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EFFICACY OF SEAWEED EXTRACT ON CHILLI LEAF CURL VIRUS

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ABSTRACT

The important cash crop of Chilli's (Capsicum annum L) production and yield is hampered by Chilli Leaf Curl Virus Disease (CLCVD) in Sri Lanka. To manage CLCVD several insecticides were promised against the vectors of CLCV. Indiscriminate use of insecticides created unwanted human health hazards. The current trends in plant pathology intend to boost the immunity of the host to increase the resistance against pathogens. Therefore, this study was conducted to investigate the efficacy of Sea-Weed Extract (SWE) to manage CLCVD. The chilli variety Vijaya was selected for this experiment with five treatments and a non-treated control, which were arranged in RBCD. Data on growth parameters, yield, aphid severity, and CLCV disease severity Index (DSI) were measured and subjected to ANOVA in SAS and Tukey's HSD multiple comparison test was used to identify the best treatment combination at P <0.05. The results showed that first application of Sea-Weed Extract (SEW) at 15 days after planting with subsequent application of SWE at 15 days interval + application of insecticides at 10-15 days interval (T4) significantly lowered the CLCV DSI of 40.24%, less aphid severity index of 5.16% with the highest chilli yield of 436.8 kg/ha. The investigation concluded that SWE induces plant immunity but no effect on vector control. Therefore, SWE with recommended insecticides is better to increase the immunity of plants for the effective management of CLCVD.

Keywords: Aphid, Chilli, Chilli Leaf Curl Virus, Insecticide, Sea-Weed Extract

INTRODUCTION

Chilli (*Capsicum annuum* L.), belongs to the family of Solanaceae, is one of the most important spice crops of cuisines of tropical and subtropical countries, native to South America (Thakur et al., 2018). Chilli is the fourth major crop cultivated in the world for its fruits, which are consumed in green as well as ripe dried form by people due to its pungency (Kumar & Kumar, 2017). Chilli is cultivated as a cash crop, mainly in the dry zone especially in the north-central province and the intermediated zones of Sri Lanka. Per capita consumption of dry chilli is estimated as 2.84 kg per year and Sri Lanka requires 60,000 metric tons of dried chilli and 63,000 metric tons of green chilli per year (https://www.doa.gov.lk/ETC/index.php/en/crop/178-2-4). In the year of 2018, the total extent of the chilli cultivation was 13553ha, the total production was 79003 tons, and average yield was 5.83 tons/ha in Sri Lanka (AgStat,2019). In 2020, the green chilli cultivation extend, total production and average yield were declined to 10,981ha, 60,593 tons, and 5.52tons/ha, respectively (AgStat, 2020). This 10-12% production loss within a year due to farmers who are cultivating Chilli in Sri Lanka face several pest and diseases attacks that are inflicting severe yield reduction. Chilli leaf curl virus disease (CLCVD) is one of the catastrophic diseases of chilli crop and it causes severe yield loss, which may be up to 100% if not properly monitored and managed.

The CLCVD in chilli is caused by Begomovirus belonging to the family of Geminiviridae and CLCVD has become highly important in recent years in Sri Lanka as a new variant of CLCV attacking in Sri Lanka, is called Chilli leaf curl Sri Lanka virus (ChiLCSLV) (Senanayake et al., 2012). Chilli leaf curl virus is transmitted by whitefly, *Bemisia tabaci*. Symptoms of the chilli leaf curl virus disease are severe leaf curl with cup-shaped, upward curling leaves, yellowing, and stunted plant growth (Briddon et al., 2010).

Different methods are being used to control CLCVD, such as cultural, physical, mechanical, biological, and chemical methods. There are no direct chemicals to control any virus diseases, but vectors who are transmitting respective virus diseases are being targeted directly to control using chemicals. Insecticides have a negative impact on human health and the environment. Injudicious use of insecticides in both doses and types often cause

problems because they can increase production costs and leave residuals on products (Astuti et al., 2013). The utilization of non-hazardous materials such as plants extracts, seaweed extracts, and bio-control agents and their effectiveness are being investigated. The seaweed extracts have achieved much wider acceptance as "plant bio-stimulants". Seaweeds belong to the algae group, and marine seaweed belongs to the families Chlorophyceae (green), Rhodophyceae (Red), and Phaeophyceae (brown). The colour of algae depends on the pigment present in algae species. The green colour of green algae is due to the presence of Chlorophyll as in higher plants. The Phaeophytes algae are brown due to the dominance of xanthophylls and fucoxanthin pigments, and the reason for red colour in Rodophytes is due to phycoerythrin pigment (Abad et al., 2011).

Usually, seaweed extracts, even at low concentrations, can induce an array of plant responses, such as increasing plant growth, improving flowering & yield, improved quality of products, and enhanced nutritional content of the edible product (Raj et al., 2018). The application of some seaweed extracts (SWE) has also been reported to enhance plant tolerance to a wide range of abiotic stresses i.e., drought, salinity, and temperature extremes. Several research findings are available to demonstrate the beneficial effect of seaweed products on plant seed germination, enhanced resistance to pathogens and abiotic stress and improved post-harvest quality (Jayaraj et al., 2011). Based on the above criticisms, an investigation was carried out to evaluate the efficacy of Seaweed extract on CLCVD and the growth and yield parameters of the chilli.

METHODOLOGY

The study was conducted during the 2019/2020 *Maha* season as a field experiment at the Field Crops Research and Development Institute (FCRDI) located in 8°6'0" N and 80°27'0" E, Maha-Illuppallama, North Central Province, Sri Lanka. The nursery and field preparation for chilli was performed according to the Department of Agriculture recommendation. *Vijaya* variety was chosen as testing material because of its higher susceptible to the CLCVD, and moderately CLCV resistant *KA2* chilli variety was used only for CLCVD comparison with *Vijaya* chilli variety.

