individual mortgaging his or her property in exchange for money. Mortgaged properties included rice lands, a house and lot, an abaca late, and coconut lands. There were agreements involved a "guarantor" and an individual who "entrusts" his properties to the guarantor, who was commonly a person of means. Interestingly, in some cases, no amount of money loaned was stated, and there was no stipulation for the recovery of these properties.

On the 9th of January 1873, in Legaspi, Don Marcelo Aguilar became the guarantor of an abaca land, a rice field, a house made of nipa, and a small plot of land planted with sugarcane and coconut. These properties were once owned by Don Juan Calleja (Protocolos de Albay Bundle 932-A). In that same month, Leon Cariñaga of Ligao "entrusted" his small reed house and a plot planted with abaca to Don Isidro Requilme (Protocolos de Albay Bundle 932-A).

Other pacto de retroventa transactions dispensed with such "niceties" and were simply straightforward transactions wherein one pawned his assets to a money lender for a specific amount, with the former having the option to buy back what he has mortgaged over a specific time frame. Bacacay resident Braulia Basalla pawned 2 pisosones (2.8 has) of land planted to abaca and coconuts to Fabian Barrameda for ₱32 in 1864. Ms. Basalla had two years to repay her debt after which she forfeits her farmland. That same year, Don Mariano Lazaro loaned ₱35 to Manuela de los Santos. In exchange, Mariano got hold of the title of Manuela's agricultural parcel in Ligao; she had four years to buy back her land (Protocolos de Albay, Bundle 932-A).

A woman named Doña Eulalia Vicentura, in fact, acquired more than one piece of cultivated property by giving out loans. A daughter of the province's inspector of roads, Ms. Vicentura acquire the plots of Don Mariano Buenafe and Acordia Borlagdan in Tabaco for a combined amount of ₱110 (Protocolos de Albay, 932-A).

Pacto de retroventa transactions reveal what Albayenos would consider to be items of economic or monetary value in their society. In the Memorias de Manila, an 1892 document that served as a de facto socioeconomic profile of the towns of Manila Province, livestock were considered as valuable agricultural assets that were of significant economic value. Water buffaloes or carabaos in Manila was valued anywhere between ₱20-40 (Memorias de Manila 1892). It is, thus, not surprising that in 1870 in Pandan, Catanduanes, there were three instances wherein carabaos and different types of cows were used as collateral along with cultivated lands. Agaton de la Rosa, Vicente Angeles, Casimiro Ylanan, Maximo Rivero, and an individual who was only known by his surname Sanches mortgaged a combined 26.6 hectares of land along with 4 cows, 16 carabaos, 3 calves, and a 2 turnera or cows that are ideal for fattening (Protocolos de Albay 1870 SDS-21194).

There was even a case wherein two men used their lands as collateral in Guinobatan in order to pay for storage fees. Ignacio Ofiendo and Don Maximo Lodia decided to mortgage three of their abaca lands to a Spaniard named Joaquin de Roco to pay for the right to store abaca in the space provided for by the latter (Protocolos de Albay Bundle 963). It can be assumed that the two men were confident enough that once they were able to sell their abaca hemp, they could easily pay the unspecified amount that they owed Don Joaquin. In addition, the fact that the two men mortgaged their properties under the assumption that they could earn

more money after all their transactions are done and over with reflects a group of people's deep understanding of how land capital can be used in various ways to produce even more money.

Land can also be disposed of and acquired by people through inheritance. Last wills and testaments were used by individuals, especially women, as a means of ensuring that their loved ones are well-provided for once they are gone. In such documents real property was a resource that was considered very important forms of inheritance (Lagman, 2020). In her will that was notarized in 1890, one of the assets that Doña Marcia Rita left behind to an unknown individual was a plot of abaca in the town of Cagsawa that was roughly a hectare in size (Protocolos de Albay SDS-21416).

Aspects Pertaining to Land Measures and Sizes

Modern states, by their very nature, strive to control, monitor, and make legible their territories, resources, and subjects. Its officials and institutions attain this by making uniform and standardized how different important elements and aspects of people's lives are weighed, measured, registered, and organized (Scott, 1998). It is for this reason why lands that were owned, acquired, used, and disposed of in Albay during the last decades of Spanish rule were subject to measures. Unfortunately, however, the systems of weights as well as liquid and linear measures in the Philippine provinces during the Spanish period were made up of a variety of local measures that were of native, Asian, and Spanish origin. While some could be converted to linear measures, this was not possible for some (Census, 1905).

The land measures used for agricultural lands in Albay initially employed both local and Spanish measures that mirrors the disorganized nature of Spanish rule that can also be observed in the different types of currency that they allowed to circulate and facilitate economic transactions in the Philippines (Bankoff, 1996). Such gauges included the pisoson, topon, and the braza de circunferencia.

The pisoson, which is equivalent to 1.4 hectares (Census of the Philippine Islands), was a land measure reflective of the changing outlook of the Albayenos towards land and their reaction to certain peculiarities in their landscape's physical geography. This measure took its name from the Mexican peso, the main means of exchanging goods at that time. Like the peso, which was equivalent to eight reales (Barrows, 1905), a pisoson of land could be subdivided into eight equal parts called the real. This reveals that by the nineteenth century land was an economic resource that had monetary value in Albay.

Just as important, the pisoson was closely associated to Albay province's main export – the abaca. Foreman (1905) noted that the pisoson was a local land measure of Albay usually associated with abaca plantations. A land area of this size could fit 2,500 abaca plants. Mallat (1983) adds that this measure was rather irregular due to the upland terrain where abaca was cultivated. This explains why most land contracts that used pisoson as a measure qualifies the size of the land with the phrase "more or less".

Ten notarized documents that were examined involved individuals who agreed to purchase several reales or pisosones of land, mostly abacales. Don Laurente de la Peña acquired 4 pisosones or 5.6 hectares of farmland from Francisca Raymundo that was located in an undetermined part of Albay (Terrenos de Albay 1864). Acordia Borlagdan mortgaged 8 pisosones (11.2 hectares) in the uplands of Tabaco to Eulalia Vicentura in exchange for a debt worth P75 (Terrenos de Albay 1864), while 4 reales or 7,000 square meters of farmland was sold to Eulalio Brotamonte for ₱34 in 1870

(Protocolos de Albay SDS-21194).

From notarized records from 1864 and 1870, there were nine agricultural lots with areas that were measured in topones, a local measure of which one unit in Albay was equal to 43 square meters (Census, 1905). Real properties whose extents were calculated through such measures were not very extensive, a feature of land parcels that were observed by the historian Norman Owen (1984) in the documents that he reviewed for Spanish era Bicol. With the exception of Don Tomas Gallego's 5,780 topones (24.85 hectares) of land planted to abaca and coconuts (Protocolos de Albay SDS-21194), lands whose extents were determined through such measures did not exceed 5 hectares. The 100 topones of land acquired by Mariano Lazaro through pacto de retroventa was only 4300 square meters or .43 hectare, while three abacales owned by Juan Pasibio, Pascual Tagalog, and Antonio Perete all had an area of 400 topones or a mere 1.72 hectares (Protocolos de Albay SDS-21194).

Local measures used in determining the areal extent of lands in Albay could be converted to the metric system (hectares). Unfortunately, one form of land measure, the braza de circunferencia (BdC), seems to not have a clear conversion. There were six land sales from 1864 to 1880 that computed the size of lands sold in terms of BdC, and their purchase price ranged from ₱40 to P121. The smallest of these was an uncultivated land parcel in Oas measuring 200 BdC that was owned by Fernando Refraceson and sold to Don Gaspar Ricafuente in 1870. The biggest was a 575 BdC of land planted to 157 coconuts in Malinao bought by Gaspar Palomar from Mariano Casalla on that same year (Protocolos de Albay SDS-21194). The most expensive land purchase using the said measure was bought in 1864 by a woman named Doña Basilia Borjal. The land that she acquired in an undetermined place in the province had an area of 436 BdC and was clearly located in the steep uplands as the parcel was said to be located in some sort of cavity. Ms. Borjal spent ₱121 for the said property (Terrenos de Albay).