Nursery Management

Nursery bed of 2mx1m was prepared and sterilized by burning method using paddy straw and paddy husk. Well rotten cow dung (8 t ac-1) was incorporated into the sterilized nursery bed after the removal of ash. Water was applied and left for few hours. Chilli seeds of the *Vijaya* variety and *KA2* variety (only for **CLCV** comparison) were treated with fungicides and sown at the spacing of 10 cm between rows with 1 cm depth. A thin, dry paddy straw layer was used to cover nursery beds as mulch to prevent insect pests. Paddy straw mulch was removed after 7-10 days of seeds germination.

Field trial

The field was ploughed 45 cm depth with a disc plough and soil was pulverized using a rotavator to make fine-textured soil. The size of the experimental plot was 4.5×4.8 m. Ridges were made with 60 cm spacing for each treatment. Drains with the 30 cm width and bunds with 40 cm width were prepared for basin irrigation in between rows and plots, respectively. Three days before transplanting, decomposed cow dung and basal fertilizer were applied to the plots according to the Department of Agriculture (DOA) recommendation (Table 1). Twenty-one days old chilli seedlings were transplanted with one plant per hill at the spacing of 60×45 cm. All the other cultural practices (weeding, irrigation, etc.) were followed according to the recommendation of DOA for chilli cultivation.

Table 1: Fertilizer recommendation for chilli

Time of Application	Rate of Application (kg/ ha)		
	Urea	**TSP**	**MOP**
Basal dressing	-	100	50
1st top dressing	100	-	-
2nd top dressing	125	-	-
3rd top dressing	125	-	50
4th top dressing	125	-	-

(Source: DOA, https://www.doa.gov.lk/FCRDI/index.php/en/crop/34-chilli)

The seaweed extract AG Fort health booster™ (composition: Processed Macroalgal extract, natural acidity regulators: 24% W/W mini stabilizer and aqueous diluent 76% W/W) produced by SUPR pathways™ Technology is being marketed by Browns Agri Solutions Pvt (Ltd) was received for pilot trials. The seaweed extract AG Fort health booster™ dosage was prepared as per the recommendation of the producer (300 mL/Ac or 1.5 mL/L), and treatments were administrated in combinations as described in Table 2.

Table 2: Details of the treatments used in the study

Treatment (T)	Application details
T1	1st application of SWE 10 DAP + 2nd and 3rd spraying of SWE at 15 days interval.
T2	1st application of SWE 15 DAP + 2nd and 3rd spraying of SWE at 15 days interval.
T3	1st application of SWE 10 DAP + 2nd and 3rd spraying of SWE at 15 days interval + Application of insecticides at 12 days interval.
T4	1st application of SWE 15 DAP + 2nd and 3rd spraying of SWE at 15 days interval + Application of insecticides at 12 days interval.
T5	Application of insecticides at 12 days interval.
T6	Control.

Note: SWE: Seaweed Extract; DAP: Days After Planting

Chilli Leaf Curl Virus Severity

Severity of CLCV was rated using 24 plants/ plot according to the scale of 0- 4, where 0=No symptoms; 1=1-5% of the plant showing CLCV symptoms; 2=6-25% of the plant showing CLCV symptoms; 3=26-50% of the plants showing CLCV symptoms; 4=51-100% of the plants showing CLCV symptoms, after 15 weeks of sawing. The disease severity index was calculated by the formula given below (Banerjee and Kalloo, 1987).

Disease severity index (DSI) = $\frac{\sum(VXn)}{NXZ} X100\%$

DSI = Severity index; V = Score value; n = Number of plants having the same score

N = Total number of plants observed; Z = Maximum scale number

Aphid damage severity

Table 3: Aphid severity rating

Rating	Number of aphids	Appearance
0	0	No infestation
1	1-4	A few individual aphids
3	5-20	A few isolated colonies
5	21-100	Several small colonies
7	101-500	Large, isolated colonies
9	>500	Large continues colonies

(Litsinger *et al*., 1977)

Aphid damage was observed in the trials visually within treatments. Hence aphid damage severity was calculated following the standard method of 0-9 scale (Table 3) proposed by the Litsinger *et al*., 1977.

The Aphid Severity Index was calculated using the same formula used to calculate CLCV.

Data collection and Statistical analysis

All the data on disease severity index, aphid severity index, number of days for 50% flowering, growth and yield were subjected to ANOVA under SAS 9.4 system and Tukey's HSD multiple comparison test was used to identify the best treatment combination at $P < 0.05$.

RESULTS AND DISCUSSION

The application of insecticides is the most commonly used method by farmers to control the leaf curl complex in Sri Lanka. However, applications of insecticides cause problems such as environmental pollution, hazarding to non- targeted organisms, etc. The results of the investigation carried out to induce the plant immunity to reduce the CLCV attack are summarized.

The CLCV disease severity increased along with the weeks after planting, but the rate of increase decreased after administration of different treatments in combination (Figure 1). The CLCV disease severity was significantly different among different treatments at P <0.05. The investigated variety *Vijaya* showed significantly lower DSI % of 40.24 and 43.07 in 1st application of SWE 10 DAP + 2nd and 3rd spraying of SWE at 15 days interval + Application of insecticides at 12 days interval (T3), and 1st application of SWE 15 DAP + 2nd and 3rd spraying of SWE at 15 days interval + Application of insecticides at 12 days interval (T4) (Figure 1), respectively, compared to the other treatments. Disease severity indexes in 1st application of SWE 10 DAP + 2nd and 3rd spraying of SWE at 15 days interval (T1), 1st application of SWE 15 DAP + 2nd and 3rd spraying of SWE at 15 days interval (T2), Application of insecticides at 12 days interval (T5) and control were 74.00%, 80.07% and 69.02%, and 100%, respectively. This finding indicated that sole application of SWE and insecticides are less effective than combined application of SWE with insecticides. The CLCV disease severity was significantly less (highly significant 60% in control) in *KA-2* variety (moderately resistant to CLCV) comparison to variety *Vijaya* (susceptible to CLCV) in similar treatment combinations (Figure 2.) The findings indicated that more prominent results could be obtainable when using the SWE to the varieties that are already genetically resistant.

The growth and reproductive parameters were not affected by the application of SWE, whereas yield was significantly different among treatment. Treatment 1st application of SWE 10 DAP + 2nd

and 3rd spraying of SWE at 15 days interval + Application of insecticides at 12 days interval (T3) (413.2 kg/ha), and 1st application of SWE 15 DAP + 2nd and 3rd spraying of SWE at 15 days interval + Application of insecticides at 12 days interval (T4) (436.8 kg/ha) showed highest significant mean yield compared to the control (252.3 kg/ha) at P <0.05. In comparison to application of insecticides at 12 days interval (T5), combined application of SWE and insecticides effectively increased the yield while reducing disease incidence.

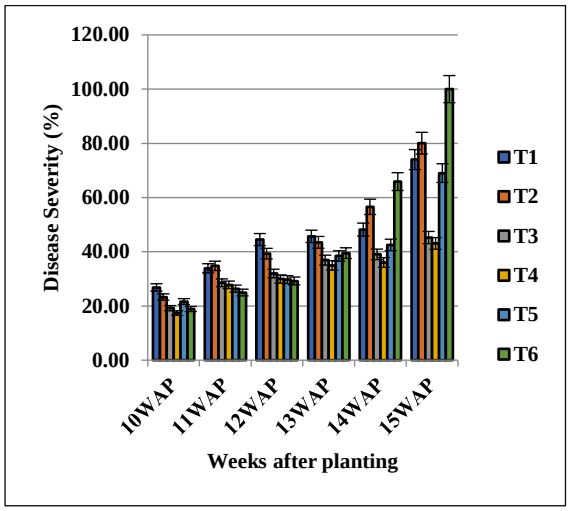

Figure 1: Chilli leaf curl virus disease progress from 10th week after planting in Vijaya

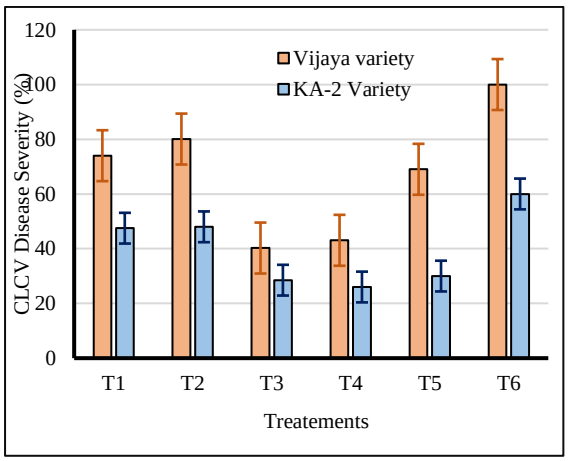

Figure 2: Comparison of Chilli leaf curl disease severity between Vijaya and KA-2 at 15 weeks after planting

In the *Vijaya* variety, there is a significant difference in aphid severity index among the different treatments (Table 4). When compared to the control treatment (16.47%), 1st application of SWE 10 DAP + 2nd and 3rd spraying of SWE at 15 days interval + Application of insecticides at 12 days interval (T3) (5.23%), and 1st application of SWE 15 DAP + 2nd and 3rd spraying of SWE at 15 days interval + Application of insecticides at 12 days interval (T4) (5.56%) showed a low mean value of the aphid severity index. Among the treatments, the variety treated with insecticides showed higher aphid severity index of 8.67% than 1st application of SWE 10 DAP + 2nd and 3rd spraying of SWE at 15 days interval + Application of insecticides at 12 days interval (T3), and 1st application of SWE 15 DAP + 2nd and 3rd spraying of SWE at 15 days interval + Application of insecticides at 12 days interval (T4). The study concluded that applying seaweed extract with insecticides could be effective than sole application of insecticides to control pest and diseases.

Table 4: Mean values of aphid severity index, number of days for 50% flowering, plant height, and yield of *Vijaya* chilli variety

Treatment	Aphid severity Index (%)	Number of days for 50% flowering	Plant height (cm)	Yield (kg/ha)
T1	14.46 [a]	45±1[a]	32.51 [a]	330.4 [c]
T2	06.60[b]	45±1[a]	31.56 [a]	358.9 [c]
T3	05.23 [c]	44±1[a]	33.48 [a]	413.2 [a]
T4	05.16 [c]	42±1[a]	32.34 [a]	436.8 [a]
T5	08.67 [b]	44±1[a]	37.93 [a]	396.0 [b]
T6	16.47 [a]	48±1[a]	29.32 [a]	252.3 [d]
CV%	38.2	6.3	9.3	34.7

Mean values with the same alphabets are not significantly different according to the Tukey's HSD multiple comparison test at 95% confidence interval

The seaweed extracts made from different raw materials, and procedures are attributed to several beneficial effects such as biotic and abiotic stress tolerance, increased nutrient uptake, and improve quality of products (Raj et al., 2018). Moreover, the biologically active compounds like polysaccharides, proteins, polyunsaturated fatty acids, pigments, polyphenols, minerals, plant growth hormones and other in the algal extracts mainly boost the antibacterial activity, scavenging of free radicals, host defense activity etc. Therefore, the yield of the plants increased and it highly recommended to use as liquid fertilizer even in poor quality soil (Narayasamy et al., 2020; Chojnacka at al., 2012). Abetz (1980) reviewed that cytokinins are a major active constituent of seaweed extracts and that the extracts may increase frost resistance, increase nutrient uptake and changes in plant chemical composition, increase disease and pest resistance, increase yields and improve seed germination.