By the 1890s the Spanish government enacted policies that would standardize the measurement of lands. One of these was the Royal Decree of 13 August 1898. This ruling stated that the market value of land prices should be based on the average value of all lands sold per hectare in each province during the last five years. Land sales should also be conducted in cash (Ahern and Basa, 1901).

This explains why the notarial records of the Protocolos Albay for as early as 1890 had land measures in hectares and its corresponding subdivision of ares and centiares, which are equal to 100 and 1 square meter, respectively (Department of Agriculture Region 5 undated). In 1890, Don Jose Sarte became the new owner of an abaca land that had a land area of 71 hectareas, 81 areas and 25 centiaraes or 7.8125 hectares that was sited in Ligao. On that same year, 3 pisosones of land planted to abaca and coconuts or a land area of 4 hectareas, 19 areas, and 23 centiareas (4.19 hectares) was mortgaged by a farmer named Saturnino Nones for ₱100 (Protocolos de Albay SDS-21515). Five years later, an abacales owned by Benito Onandia was accurately measured as having a definite land area of 2.09 hectares. It sold for ₱70. (Protocolos de Albay 1032-A).

The standardization of land measurements and the approximation of land sizes from hectares up to one square meter not only indicate exactness of measures. It also implies that land became so valuable that accuracy was now required in measuring properties. This increasing prudence in measures was also reflected in the practice in agricultural towns like San Ildefonso, Bulacan in the late 1990s where farmlands were being purchased by the square meter instead of in hectares.

Moreover, increasing accuracy in measuring land also implied that the Spanish colonial bureaucracy of the late nineteenth century now had enough personnel, like surveyors, notaries, and registrars of lands, to do such tasks (Owen, 1984).

Landowners in Albay eventually adhered to metric measures. For some Albayenos, however, the pisoson remained as the preferred land measure even after the implementation of the 1895 provision. In fact, majority of the landholdings confiscated by revolutionary forces in Albay in 1899 had land measures that were still in units of pisoson (Philippine Insurgent Records Albay).

Land Sizes

The historian Norman Owen noted that landholdings in the Bicol settlements were not as extensive compared to their cash crop growing counterparts in other provinces in the Philippines (Owen, 1984). While the data collected for this research is by no means complete, the crude calculations that were generated from such information seems to support Owen's assertion. Almost of six out of every 10 transactions (57%) where the land area of the property being sold or possessed is provided have farmlands whose size do not exceed two hectares. In fact, almost three out of every 10 land dealings concern real properties that do not even reach a hectare in area. Only 9% of these purchased, owned, or mortgaged assets are between to two to five hectares, while only 14% of transactions deal with cultivated or farmable land that is between 5 to 10 hectares. There were four parcels who areas were within the 11-to-25-hectare range (9%), while there were only three properties (9%) that were more than or equal to 56 hectares.

The sizes of land being sold, irrespective of land use, seems to reflect an increasing trend over time. For the year 1864, lands in notarized documents had an average size of 2.59 hectares. This increases to an average of 4.72 hectares by the years 1870 and 1873. By 1880, 1890, and 1895, however, the average size of agricultural properties whose documents were notarized shoots up to 22 hectares. However, it should be noted that the samples used are too small, and three properties that had land areas of 23.85, 73.3, and 101.78 hectares, respectively, clearly skewed the average

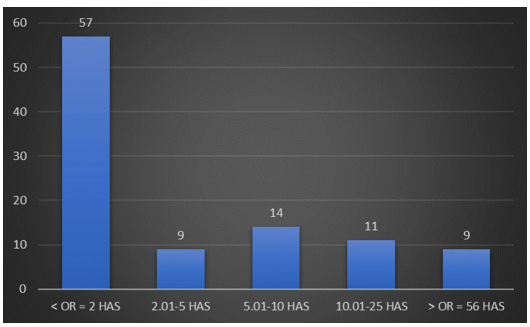

Fig. 4. Percentage of land sizes by range.

size of parcels sold or owned for those years. Without those three properties, the average hectarage would go down to 8.72 hectares. If the biggest land sizes for 1864 and 1870-1873 were also removed, the average land sizes would also be reduced to 1.52 hectares and 2.24 hectares, respectively. Yet even when such agricultural properties with unusually large land sizes were not included, land parcels over the years clearly reflect an upward trend in average area.

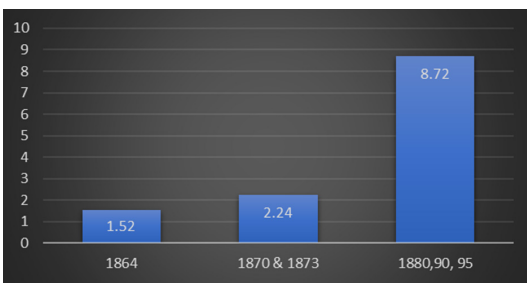

Fig. 5. Average land size in hectares of cultivable lands in selected years.

Land Values

The usual price of agricultural land by hectare also demonstrates and upward trend. In 1864, the average value of a hectare of cultivated/cultivable parcel had an average price of ₱15.25. This nearly triples in value to ₱45.5 per hectare by the years 1870 and 1873. By the last decades of the nineteenth century, a hectare of agricultural property could be had for an average of ₱70. The comparison of these land values upholds the common notion that land becomes more expensive over time and rarely decreases in value. Increases in land prices also show that land had become an item of speculation. For this reason, the Spanish colonial administration eventually enacted provisions that places a standard market price for land per province based on the average price of all the land sales made in a particular province within a time span of five years (Ahern and Basa 1901).

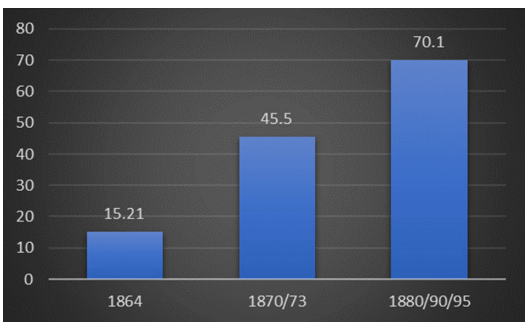

Fig. 6. Land values in Pesos/Hectare over the decades in nineteenth century Albay.

Agricultural Land Utilization

The use of agricultural land in Albay in the 19th century could be divided into three categories – for export, local consumption, and mixed-use. Abaca lands make up the export category, while lands planted rice, coconut, and bamboo were landholdings that produced commodities for domestic purposes. Mixed-use plots were a combination of export and local consumption.

Of the three classes, abaca lands, whose harvested hemp was used as ropes in navies and merchant shipping companies all over the world (Owen, 1984), was the most widely traded land type as it provided the most profit. At some point, the cultivation of abaca became so profitable that owning a plantation in the "declivities of the mountains" and "volcanic soil" (Gironiere, 1962) could yield an annual return of investment around 25-30% (Atkinson, 1905,). Incidentally, in the first three months of the year 1887, 20 land transactions involved abaca lands and another five had a mixed land use that had abaca as one of the indicated crops. This number was based on the 33 recorded land transactions that contained a particular land use. Purchased abaca lands include those acquired by Don Antonio Muñoz from Estevan Nievez, Marcelo Pelayo, Clara Arnife, and Victoria Nievez, while a Chinese native who used the Hispanized name Martin Garcia purchased three out of the five lands planted to both abaca and coconut that were the subject of notarized documents from January to March of 1887 (Protocolos de Albay Bundle 1000-A).

Among the croplands utilized for local consumption, rice lands were the most dominant form of use in this category. What is very important to note with rice lands was that most of its owners and buyers were members of the elite. Such plots offered not only potential food security but political influence in society as well. Unlike abaca lands, plots planted to rice, required more personnel and constant contact between landlord and tenant. This kind of relationship easily becomes a source of political patronage and social capital in the community (Owen, 1984). On the other hand, coconut lands were rarely identified in the course of the study.