Venkates (2016) stated that the red seaweed extracts of *Kappaphycus alvarezii-1* (0.4%)

reduced the percentage of disease index (PDI) of Cucumber Mosaic Virus (CMV) in gherkins in the field experiments. Pushpa et al., (2018) reported the delay in appearance of Papaya Ring Spot Virus (PRSV) symptoms in papaya plants treated with *K. alvarezii* (0.4%). Kavyashri and Nagaraju (2019) recorded that there was a significant reduction in the severity of CMV disease in chilli treated with *K. alvarezii* as a biotic inducer. Seaweed extracts have been highly reported to enhance plant growth, vigour, and productivity and improve resistance to pests and diseases (Raj et al., 2018). The current findings are in agreement with the previous findings.

The application of SWE triggers the plant defense genes very effectively than the water applied as acontrol, and suppresses the fungal diseases *Alternaria radicina* and *Botrytis cinerea* than Salicylic acid. Application of SWE in carrot exhibited the overexpressed level of protein products of genes such as pathogenesis-related protein I (*PR-1*), chitinase, lipid transfer protein (*Ltp*), phenylalanine ammonia-lyase (Pal), chalcone synthase, non-expressing pathogenesis-related protein (*NPR-1*) and pathogenesis-related protein 5 (*PR-5*) than the untreated control explained that SW enhances disease resistance in plants through induction of defense genes or proteins (Jayaraj et al., 2008).

Devi and Mani (2015) reported that the application of *K. alvarezii* sap with 100% recommended dosage of fertilizer to rice plants increased in growth, yield attributes, quality and chlorophyll content. Application of *K. alvarezii* (0.4%) and *P. fluorescens* (0.6%) significantly improved plant yield under field condition (Kavyashri and Nagaraju, 2019). Arthur (2003) reported that capsicum yield could be increased by using a different concentrated mixer of SWE. These evidences tally with the current findings. Stephenson (1966) further proved that application hydrolyzed seaweed on crops in two weeks interval significantly reduced the severity of aphids, red spider mites, powdery mildew, botrytis and an unidentified complex of fungi responsible for the damping-off of seedlings.

The present study evidenced that there is no vector controlling effect of SWE. But the vector's effect has been reduced by the activation of the plant immune system. The tolerance level could be further maintained by the combined application SWE with recommended insecticides.

CONCLUSIONS

Results revealed that application of SWE with recommended insecticides at 10-15 days interval could be effective than a sole application of insecticides to reduce the severity of CLCV in Chilli. The first application of SWE at 15 days after planting is better than the first application of SWE at ten days after planting because it showed lower CLCV and high growth and yield.

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FISHERY SOCIO ECONOMICS OF VALAICHCHENAI LAGOON, SRI LANKA

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ABSTRACT

Valaichchenai lagoon is one of the major inland fishery sources in Batticaloa. However, status of fishery & socio-economic information were lacking in literature, and this study aimed to fulfil this research gap. Primary data including fishing practices, species, marketing system and supply chain, catch per unit effort, sustainable fishery constraints, and environmental impacts of fishing & related activities, were collected using questionnaire, interviews, and direct field observations. Secondary data were obtained from Fisheries Department of Batticaloa and journal articles. Total of 12 types of fishing gears and the outrigger lagoon canoes (Thoni) were used for fishing and 38 species were identified during study period. Only a very small percentage directly sells fish catch to final consumers, and supply chain includes local and foreign market interventions. Fishermen caught 0.009 to 0.027 kg/net square meter-day, and 0.75 to 3.1 kg/day using a gill net and cast net respectively, on average. Regulations for mesh sizes and certain unauthorized activities, licensing system, and seabass cage culture for sustainable fisheries have been imposed in Valaichchenai lagoon, but there were no species/size limitations, off-season/time limitations with prevailing irresponsible fishing (IUU), seagrass/benthic environment destruction, shrimp farm effluent discharge, disposal from cage fishing harbour & adjacent bout repairing centres, oil spilling from boats and sound pollution issues. It can be suggested that introducing a co-management system, implementing voluntary code of conduct, proper rules and regulations, frequent monitoring, conducting awareness programmes & training programmes for the sustainability of Valachchenai lagoon fishery.

Keywords: Catch unit effort, Co-management, Fishery sustainability, Supply chain, Valaichchenai lagoon

INTRODUCTION

Valaichchenai Lagoon is situated between 81.548952-7.941750 and 81.554221-7.942600 in the vicinity of Passikudah Bay. It is an estuarine lagoon, encompassing an area of about 13.21 ha which may provide nursery ground for many marine species. Its fisheries provide a primary source of income for at least 3,000 fisher families from the 26 villages bordering the lagoon and around 5,000 people engage in fishing there providing protein rich food source additionally for fishermen livelihood. Santharooban, et. al., (2012) recorded that Valachchenai lagoon has higher levels of Nitrogen and Phosphorous which were discharged from the fisheries harbour, paper mill, rice mills, and shrimp farms. Udagedara, et. al., (2017) also mentioned Valachchenai lagoon has been polluted by anthropogenic activities; this may lead to the degradation of aquatic resources in the lagoon. Over-fishing and environmental impacts associated with irresponsible fisheries and related activities that are related to post-tsunami recovery Post-war developments such as the Valaichchenai fishery harbour and shrimp farms have severely been degraded from the Valaichchenai lagoon (Santharooban, et. al., 2012). No previous detailed studies have been carried out on the fishery in the lagoon due to the civil unrest in the area, and no or less separate data was available on socio economics of lagoon fisher community. This study mainly focuses on the current socio-economic status of the Valaichchenai lagoon fishing community; seek proper implementations of fishery regulations including environmental impacts associated with fishery related activities. Current study paves path for proper fishery management for the relevant authorities in regulating the fishing activities, strengthening the socioeconomic status of the fishermen while maintaining the lagoon fishery & aquatic resources in a sustainable manner.

METHODOLOGY

The stratified sampling technique with 50% sample size was used as a probability sampling method to select the sample, representing all sub samples, since the fishermen involved in fishery activities in Valaichchenai lagoon were divided into 05 subgroups (strata) based on their landing sites. Primary data were collected by using quantitative

method and qualitative method. Quantitative data were collected by using a close-ended method questionnaire through a field survey, which included stratified questions with five-point Likert type questions. Qualitative data such as implementations and failures of sustainability and impacts of fisheries and its related activities on the lagoon environment were collected by using interviews or informal discussions with fishermen. Identification of species was confirmed using the FAO Species Identification Guide for fishery purposes (Bruin, *et. al*., 1994), Fish Base World Wide Web Database (Froese and Pauly, 2019) and the internet. Catch per unit effort (CPUE) data for the main two types of fishing gear, such as gill net and cast net, were collected over twenty-one days at an equal interval during the study period and total catch and the amount of unit effort used to harvest the catch data were collected from each specific individual who is using specific or same net for unit effort (fishing day). Secondary data such as fishing population, and the number of fishing crafts operated at the landing sites and basic information about the lagoon were collected mainly from the Department of Fisheries and Aquatic Resources Development. The Statistical Package for Social Sciences (SPSS 26.0 version) and Microsoft Excel 2016 software were used to simplify the analysis work of this study. Supply chain analysis was also performed.

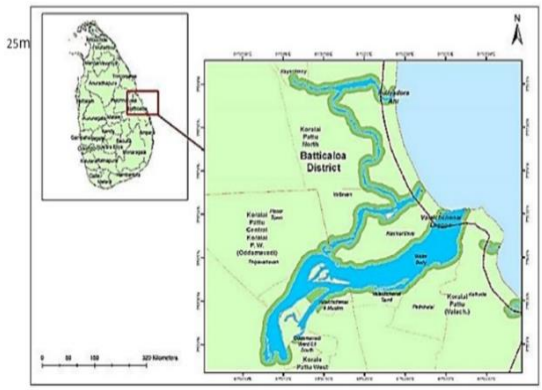

Figure 1. Location of the study area (Source: Udagedara, et. al., (2017).

RESULTS AND DISCUSSION

Socio-economic status of fishermen

According to the study, the fishers of Valaichchenai lagoon were 100% males. However, women were involved in the activities of oyster, clam and prawn catching and drying fish catch. Through an efficient study, it was found that 18.6% of respondents occupied full-time fishing and rest, 81.4% of respondents perform part-time fishing, revealing that the majority were part-time fishermen. Nearly 44.63% of respondents caught 1-5 kg of fish per day, 37.60% of respondents' catch was 6-10 kg of fish per day while 10.33% of fishermen caught 11-15 kg of fish per day, where 2.07% of respondents caught 16-20 kg of fish per day, with 5.37% of fishermen caught more than 20 kg of fish per day. This indicate that the catch of majority of fishermen were 1-5 kg of catch per day at the landing sites of Valaichchenai lagoon. Fish catch depends on a range of factors, such as skill, fishing gear, weather, seasonal changes in biophysical parameters and, unavoidably, also an unknown portion of luck (Funfgeld, 2006).

According to the survey, 13.64% of respondents had a monthly income of less than Rs. 10,000.00, 35.12%, monthly income was between Rs. 10,000.00 and Rs. 15,000.00, where 39.67% had a monthly income of Rs. 15,000.00 and Rs. 20,000.00 while 11.57% income was above Rs. 20,000.00, revealing more than half of all fishermen income was below Rs. 20,000.00 through fishing. The profit margins in lagoon fishing were generally low (Funfgeld, 2006), and Ugagedara, et. al., (2017) estimated that the average monthly income for fishers in Valaichchenai lagoon was Rs. 17,000, which matched the current study. The yearly average annual income of a household is a dominant socio-economic indicator that greatly affects the livelihoods of fishermen (Hossain, et. al., 2009). Current study found that 32.23% of respondents belonged to the category of annual income below Rs. 100,000.00, while 47.52% of respondents' annual income range was between Rs. 100,000.00 to Rs. 200,000.00, with 10.33% of respondents with an annual income in between Rs. 200,000.00 to Rs. 300,000.00 category, 9.92% of respondents' annual income level was above Rs. 300,000.00 (Figure 2).

Out of 242 respondents, 18.18% represent fishermen who are in the age group 20–30 years, while 28.5% were in between 31-40 years, where 17.36% and 35.95% represent fishermen who were aged between 41-50 and above 50 years, respectively. 4.96% of fishermen have not received any education and fishermen who are at primary level represent 52.07% of the sample. 34.71% of fishermen have received the secondary level of education, 8.26% have reached ordinary level of education, and there were no undergraduate fishermen in that community. Nearly 31.40% of respondents have 1-5 years of fishing experience, while 17.36% have 6-10 years of experience, and

22.31% have 11-15 years of experience. Nearly 28.93% of respondents had above 15 years of fishing experience.