Most farms that were mixed-use contained abaca plants and coconut trees. There are probably two reasons why these two crops were planted together. One is that abaca plants require shade which

coconuts could easily provide (Owen, 1984). Another possible explanation for this kind of combined land use is that while the owner earns a significant amount of money from abaca, coconut tress provided for the everyday needs of the Bicolano like coconut milk, oil, and toddy.

CONCLUSIONS

During the late 1700s, Bicolandia was so poor that its inhabitants could barely but tobacco from the monopoly stores. A native elite was even quoted to have said that the money families saved for generations were squandered to buy tobacco. Such contention reflected the reality that the region's inhabitants lacked revenues that could earn them income to sustain their needs (De Jesus, 1980).

This gloomy description of Albay soon changed when abaca became a prime export item in the world market. The province, reportedly the best place to cultivate abaca (Marche, 1970), benefitted from its export earnings and eventually developed a monetized economy. Such an economy in Albay is reflected in documents that reveal the increasing acquisition and ownership of agricultural lands, the money spent to pay for them, the different means by which such wealth-producing parcels were purchased, the increasing values of farm properties over the years, and even by how lands were measured (pisoson = 8 reales = Peso). Sadly, the records of those who owned, bought, and sold lands reflect a sad reality in Albay society wherein upper-class males increasingly consolidated land resources at the expense of those from humbler backgrounds. From these records, the people who were part of centuries old records cease to become mere statistics and their stories relate to present realities in Philippine society.

The documents also reveal aspects and patterns in the culture and way of life of the people of Albay. These land transactions illustrate the growing legalism of these people (i.e., existence and recognition of land contracts), as well as their ability to respond to peculiar features of their environment (i.e., the pisoson as a unique land measure). The measuring of agricultural parcels using a variety of local and Hispanic gauges highlights the localized nature of land transactions and the lack of uniformity, accuracy, and central government control in determining the metes and bounds of properties, which only began to be addressed in the last years of Spanish rule. Land-related legal documents in Albay from 1864 to 1895 also corroborate the assertion that real properties in the said province were not as extensive as those in other provinces, and how Albayenos used, acquired, and cultivated lands to produce more wealth like abaca or mainly address their subsistence needs such as coconuts and rice.

REFERENCES

Ahern, G. and Basa, G. 1901. Spanish Land Laws in the Philippines and their History to August 17, 1898. Washington, D.C.: Government Printing Office. 61p.

Atkinson, F. W. 1905. The Philippine Islands. Boston: Ginn and Company. 426p.

Bankoff, G. 1996. Crime, Society, and the State in the Nineteenth Century Philippines. Quezon City: Ateneo de Manila University Press. 251p.

Barrows, D.P. 1905. A History of the Philippines. New York: American Book Company. 332p.

Bauzon, L.E. 1974. "Rural History, Land Tenure and the Negros Hacienda Complex: Some Preloiminary Notes. PSSC Social Science Information 4-7, 21 and 23.

Benitez, C.S. 1916. The Old Philippines' Industrial Development. In Philippine Progress Prior to 1898. Manila: Philippine Education Company, Inc. A. Craig, and C. S. Benitez. Editors. pp. 1-78.

Burke, P. 2002. New Perspectives in Historical Writing, 2nd Edition. Cambridge: Polity Press. 254p.

Camagay, M.L. 1995. Working Women of Manila in the 19th Century. Quezon City: University of the Philippines Press and Center for Women's Studies. 197p.

Casino, E. 1976. The Jama Mapun: A Changing Samal Society in the Southern Philippines. Quezon City: Ateneo de Manila University Press. 159p.

Census, U.S. 1905. Census of the Philippine islands, taken under the direction of the Philippine Commission in the Year 1903. Wahington, D.C.: Bureau of Printing. 700p.

Corpuz, O.D. 1965. The Philippines. New Jersey: Prentice Hall. 149p.

Corpuz, O.D. 1997. An Economic History of the Philippines. Quezon City: University of the Philippines Press. 312p.

Cushner, N.P. 1971. Spain in the Philippines: From Conquest to Revolution. Quezon City: Institute of Philippine Culture. 272p

De Jesus, E.C. 1980. The Tobacco Monopoly in the Philippines: Bureaucratic Enterprise and Social Change, 1766-1880. Quezon City: Ateneo de Manila University Press. 228p.

Department of Agriculture Region 5. Undated. Bicol Agricultural Profile. Pili, Camarines Sur: Department of Agriculture Region 5.

Foreman, J. 1905. The Philippines, 3rd Edition. London: T. Fisher and Unwin. 668p.

Gironiere, P.P. 1962. Twenty Years in the Philippines. Manila: Filipiniana Book Guild. 371p.

Huetz de Lemps, X. 1998. Materiales ligeros vs. materiales fuertes : the conflict between nipa huts and stone buildings in nineteenth century Manila. In The Philippine Revolution and Beyond: International Conference on the Centennial of the 1896 Philippine Revolution. Manila: Philippine Centennial Commission. E. A. Ordonez. Editor. pp. 160-172.

Lagman, M.S. 2020. Property Owners, Workers, and Public Women: Stories and Geographies of the Late Nineteenth Century Manilena, 1860-1896. Murdoch University: Unpublished Dissertation. 705p.

Larkin, J.A. 1972. The Pampangans: Colonial Society in a Philippine Province. Berkeley: University of California Press. 340p.

Lynch, O.J. 1988. Land Rights, Land Laws, and Usurpation: The Spanish Era, 1565-1898. The Philippine Law Journal 63, 82-11.

Madrid, C. 2021, May 19. Peninsulares. Retrieved from Guampedia: https://www.guampedia.com/peninsulares/ Date Accessed: August 21, 2021.

Mallat, J. 1983. The Philippines: History, Geography, Customs, Agriculture,

and Commerce of the Spanish Colonies in Oceania. Manila: National Historical Institute. 528p.

Marche, A. 1970. Luzon and Palawan. Manila: Filipiniana Book Guild. 296p.

Memorias de Manila, 1892. National Archives of the Philippines. Electronic File. Manila

Owen, N. 1984. Prosperity Without Progress: Manila Hemp and Material Life in the Colonial Philippines. Berkeley: University of California Press. 311p.

Philippine Insurgent Records Albay. National Archives of the Philippines. Manila

Protocolos de Albay. National Archives of the Philippines. SDS-21194 (1870). Manila.

Protocolos de Albay. National Archives of the Philippines. Bundle 932-A (1873). Manila.

Protocolos de Albay. National Archives of the Philippines. SDS-21302 (1880). Manila

Protocolos de Albay. National Archives of the Philippines. Bundle 1000-A (1887). Manila.

Protocolos de Albay. National Archives of the Philippines. SDS-21416 (1890). Manila.

Protocolos de Albay. National Archives of the Philippines. Bundle 1032-A (1895). Manila.

Rodriguez, F.I. 1998. Land and the Philippine Revolution: An Ecologist's Perspective. In The Philippine Revolution and Beyond: Papers from the International Conference on the Centennial of the 1896 Philippine Revolution. Manila: Philippine Centennial Commission. E.A. Ordonez. Editor, pp. 197-214.

Scott, J.C. 1998. Seeing Like a State: How Certain Schemes to Improve the Human Condition Have Failed. New Haven: Yale University Press. 445p.

Serote, E.M. 2004. Property, Patrimony, and Territory: Foundations of Land Use Planning in the Philippines. Quezon City: University of the Philippines Press. 463p.

Sharpe, J. 1991. History from Below . In New Perspectives in Historical Writing. Oxford: Polity Press. P.. Burke. Editor. pp. 24-41 .

Terrenos de Albay. National Archives of the Philippines. Manila

Warren, J.F. 2000. "The Lives of Ah-Ku and Karayuki-San in Singapore: Sources, Method, and the Historian's Representation. In Researching the Fragments: Histories of Women in the Asian Context. Quezon City: New Day Publishers.C. Brewer and A. Metcalf. Editors. pp. 87-102.

Warren, J.F. 2003. Ah Ku and Karayuki-San: Prostitution in Singapore. Singapore: Singapore University Press. 433p.

Zunz, O. 1985. Reliving the Past: The Worlds of Social History. Chapel Hill: University of North Carolina Press. 346p.

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CAPACITY STRENGTHENING OF RURAL WOMEN TOWARDS SCHOOL-GOING CHILDREN'S NUTRITION: A CASE FROM BANGLADESH

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Abstract — The study investigated the need for capacity strengthening of rural women towards nutrition management of school-going children, conducted in four villages purposively selected from Lama upazila under Bandarban district of Bangladesh. A total of 110 households were selected with data collected from the women of those households through face-to-face setting using pretested interview schedule. Measurement for the need for women's capacity strengthening used 21 issues under four broad dimensions such as 'need for decision-making ability', 'need for support services', need for managerial skill' and 'need for physical facilities' were formulated. A four-point rating scale with the responses like 'no', 'low', 'medium' and 'high' was administered with their corresponding scores such as 0, 1, 2 and 3, respectively. Pearson's product moment correlation coefficient (r) was computed to explore the relationships between selected characteristics of the respondents and their extent of need for capacity strengthening. The findings indicated that for all the four dimensions, the highest proportion of respondents were noticed with medium to high level of need for capacity strengthening towards maintaining school-going children's nutrition. Among the dimensions, the highest percentage of respondents (64.44%) was reported with the issues related to the dimension of need for decision-making ability. Correlation analysis indicated that respondents' year of schooling, annual family income, training exposure and household dietary diversity had significant positive relationships with their extent of need for capacity strengthening. It deems necessary to undertake and follow up women focused development initiatives in study areas through better access to resources, inputs and services so that the women folks can play their greater role in maintaining household nutrition for household in general and for school-going children in particular.

Keywords **— Bangladesh, capacity strengthening need, nutrition, rural women, school-going children**

INTRODUCTION

Nutrition is an important determinant of good health and active life. Food is the main source of good nutrition and people eat food to supply us with substances that are referred to as nutrients. Nutritional value or nutritive value as part of food quality is the measure of a well-balanced ratio of the essential nutrients- carbohydrates, fat, protein, minerals, and vitamins in items of food or diet in relation to the nutrient requirements of their consumers. In Bangladesh, rural women breastfeed the newborn babies, prepare meals for members of theirfamily and their extensive professional involvement in food manufacturing, trade, public catering, health care and education are commendable (World Bank, 2007).

Women's nutritional knowledge have a great impact on the health of their children and, therefore, of the future generation. Lack of nutritional knowledge is one of the most important reasons of nutritional problems and consequently improper practice which can lead to several complications of women. All these they do in the face of constrain and attitudes that conspire to undervalue of their work. This discrimination hampers on food security as well as nutritional security (Islam, 2019).

Many children around the world, especially those from low-income families, start their school as stunted, underweight or suffering from multiple micronutrients deficiencies. At the same time, nutrition and diet-related problems are also highly prevalent in middle- and high-income countries. Indeed, all countries suffer from at least one form of malnutrition (IFPRI, 2017). Increasingly, children are suffering from several forms of malnutrition, ranging from undernourishment to excessive weight or obesity, with both extremes often occurring in combination with micronutrient deficiencies. Schools provide an opportunity to prevent and manage these various forms of malnutrition and contribute to improving educational outcomes. Students who have participated in school nutrition activities can further act as influencers, with a particular impact on their families and younger siblings, potentially reducing the number of children starting school already malnourished (UNSCN, 2017).

The nutrition experts echoed that a large number of Bangladeshi children and mothers suffer from malnutrition, which is affecting the national development (Ahmed et al., 2012). Women and children suffer from stunting, thinness, underweight, obesity, low-birth weight, micronutrient deficiency and other snags. The main reasons for this poor situation are poverty, inadequate intake of nutritious food and lack of access to diverse foods (FRAC, 2017). Poor nutrition starts before birth, and generally continues into adolescence and adult life and can span generations. Chronically malnourished girls are more likely to remain undernourished during adolescence and adulthood, and when pregnant, are more likely to deliver low birth-weight babies (WHO, 2006). Nutritional status is an important index for measuring quality of life especially in children.

In Bangladesh, most of the people are still undernourished, especially in case of school- going children's it is seen in large scale, where women have been found to control their households nutritional status through food preparation, processing of food products and through daily use of the available resources for maintaining school going children's nutrition. Additionally, the rural women also actively help in producing vegetables and other crops in homestead and field. Eventually, they are directly assisting in supplying nutritious food in the households. The case is especially significant in the mountainous region where the study was conducted. This area was inhabited mostly by the tribal people and their women usually take part in most of the household and field activities including farming. So, the involvement in and role played by the rural women of mountainous region towards

maintaining household nutrition is of special implication. Analyzing the issues from these rural women's perspectives, the study was particularly designed to find out the need for capacity strengthening of rural women in maintainingschool-going children's nutrition and to explore the relationship between the selected characteristic of rural women and their need for capacity strengthening in maintaining school-going children's nutrition.

Thus, the present study was carried out with the following specific objectives: 1) To find out the existing role played by rural women in maintaining school going-children's nutrition; 2) To assess the need for capacity strengthening of rural women in maintainingschool-going children's nutrition; and 3) To explore relationship of the need for capacity strengthening of rural women in maintaining school-going children's nutrition and their selected personal characteristics.

MATERIALS AND METHODS

Study Area

This study was conducted in four in four villages purposively selected from four unions namely, Aziznagar, Fasyakhali, Rupshipara, and Sarai under Lama Upazila of Bandarban district. In those unions, the Government of Bangladesh has been piloting school nutrition projects with support from FAO and other partners since the early 2000s, and began school feeding in 2011 based on the positive results and experiences of the World Food Programme (WFP) school feeding program. FAO and WFP agreed to implement this project as part of their broader collaboration on promoting nutrition-sensitive initiatives. The project focused on the institutionalization of a nutrition-sensitive school meal program in Bangladesh to ensure its sustainability, by building the capacities of relevant government institutions, local women growers, school teachers and School Management Committees (SMCs) of Lama Upazila, Bandarban District (FAO, 2021).

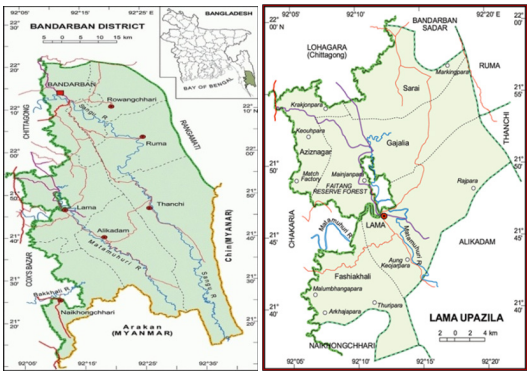

Fig. 1. Map of Bangladesh showing the study areas.

Lama Upazila consists of one municipality, seven Unions Parishads, 18 Mauzas and 247 villages. Lama had a population of 64,717, of whom 33,732 were aged 18 or older. Males constituted 53.94% of the population, and females 46.06%. Lama had an average literacy rate of 21.1% (7+ years), against the national average of 32.4%. The main source of income is agriculture which is 62.18% of the total household income.

Sampling, Data Collection and Analysis

An updated list of all the women was collected from the WFO and 300 selected households of the villages. A total of 110 households with at least one school-going child in each household) were selected purposively from those four villages constituted the sample for this study. Data were collected through personal interview using a pre-structured interview schedule. An interview schedule was carefully prepared in English, keeping in mind the objectives of the research. Appropriate scales were developed to operationalize the dependent and independent variables of the study. A draft interview schedule was pre-tested with 10 farmers from the study area that facilitated the researcher to identify

faulty questions and statements in the draft schedule. On the basis of pretest results and aswers of the respondents necessary corrections, alternations, additions, and modifications were done in the interview schedule.