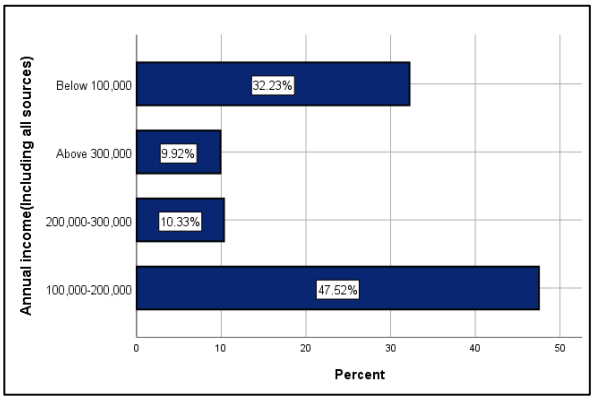

Figure 2: Annual income range of the studied lagoon fishermen (SPSS output from field information)

Fishing gears and crafts operated in the study area.

The types of fishing gears mostly used for fishing activities in the landing sites of Valaichchenai lagoon are shown in Figure 3.

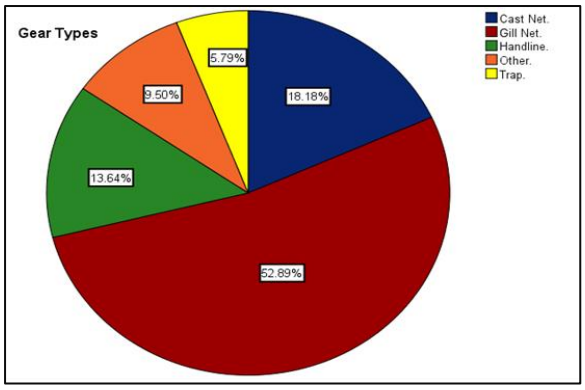

Figure 3: Percentage composition of fishing gears mostly used for fishing in the study area (SPSS output from field information)

Majority of respondents used gill nets (52.89%), 18.18% of fishermen used cast nets while 13.64% used hand lines and 5.79% of respondents used traps for fishing. 9.50% of respondents used other gear types such as scoop net/athangu and longlines showing that majority of fishermen use gill nets for fishing in Valaichchenai lagoon. Gill net (mostly set in the evenings), cast net, and traps are used on a daily basis, which were used in the morning from 6.00 am to 11.00 am and in the evenings from 5.30 pm to 6.00 am. Other gears, such as scoop net, longline, and hand line, were used any time of the day. Fishermen attached baits (chicken intestine, cattle fish pieces and commercially available trash fish) on gears such as hand line, long line and traps to attract the target species. In recent times, to attract the target species fishermen have used artificial lights such as torches, kerosene lamps, and petromax lamps.

In the field survey, it was found that artisanal fisheries have been identified as common activity in the lagoon. Fishermen used trammel net too, which was prohibited in the lagoon area. Moreover, brush pile, harpoons, karappu (using artificial lights such as torch light to attract the fishes and catch them by using long wooden basket) and parikudu/kuddupedi (small L shaped wooden box) were, only used by a limited number of fishermen due to high availability of modern fishing gears with high efficiency.

Analysis of different kinds of fishing crafts used by fishermen shows that a considerable majority of respondents used an outrigger lagoon canoe (Thoni). It is used for cast net fishing, gill net fishing, trap fishing, handline fishing and longline fishing. A substantial number of fishers in Valaichchenai lagoon also used fishing gears, such as scoop net, which do not require a fishing craft. Motorized crafts are prohibited in the lagoon because of sound pollution and oil spilling.

Species composition

According to the interviews and direct field observations, Green chromide and Common carp were the species mostly caught in the Valaichchenai lagoon, and Mullet, Double spine foot, and Seabass were the high-priced species. Three prawn types, namely Green Tiger prawn, Indian White shrimp and Wild King Tiger prawn, were caught in the Valaichchenai lagoon. Prawns were mainly caught using traps (fyke net) and prawn nets, cast net, and also scoop net. Mud crabs were caught mainly by crab traps and crab nets. Prawns and crabs have high market demand, and they are exported to other countries. Clams and oysters are collected by hand or using knives and they are sold in the local markets.

Marketing system

The marketing system of the Valaichchenai lagoon area is shown in Figure 4. It was found that 11.57% of the fishermen sold their captured species to consumers directly, 54.55%, to fish vendors and 33.88% sold their species to wholesalers.

Lagoon fishermen do not receive higher prices in selling their harvest at the lagoon site because of mobile traders who buy the fish directly at the landing sites, packed fishes in iced boxes and

transport to the nearest market using bicycles and motorcycles.