Five dimensions were selected. Each of the dimensions had 5 statements obtained from the FGD. A four-point rating scale was used to measure the role of focus variable. Possible responses were high, medium, low and no with the corresponding scores of 3, 2, 1, and 0 respectively. The innovation capacity of the farmers was computed by adding all the scores obtained from each of the dimension of innovativeness from which respondents will be benefitted. Hence, the scale score ranged from 0 to 15 for each dimension, where 0 indicates no innovation capacity and 15 indicates high innovation capacity of the farmers for adoption of farm machinery. Ranking of the statements was done to prioritize the statements where informal education, interest towards machineries, social networking, good physical health and income were number one for each dimension respectively.

Need for Capacity Strengthening of Rural Women towards Maintaining School-going Children's Nutrition

Need for capacity strengthening of rural women towards school- going children's nutrition was the main focus of the study. Capacity development is the process of strengthening the abilities of individuals, organizations and societies to make effective use of the resources in order to achieve their own goals on a sustainable basis (UNDP, 2009). To measure need for capacity strengthening of rural women regarding post- harvest activities for selected fruits and vegetables, Rahman and Begum (2009) - suggested five aspects viz. a) need for financial ability, b) need for decision making ability, c) need for access to support services, d) need for management skill, and e) need for physical facilities. Ahmed (2007), Sharmin (2008) and Gazi (2009) also reported similar aspects in measuring capacity strengthening of rural women in their respective studies. By analyzing these earlier studies, the researcher selected four broad dimensions of capacity strengthening towards maintaining school going children's nutrition. These were:

1. Need for decision making ability
   - Identification of nutritious food
   - Selection of nutritious food
   - Processing of nutritious food
   - Buying of food for consumption
   - Distribution of food and nutrition
   - Preservation of food and nutrition
2. Need for access to support services
   - Credit facilities
   - Motivational video about nutrients
   - Awareness program nutrition
   - Information about nutritious food
   - Development workers for advice
3. Need for management skill
   - Knowledge on nutritional value
   - Operational ability
   - Time allocation for cooking
   - Allocation of nutritious food items
   - Nutritious food serving
4. Need for physical facilities
   - Preservation facilities
   - Processing equipment
   - Uninterrupted supply of electricity
   - Storage facilities
   - Water and sanitation facilities

Thus, a total of 21 issues were selected emphasizing the four broad dimensions of need for capacity strengthening of women. All the issues under each of the dimensions were measured on a four-point rating scale. Scores were assigned as 0, 1, 2 and 3 for the responses like 'no, 'low', 'medium' and 'high' need, respectively. The scores of all issues of each dimension are added to obtain the total score of a single dimension. The scores of all the four dimensionsformed the total score of their need for capacity strengthening of rural women who could

vary from 0 to 63, where 0 indicates no need and 63 indicates high level of need. In addition, for making the rank order of each issue of four broad dimensions, the responses were multiplied with the total number of respondents (110) and thus, the total score of an issue in rank order could range from 0 to 330.

The coded data were put into the computer for statistical analyses. The SPSS computer program and MS Excel was used for analyzing the data. Pearson's product moment correlation co-efficient (r) was computed (Ray and Mandal, 2004) to explore the relationship between need for capacity strengthening of rural women and their selected characteristics towards maintaining school-going children's nutrition.

RESULTS AND DISCUSSION

Characteristics Profile of the Respondent Rural Women

There were various characteristics of the rural women that might influence their extent of need for capacity strengthening towards maintaining school going children's nutrition. In the present study, eleven personal characteristics of the rural women were selected which included age, year of schooling, household size, household farm size, annual family income, involvement in local associations training exposure, exposure of nutritional information and household dietary diversity. The salient features of the characteristics of the respondents are presented in Table 1.

Age of the respondents ranged from 20 to 50 years with a mean of 36.66 years and astandard deviation of 9.53 years. Based on their age, the women were classified into three categories as young (18-35), middle-aged (36-55) and old (>55).

Data presented in the Table 1 revealed that 52.7 percent of the respondents were young, 40.9 percent were middle-aged and 6.36 percent were found as old. Ahmed (2007), Hoque (2011), Kowsari (2014) and Nasrin (2015) found 68 percent, 50 percent, 54 percent and 51.2 percent as middle-aged respondents, respectively. It should be mentioned that women involved in household food utilization were mostly covered by the young and middle-aged women. This seems logical, because it is expected that the young and middle-aged women were more active, energetic and enthusiastic in performing their activities for ensuring effective household food utilization. It was observed from the research that most of the young women were very much enthusiastic to learn new things about capacity strengthening towards maintaining school going children's nutrition and to contribute more in these kinds of activities.

The level of education of the respondents ranged from 0 to 10 years of schooling having a mean of 4.41 years and a standard deviation of 3.25 years. On the basis of their level of education, the women were classified into four categories as illiterate (0), primary (1- 5), secondary (6-10) and higher secondary (>10) presented in Table 1. Farm size influences both access to technology adoption and increase innovation capacity towards farm machinery (Lashgarara et al., 2012). Table 1 also reveals that average farm size of the respondent farmers was 0.7 ha and average annual family income 73,000 BDT. As family income is the key factor in the process of innovation capacity and adoption of new farm machinery. It is imperative to take necessary decisions towards innovation and adoption capacity apply machinery to the farm (Wang et al., 2008).

About 71.4 percent of the women were literate. It was quite logical, because most of the respondents were young and middle-aged and education was generally correlated with age. So, most of the respondents were literate. It might help improve their knowledge on capacity strengthening

Table 1. Socioeconomic characteristics of the respondents.

Characteristics	Respondent Categories	No	%	Mean	SD*
Age (Years)	Young (18-35)	58	52.7	36.66	9.53
	Middle aged (36-55)	45	40.9		
	Old (> 55)	7	6.36		
Years of schooling (Years)	Illiterate (0)	31	28.2	4.41	3.25
	Primary (1-5)	42	38.2		
	Secondary (6-10)	36	32.7		
	Above secondary (>10)	1	0.9		
Household size (No. of farmers)	Small (2- 4)	37	36.6	5.22	1.64
	Medium (5-6)	65	59.1		
	Large (>7)	8	7.3		
Household farm size (ha)	Landless (0.002-0.02)	2	1.82	0.65	1.6
	Marginal (0.021-0.2)	39	35.44		
	Small (0.21-0.99)	53	48.2		
	Medium (1.0-3.0)	16	14.5		
	Large (>3.0)	0	0		
Annual family income ('000' Tk.)	Low (≤80)	52	47.3	98.73	54.39
	Medium (81-150)	45	40.9		
	High (>150)	13	11.8		
Involvement in local associations (Years)	No (0)	62	56.36	0.99	1.42
	Low (≤2)	39	35.45		
	Moderate (2-4)	6	5.45		
	High (>4)	3	2.74		
Training exposure (Days)	No (0)	35	31.8	1.2	1.45
	Short (1- 3)	59	53.64		
	Medium (4-7)	5	4.56		
	Long (>7)	11	10		
Exposure to nutritional information (Scale score)	No (0)	5	4.54	7.73	3.43
	Low (up to 10)	57	51.82		
	Moderate (11-20)	48	43.64		
	High (above 20)	0	0		

*SD = Standard Deviation; *BDT = Bangladeshi Taka

towards maintaining school going children's nutrition. Rahman and Begum (2009), Hoque (2011), and Nasrin (2015) found 50 percent, 34 percent, 40 percent and 30 percent of the respondents had secondary level of education in their respective studies. Education is one of the basic needs of human life. It helps individuals become conscious of their surroundings and develop logical insight into many affairs of daily life. It also broadens outlook of individuals and leads them to explore new ideas to overcome many unwanted situation. It is assumed that women having higher education are more progressive and innovative than those of illiterate. They could perform better in managing capacity strengthening towards maintaining school going children's nutrition and also could contribute many more than those who have less education.