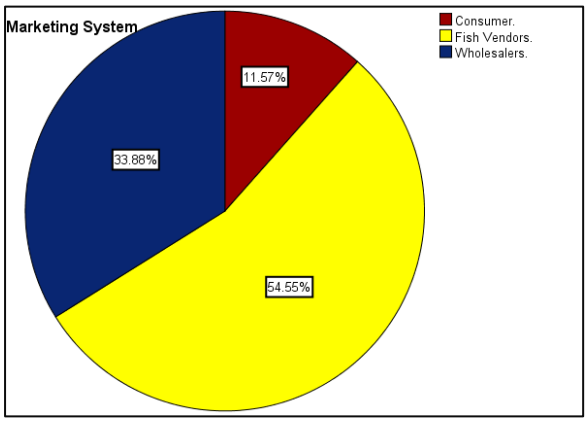

Figure 4: Percentage composition of marketing system in the study area (SPSS output from field information)

Supply chain

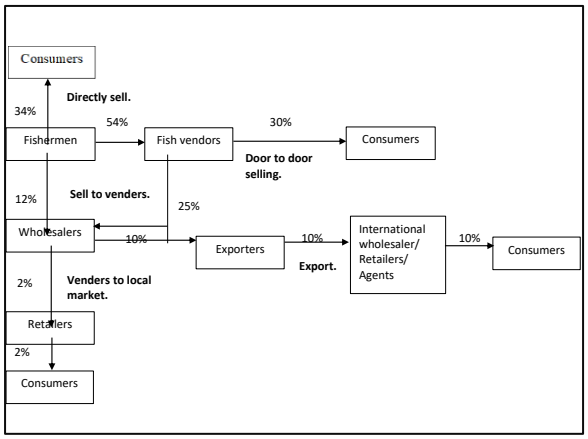

Figure 5: Supply chain system of Valaichchenai lagoon fishery (SPSS output from field information)

The status of the marketing channel of the species with high demand of Valaichchenai lagoon fishery is shown in Figure 5. Prawn and crab were high demanded and export-oriented products. Islam, et. al., (2014) reported in detail on marketing channels were product flow from producers to ultimate consumers.

Catch per unit effort analysis

According to the data collected from each specific individual who used a gill net and a cast net, the catch per unit effort (kg per net square meter-day) of the fisherman, catch per unit effort of gill net was in between 0.009 to 0.027 kg during the study period. Catch per unit effort (kg per day) of the fisherman for the cast net used was in between 0.75 to 3.1 kg. The catch per unit effort (CPUE) in fisheries and conservation biology is an indirect measure of the abundance of a target species (Hossain, et. al., 2009; Rosario, 2017).

The overall mean value of awareness of the sustainable fisheries is 3.74, hence Valaichchenai lagoon fishermen have good awareness of the importance of fishery sustainability, and they have moderate awareness on importance of lagoon environmental protection and suggestions to maintain the sustainable fishery and reduce negative environmental impacts, the overall mean value for those are 3.33 and 3.35 respectively. But in nature, they give more priority to their income than sustainable fishery and lagoon environmental protection. 51.2% of fishermen reported poor storage facilities as a major constraint in the Valaichchenai lagoon landing sites. Then, 22.3% of fishermen mentioned poor transportation network, 16.9% of respondents indicated lack of hygiene and sanitation and 7.4% of respondents said delay in selling as constraints. 2.1% of respondents mentioned conflicts among fishermen were minor in the Valaichchenai lagoon landing sites. 34.3% of fishermen reported the low economic value of lagoon fishes as a major constraint in the Valaichchenai lagoon marketing sector. Then 31.0% of respondents said fluctuation in price, 28.5% of fishermen mentioned about lack of market infrastructure and 3.7% of respondents indicated the delay in payment and 2.5% of respondents said competition among traders as constraints.

Implementations and failures of sustainable fishery in Valaichchenai lagoon area

Inland Fisheries Management Regulations No.2 of 1996 such as licensing system, prohibition of mesh size 85mm or below, surrounding or towing nets (such as purse seine, trawl net), trammel net, monofilament netting material, cancellation of license for penalties or imprisonment according to the level of violation of rule and regulations were currently implemented in the lagoon. Seabass culture system to increase income of fishing community while reducing the issues rising from over-exploitation due to intense lagoon fishing were also implemented in the lagoon. Over-exploitation of the fishery at the very least means lower returns from the fishery and, at worst, can lead to the elimination of biological species (Wijayaratne, 2001). The lagoon has open access for fishing; fishermen have free access to the lagoon even without fishing licence. Therefore, proper monitoring system should be implemented and the effects of oversupply of fishing crafts thereby increment of fishermen beyond actual

demand (Gunawardena and Wickramasinghe, 2009).

No species or size limitations were obeyed by the lagoon fishermen in the lagoon fishery and no off-season or time limitations (especially during the breeding and spawning seasons) were implemented. One fisheries inspector (FI) was in charge of the five landing sites, so it was practically impossible to monitor the whole lagoon. Therefore, fishermen tend to catch undersized fish (juveniles) species during the fishing seasons (prawns and crabs), by-catch of live juveniles were high and fishermen do not release these back into the lagoon. Moreover, some fishing gears which were frequently used in the lagoon, such as scoop net, traps (Fyke net) were considered problematic because these catch all sizes of fishes including pre-matured species. Karakulak, et. al., (2012) reported that the high price and profitability situations may encourage over-fishing, resulting in stock depletion and final extinction of species, and the catch of non-target species or bycatch, immature individuals, and economically non-important species may affect the fishery sustainability and reduce fish catch in the future. Further, seabass species cultured in cages at Valaichchenai lagoon do not reach marketing size when they were harvested due to anthropogenic activities.

Environmental impacts of fisheries and related activities in Valaichchenai lagoon area

Traps (including fyke nets) and scoop nets used to catch prawns and crabs, as well as hand or knives used to collect mussels and oysters, seagoing boat movements to reach the harbour and anchorages, and the use of outboard motors and propellers in shallow seagrass beds affect the seagrass and benthic environment of the lagoon. Oil spills through boats and effluent discharges of aquaculture farms are also harmful. Fish offal and waste discharge from the Valaichchenai fisheries harbour may also affect the lagoon environment and the degradation of excess feeds (commercially available trash fish) were harmful to the particular lagoon. Sand mining to increase the lagoon depth in facilitating the movement of seagoing boats may destroy the seagrass bed by increasing turbidity. This can change the currents, wave action, tidal fluctuations and the transport of sediments along the coast. Moreover, feed waste and faecal matter disposal from the aqua cage cultures pollute the lagoon environment.