The household size of the respondents ranged from 2 to 8 members, with a mean of 5.19 and a standard deviation of 1.7. On the basis of their household size, the respondents were classified into three categories as small (2-4), medium (5-6) and large (>7) as shown in Table 4.1. Similar categorizations were followed by Mandal (2011), Billah (2013), and Nasrin (2015). Result showed that among the respondents 36.6 had small sized, 59.1 percent had medium sized and 7.3 had large sized family. Data revealed that the most of the respondents (59.1 percent) had medium sized family. Islam (2019), Hoque (2011), and Nasrin (2015) found 53.33 percent, 53.85 percent, 56 percent and 48.8 percent respondents had medium sized household respectively. It should be mentioned that almost all of the respondents had small and medium sized family. Additional family related information of the respondent women were investigated and presented in Table 1. The table indicates that in average every family has one school going (pre-primary and primary) children. It is also shown that average number of non-school going children is very low in the study area. Thus, it is infers that the school going children's percentage is relatively higher in the study area. This is a common trend as large households are breaking down into small household. It is assumed that the respondents having small and medium household likely to play more contribution in capacity strengthening towards maintaining school going children's nutrition.

Farm size of the rural women's household was measured in terms of hectare. Farm size of the women ranged from 0.02 to 1 hectare, with a mean of 0.65 hectares and a standard deviation of 1.6 hectares. On the basis of their farm size, the respondents were classified into five categories following the classification

of DAE (1999) such as landless (<0.02), marginal (0.021-0.20) and small (0.21-1.0). Distribution of the respondents according to their farm size has been shown in Table 1. Data presented that the highest proportion of the rural women (48.2percent) had small farm size, 35.44 percent had marginal, 14.5 percent had medium and 1.82 percent were landless respectively and there were no large farm sized women in the study area. The findings indicated that majority (about 83.6 percent) of the women had marginal to small sized farm. Almost similar findings were found by Rahman and Begum (2009), Hossain (2013), and Nasrin (2015) in their respective studies. The findings indicated that most of the respondents had marginal household farm size. This is a general trend in Bangladesh that farm size of the people is being decreased day by day due to land fragmentation from generation to generation.

The family income of the respondents ranged from Tk. 15 to 375 thousand, with a mean of 98.73 thousand and a standard deviation of 54.39 thousand. On the basis of their annual family income, the respondents were classified into three categories such as low (≤80), medium (81-150) and high (>150) income. Distribution of the respondents according to their annual household income has been shown in Table 4.1. Data presented that the highest proportion of the rural women (47.3 percent) was in low income category, while 40.9 percent and 11.8 percent of them were in medium and high income category, respectively. Hossain (2013), Nasrin (2015) and Khalak (2016) found 75 percent, 52 percent, 70 percent and 53.3 percent medium annual household income respectively in their studies. Results revealed that most (88 percent) of the respondents had low to medium annual family income which had positive relationship with household farm size. Since most of the respondents had small to marginal household farm size, less number of earning member in 58 the family and did not operate new technologies and other income generating activities, the annual income tended to be medium to low.

Involvement in local association score of the respondents ranged from 0-4 with a mean of .99and a standard deviation of 1.42 (Table 1). On the basis of local association score, the respondents were divided into four categories as No (0), low (≤2), moderate (2-4) and High (>4). Data revealed that most of the respondents (56.36 percent) had no involvement while 35.45 percent and 5.45 percent had low and moderate involvement and only 2.74 percent had high involvement in different association. Ahmed (2007), Sharmin (2008) and Rahman and Begum (2009) observed almost similar findings in their respective studies. They found 79 percent, 50 percent and 92 percent less involvement in association respectively. Most of the respondents were involved with less number of an association for less number of years. It might be due to women being normally less affiliated with associations than that of men.

Training exposure score of the respondents ranged from 1 to 30 days with a mean of 1.2 days and a standard deviation of 1.45 days (Table 1). On the basis of training exposure, the respondents were divided into three categories as short-term (1-3), mid-term (4-7) and long-term (>7). Findings showed that majority of the women (53.64 percent) had short-term training exposure, while 4.56 percent having mid-term and 10 percent having long-term training exposure. Ahmed (2007) found similar findings in her study. Training exposure was directly related to organizational affiliation which reflected in the present research. Most of the respondents had less participation in different organizations and hence their training exposure was also low. Though these training were helpful for their improvement, they were not functionally active to income generating activities because of insufficient and high interest credit.

Exposure to information score of the respondents ranged from 0 to 24 against a possible range of 0 to 45, with a mean of 7.73 and a standard deviation 3.43. On the basis of their exposure to information, the respondents were classified into four categories No (0), low (up to 10), moderate (11-20) and high (>20) contact. Distribution of the respondents according to their exposure to information has been shown in Table 1. It was found that 51.82 percent of the respondents had low exposure of information, while 43.64 percent and 4.54 percent had moderate and no exposure information. None of the respondents had high exposure information. Rahman (2010) and Nasrin (2015) also reported almost similar findings in their respective studies. They found 76 percent and 93.8 percent respectively. Exposure to information is a very effective source of receiving information about new and modern technologies. The findings clearly showed that most of the rural women had low exposure to information which was an indication of inadequate extension service to that community.

Household Dietary Diversity

The information on dietary diversity was collected using a qualitative 24-hour recall at individual level of all the foods and drinks consumed by the respondent in the previous day, inside and outside the home for calculating household dietary diversity in Lama. The data collected with the dietary diversity questionnaire was analyzed to calculate dietary diversity score. While calculating the average dietary diversity score, the proportion of respondents consumed individual food groups of interest were also calculated. Information on consumption of individual food groups was also calculated to investigate dietary patterns by quintile of the dietary diversity score (terciles) has been shown in Figure 2. The percent households consuming each food group are normally used as a one-time measure or for on-going monitoring. The study included 110 households in Lama and the distribution of the households consumed each food group by any member in last 24 hours is presented in Figure 2.

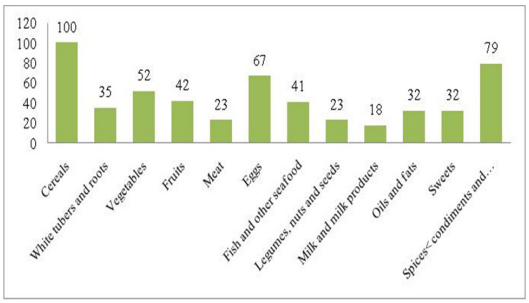

Fig. 2. Distribution of respondents (%) to household dietary diversity.

Figure 2 shows all the respondent sate cereals as a source of carbohydrates. Vegetables and fruits groups were the next predominant food groups from where nearly two thirds of the total respondents included items to their diet. More than half of the households consumed eggs and fish/other sea-foods food groups. The proportion of respondents who eat meat and legumes/nuts, milk/milk products, oils/ fats food groups were only 23%, 18%, 32% respectively. Besides cereals, white tubers, and nuts remained as the partial source of energy for slightly above of one third of the total respondents (35%). However, a large majority of the households (79%) consumed spices/condiments/ beverages food group as a taste enhancer of their diet.

Role Played by Rural Women in Maintaining School-Going Children's Nutrition

Good nutrition can help reduce the risk of some diseases, including heart disease, diabetes, stroke, some cancers, and osteoporosis. Food insecurity at the household level constricts the opportunities that an education can provide. In a nutshell, children from poor and food-insecure families face significant constraints in going to school, continuing schooling and learning in school.

Maintaining school going children's nutrition promote educational outcomes by enabling more children to attend class consistently and improving children's ability to learn once they are there. Existing role played by rural women in maintaining nutrition may include health and nutrition improvements and local economic development along with educational outcomes.

Anyway, the mountainous women played their great roles in both production and utilization of food for the households and especially school-going children. Their contribution were regarding in main areas of food production and preparation, food preservation, water quality maintenance and sanitization, and household food distribution. The major roles played by the women for household nutrition were as follows:

1. Growing vegetables in main land and homestead
2. Growing vegetables in homestead year-round to meet household nutrition
3. Helps husband to select appropriate vegetables for year-round cultivation
4. Discarding the disease affected parts of raw materials before cooking
5. Selection of nutritious food material for cooking
6. Measuring and allocating nutritional food material as per body requirement of the household members, especially for the school-going children
7. Cleaning/washing food materials before cutting/preparing raw materials for cooking
8. Using lid on pots or cover the of food materials to keep them safe
9. Preserving food through heating
10. Food preservation in fridge
11. Using clean, tube-well water for drinking and cooking
12. Instructing/practicing school-going children for washing hands with soap after using latrine
13. Instructing to use sanitary latrine by the children
14. Cleaning kitchen, home and homestead to keep food hygienic
15. Using water after boiling when tube well water is not available
16. Contacting health workers to know about nutrition, hygiene and sanitation for the children and the overall household members

In conclusion, it can be said the women in mountainous villages play a great role to maintain nutrition of school-going children of them. Studies of Nasrin (2015) and Fariha (2018) revealed similar findings in their studies on related issues. But the remoteness of housing areas from the school and farming land, uneven and poor road communication, poverty, lack of irrigation waters in summer/winter, lacking in knowing about nutrition etc. hindered their role to be played appropriately. They need support and services from the concerned agencies in the mountain areas to keep up their household nutrition in general.

The Need for Capacity Strengthening

The capacity strengthening of rural women towards maintaining school going children's nutrition was defined as the extent to which they have the need for accessibility to physical, managerial, support services as well as the ability to make decision about maintaining nutrition. Need for capacity strengthening of rural women was the focus variable of the present study. Four aspects of capacity strengthening were selected to measure need for capacity strengthening of rural women. The findings have been interpreted in the following subsections.

Overall need for capacity strengthening of Rural Women

The need for capacity strengthening of rural women was assessed in terms of score. Possible need score could range from 0 to 63, while observed score ranged

from 16 to 61. The mean score is 38.81 with a standard deviation of 10.66. Based on the need score the respondents were classified into three categories as shown in Table 2.

Table 2. Overall need for capacity strengthening of rural women (n=110). Possible score=0-63 and observed score=16-61.

Categories of need	Respondents		Mean	Std. Dev.
	No	%		
Low (≤21)	0	0		
Medium (25-41)	0	0	38.81	10.66
High (>45)	110	100		

Data presented in Table 2 shows that 100 percent of the respondents had high extent of need for capacity strengthening. While collecting the data, it was observed in the study area that there was scarcity of different facilities e.g. physical, support services, managerial and ability to make decision regarding strengthening of nutrition and even a little facility was available but those were not easily accessible form for the rural women. Thus, the respondents logically felt high need for their capacity strengthening towards maintaining school going children's nutrition. Having similar socio-economic background, the women included in the sample expressed similar opinion for their need for capacity development. Hence, they all fell under same category of need for their development. Ahmed (2007) and Rahman and Begum (2009) also showed similar outcomes in their respective studies.

Aspects-wise Need for Capacity Strengthening of Rural Women

Four aspects of capacity strengthening were selected to assess the extent of need for capacity strengthening towards maintaining school going children's nutrition. The computed need score of all the aspects have been shown in Table 3.

Almost 65% of the respondents was in high need for decision making ability with a mean of 11.36 and a standard deviation of 2.84. This was logical because the aspects of decision making ability like identification of nutritious food, selection of nutritious food, processing of nutritious food, buying of food for consumption, distribution of food and nutrition, preservation of food and nutrition were explored in the present study area but these were not atsatisfactory level. These issues were actually connected capacity strengthening in maintaining school going children's nutrition that's why

Table 3. Aspect-wise need for capacity strengthening.

Aspects of need	Possible score (Observed score)	Respondents			Mean	SD
		Categories	No	%		
Decision making Ability	0-18 (5-16)	Low (≤6)	11	10	11.36	2.84
		Medium(7-11)	28	25.45		
		High(>11)	71	64.55		
Access to support services	0-15 (6-15)	Low (≤5)	0	0	10.19	2.03
		Medium(6-10)	59	53.64		
		High(>10)	51	46.36		
Management skill	0-15 (3-15)	Low (≤5)	7	6.36	9.52	2.98
		Medium(6-10)	67	60.91		
		High(>10)	36	32.73		
Physical facilities	0-15 (2-15)	Low (≤5)	27	24.54	7.74	2.81
		Medium(6-10)	58	52.73		
		High(>10)	25	22.73		

women felt high need for that aspect in the study area. Second highest proportion (60.91 percent) of the respondents was in high need for management skill.

Management skill was directly associated with proper utilization of household food. If their existing skill increased, they would contribute effectively. The third and fourth highest proportion followed by 53.64 percent access to support services and 52.73 percent need for physical facilities respectively. It seems normal that women did not have low need for any aspects of capacity strengthening.

Thus, it was a simple analogy that the components available in low quantity would be felt as high need components.

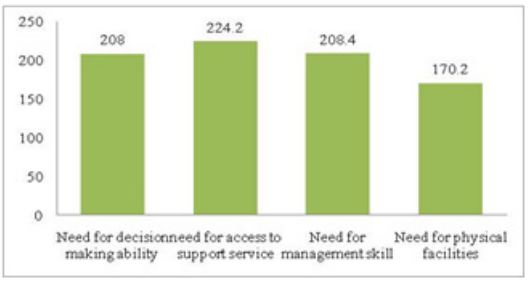

Fig. 3. Comparison of different aspects of need for capacity strengthening.

Figure 3 shows that the highest need score (224.2) of the respondents was in access to support services followed by access to management skill (208.8), decision making ability (208), respectively and the lowest need (170.2) of the respondents was in physical facilities.It might be worthy to mention that the differences among the aspects of capacity strengthening in respect of need felt by the respondents were small. Therefore, the rural women felt more or less same need for all the aspects of capacity strengthening towards maintaining school going children's nutrition.

Rank Order of the Issues of Need for Capacity Strengthening of Women

Different issues associated with need for capacity strengthening of women has been examined by computing rank order through score are shown in Table 4. Data presented that score of the issue associated with need for capacity strengthening of women ranged from 0 to 255 against a possible range 0 to 330. The value of score of twelve issues exceeded 200 and eight issues exceeded 150, the value of one issue is below150.However, top one issue in each four aspects of need for capacity strengthening of rural women have been discussed here. Preservation of food and nutrition (239) shows higher score in need for decision making ability. In most cases women take decision about how to preserve their food and nutrition. But they were not in satisfactory level that is why they felt high need for decision making about preservation of food.

Awareness program on nutrition (255) scores high in need for access to support services. Rural women felt high need in awareness program on nutrition.This issue is completely involved with effective maintaining of nutrition. It was observed in the study that awareness program on nutrition was not in a good condition. This condition should be improved and this is why women felt high need of awareness program on nutrition and they can contribute a lot.

Knowledge on nutritional value shows high score (227) in need for management skill which is an important issue in this regard. Respondents in the study area have fair knowledge on different aspects in maintaining nutrition. They were interested about learning new things but they did not get proper support. Thus, they felt high need about knowledge on nutritional value. Finally, water and sanitation facilities showed a high score (198), in need for physical facilities. It was an important issue in maintaining nutrition. Need for water and sanitization facilities also appeared as an important physical facility. However, there is a huge crisis of water and sanitary facilities in remote hilly areas.

Relationship between the Selected Characteristics of Rural Women and their Need for Capacity Strengthening

Among nine characteristics, the years of schooling, annual family income, training exposure, and household dietary diversity of the rural women were positively correlated with the need for capacity strengthening in maintaining school going children's nutrition. Other characteristics of the rural women were not significantly correlated with the

Table 4. Ranking of the issues of need for capacity strengthening of the respondents.

Issues	Score	Rank
Need for decision making ability		
Preservation of food and nutrition	239	1
Processing of nutritious food	219	2
Identification of nutritious food	219	2
Selection of nutritious food	201	3
Distribution of food and nutrition	193	4
Buying of food for consumption	177	5
Need for access to support services		
Awareness program on nutrition	255	1
Development workers for advice	239	2
Information about nutritious food	227	3
Motivational video about nutrients	224	4
Credit facilities	176	5
Need for management skill		
Knowledge on nutritional value	227	1
Allocation of nutritious food items	214	2
Nutritious food serving	209	3
Operational ability	202	4
Time allocation for cooking	192	5
Need for physical facilities		
Water and sanitation facilities	198	1
Uninterrupted supply of electricity	197	2
Processing equipment	168	3
Storage facilities	158	4
Preservation facilities	130	5

need for capacity strengthening maintaining school going children's nutrition (Table 5).

So, from these it can be said that with the increase of these characteristics their need for capacity strengthening maintaining school going children's nutrition also increases. Patilkhede et al. (2016) and Khalak (2016) found almost similar relationships in their respective studies. This indicated that the educated women had more information seeking behavior about the programs that were related to training, skill development, maintaining and strengthening competencies of women which, therefore, contributed to their increase in the level of need for capacity strengthening in maintaining school going children's nutrition.

Table 5. Relationship between the characteristics of the rural women and need for capacity strengthening.

Personal characteristics of the rural women	Correlation Coefficient (r) with 108 df
Age	-0.004
Years of schooling	0.208*
Household size	-0.013
Household farm size	-0.076
Annual household income	0.202*
Training exposure	0.328**
Exposure to nutritional information	-0.037
Involvement in local association	0.030
Household dietary diversity	0.240*

CONCLUSIONS

The remoteness of housing areas from the school and farm land, uneven and poor road communication, poverty, lack of irrigation waters in summer/winter, lacking in knowing about nutrition etc. hindered their role to be played appropriately. Concerned GOs and NGOs may conduct training and awareness programs, provide supports according to need of rural women for increasing their operational ability in maintaining school-going children's nutrition.

All of the respondents felt high need for capacity strengthening to maintain school going children's nutrition. The felt needs for capacity escalation must be fulfilled to ensure better involvement of women maintaining school going children's nutrition. But it is not an easy task alone for government to discharge the responsibilities. Government

organizations like Department of Agricultural Extension, Ministry of Health and other Non-Government Organizations like BRAC, Helen Keller, GRAMEEN BANK may take proper initiative to provide motivational video, information about nutritious food, periodical campaign on food safety issue to the women so that they can strengthen their capacity.

Years of schooling, annual family income, training exposure, and household dietary diversity of the were some of the personal characteristics of the rural women found to be significantly linked to their felt need for capacity strengthening towards maintaining school going children's nutrition. In formulating any action plan for the women regarding such activities, at least these variables might be considered on priority basis.

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REFERENCES

Ahmed, N. 2007. Need Assessment for Capacity Building of Rural Women for Practicing Post- Harvest Activities of Vegetables. MS Thesis, Department of Agricultural Extension Education, Bangladesh Agricultural University, Mymensingh, Bangladesh.

Ahmed, T., Mahfuz, M., Ireen, S., Shamsir Ahmed, A.M.S., Rahman, S., Islam, M.M., Alam, N., Hossain, M.I., Rahman, S.M.M., Ali, M.M., Choudhury, F.P. and Cravioto, A. 2012. Nutrition of Children and Women in Bangladesh: Trends and Directions for the Future. Journal of Population and Health Nutrition, 30(1), 1–11.

Billah, M. 2013. Adaptation of Farming Practices by the Smallholder Farmers in Response to Climate Change Status, MS Thesis, Department of Agricultural Extension Education, Bangladesh Agricultural University, Mymensingh.

DAE, 1999. Agricultural Extension Manual (Revised). Department of Agricultural Extension, Khamarbari, Dhaka-1215.

FAO. 2021.Enhanced Food and Nutrition Security in Selected Communities of Lama upazila, Bangladesh. A Report on a Project "Integrated Support to Smallholder farmers under the School Meal Program in Lama (Project code- FAO:UNDP/ BGD/072/WFP).

Fariha, N. 2018.Participation of Rural Women in Maintaining Nutritional Value of Household Foods in Haor Area.MS Thesis, Department of Agricultural Extension Education, Bangladesh Agricultural University, Mymensingh.

FRAC (Food Research & Action Center). 2017. The Impact of Poverty, Food Insecurity, and Poor Nutrition on Health and Well-Being. Retrieved from www.frac.org.

Gazi, M.A.R. 2009. Need for Capacity Strengthening of Rural Women in Conducting Post Harvest Activities of Potato, MS Thesis, Department of Agricultural Extension Education, Bangladesh Agricultural University, Mymensingh, Bangladesh.

Hoque, M.Z. 2011. Improvement of Socio –Economic Status of the Commercial Fish Farmers due to Transformation

from Crop Farming to Aquaculture, MS Thesis, Department of Agricultural Extension Education, Bangladesh Agricultural University, Mymensingh.

Hossain, M.J. 2013. Change of Livelihood Status of the Farmers due to Climate Change in a Selected Area of Satkhira District, MS Thesis, Department of Agricultural Extension Education, Bangladesh Agricultural University, Mymensingh.

IFPRI. 2017, "Agriculture, Nutrition, and Gender Linkages (Angel)." Available at: https://www.ifpri.org/project/agriculture-nutrition-and-gender-linkages-angel.

Islam, T. 2019. A Comparative Study on Nutritional Knowledge of Rural and Urban Women in Mymensingh District.MS Thesis, Department of Agriculture Extension Education, Bangladesh Agricultural University, Mymensingh, Bangladesh.

Khalak, A. 2016. Farmer's Access to ICT Based Media in Receiving Agricultural Information.MS Thesis, Department of Agricultural Extension Education, Bangladesh Agricultural University, Mymensingh.

Lashgarara, F., S.M. Mirdamadi and S.J.F. Hosseini, 2012. Role of ICTs in improving food accessibility of Iran's rural households. Anal of Biological Research, 3: 73-80.

Mandal, S. 2011. Improvement of Livelihoods of the Farmers due to Extension Activities of Krishi Gyan Samprosaran Kendra (KGSK), MS thesis, Department of Agricultural Extension Education, Bangladesh Agricultural University, Mymensingh.

Nasrin, Z. 2015. Contribution of Rural Women to Their Household Food Utilization.MS Thesis, Department of Agricultural Extension Education, Bangladesh Agricultural University, Mymensingh.

Paktilkhede, B., Krishna, T. G., Pal, R, and Shalu, K. 2016. Level of Capacity Building and Personal, Socio-economic and Psychological Characteristics of Members of Women Self Help Groups. Advances in Life Sciences, 5(8):3021-3025.

Rahman, M. A. (2010). Role of Women towards Household Food Security in Small Farm Family. MS thesis. Department of Agricultural Extension Education, Bangladesh Agricultural University, Mymensingh.

Rahman, M.Z. and Begum, A. 2009. Capacity Strengthening of Rural Women in Carrying out Post Harvest Activities of Vegetables and Fruits towards Food Security. NationalFood Policy Capacity Strengthening Programme. Available at http://nfpcsp.org.

Ray, G.L. and Mandal, S. 2004. Research Methods in Social Sciences and Extension Education.Ew Delhi: Kalyani Publishers.

Sharmin, E.M. 2008. Need Assessment for Capacity Building of Rural Women in Practicing Post-Harvest Activities of Brinjal Production. MS Thesis, Department of Agricultural Extension Education, Bangladesh Agricultural University, Mymensingh.

UNDP. 2009. Capacity Development: A UNDP Primer. Retrieved from: https://www.undp.org/capacity

UNSCN. 2017. School as a System to Improve Nutrition, United Nations System Standing Committee on Nutrition. Retrieve From, http://www.unscn.org.

Wang, C., Iuan-yuan, L. and Chie-bein, C. 2008. Evaluating farm technological innovation capability under uncertainty. Technovation, 8: 349-363.

WHO. 2006. Adolescent nutrition: a review of the situation in selected South-East Asian Countries, New Delhi.

World Bank. 2017.World Bank Bangladesh Country Overview 2017. Retrieve from https://www.cnpp.usda.gov/dietary-guidelines.

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Journal welcomes submission of quality researches in any of the following academic domains: Agriculture and Fisheries; Socio-economics, Policy and Ethics; Agricultural Technology and Biosystems; Food Technology and Nutrition; Environmental Sciences; Genetics and Biotechnology; and Innovative Extension Modalities. The journal has two (2) issues, one in December and the other in June, printed and on-line.

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