Fiberglass waste from boat repairing centres in the fisheries harbour may contaminate with the water and can be inhaled by the species, settle in the airway and lungs and end up in the food chain (Mithipala, 2013). Sound pollution is a minor issue in the Valaichchenai lagoon, and this may not kill the fish directly, but can disrupt their ability to find food, mates, or avoid of predators.

Other than fisheries and related activities, there are other environmental issues that have been observed on the landing sides, such as salinity changes due to Maduru Oya mixing, agriculture runoff, mangrove exploitation, invasive alien species, and illegal construction and land filling. The effects of lack of enforcement mechanism of management rules and regulations and failures in monitoring can lead to the depletion of lagoon fishery resources were stressed in FAO, 2012. Moreover, Miththapala, (2013) indicated the importance of lagoon environment but due to overexploitation, illegal fishing, coastal infrastructure, aquaculture development and pollution, habitat destruction, eutrophication, changes in sedimentation and waterflow may occur.

CONCLUSIONS

During the survey, it was found that a total of 12 types of fishing gear, and the outrigger lagoon canoe (Thoni) are used in the Valaichchenai lagoon. A total number of 38 species were identified at the landing site. In marketing, fish vendors play a major role, and a small number of fishermen directly market their catches. Supply chain includes both local and foreign market interventions. On average, fishermen caught 0.016 kg/net square meter-day and 2.140 kg/day using a gill net and cast net respectively. For sustainable fishery, regulation for mesh sizes and certain unauthorized activities, a licensing system, penalties or imprisonment according to the level of violations, and seabass cage culture are taking place in the Valaichchenai lagoon, but the implementations are inadequate to manage the lagoon in a sustainable manner. The environmental impacts associated with irresponsible fisheries, shrimp farm/aquaculture and Valaichchenai fishery harbor are deteriorate the water quality, visual pollution, oil spiling, sound pollution, etc. Solutions and recommendations for improving sustainable fishery and lagoon environmental protection, such as introducing co-management system, implementing voluntary code of conducts, strengthening rules and regulations implementation, conducting awareness and training

programmes and etc, will help the further management and development.

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EFFECTS OF "NEWLY MODIFIED PANCHAGAVYA" ON GROWTH, YIELD AND PEST INCIDENCE OF *Capsicum annuum* IN OPEN FIELD CULTIVATION

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ABSTRACT

The Panchagavya is an organic product derived from five products obtaining from cow and it can be modified by adding dry yeast to accelerate the fermentation process. The study was aimed to evaluate the effect of 'Newly Modified Panchgavya' (NMP) on growth, yield and pest incidence of Capsicum annum (variety- Muria 358 F1) in an open field condition. This experiment was carried out using Randomized complete block design (RCBD) with three replicates each contain 25 plants in open field in Bandarawela. The water (control), 3% NMP, 5% NMP and neem seed kernel extract were applied as treatments and data collected at weekly intervals. According to the study, NMP contains 2.76% N, 0.25% P, 2.41% K, 0.22% Mg, 0.0027% Fe and 0.003% ppm Cu. The application of 5% NMP showed significant ($P<0.05$) increment in number of leaves per plant from three weeks to eight weeks after planting. There was a significant ($P<0.05$) increment in plant height and yield compared to the control in plants treated with 5% NMP. The number of pest damaged leaves compared to the total numbers of leaves was lower in plants treated with 5% NMP. Thus, the study revealed that 5% NMP is applicable as an organic product to increase growth and yield while reducing pest damage for C. annum.

Keywords: Capsicum annuum, Growth, Modified, Neem Seed Kernel Extract, Panchagavya

INTRODUCTION

Vegetable cultivation is one of the main income sources of Up-country farmers and the area is very popular for exotic vegetables. Capsicum (*Capsicum annuum*) can be considered as a popular vegetable grown because it always fetches high market price (Weerakkody and Mawalagedera., 2020). Muria 358 F1 is a recently introduced exotic variety which popularized within short time. One of the main problems associated with capsicum cultivation, irrespective to varieties, is heavy use of agro-chemicals for pest/disease control and application of large quantities of synthetic fertilizers to get high yield (Hasan *et al*., 2019; Latifah *et al*., 2019). The overuse of chemical fertilizer and pesticides in vegetable cultivation make detrimental impact on human health and environment (Savci., 2012). Organic agriculture or cultivating crops without synthetic inputs is one of the popular ways to produce healthy foods under low environmental impact (Scialabba, and Hattam., 2002). There are many natural preparations used in organic agriculture which provide nutrients to plant and protect them from problematic pests and diseases. 'Panchagavya' is a popular organic fertilizer prepared by organic farmers in Tamil Nadu (Rakesh *et al*., 2017). They used five products obtained from cow to prepare the nutrient mixture as cow dung, cow urine, milk, curd and ghee (Ram., 2017). The organic growers in Tamil Nadu widely use Panchagavya for agricultural and horticultural crops (Sinha., 2014). Panchagavya contains several macro and micronutrients which are required for the growth and development of plants. It contains nutrients, various vitamins, growth regulators, and beneficial micro-organisms (Ram., 2017). It has the potential to promote growth and provide the resistance against pest and diseases (Raghavendra *et al*., 2014). Since the lactic acid forming bacteria Lactobacillus is present in Panchagavya, pH is low due to fermentation and the preparation is effective in killing the plant pathogens (Manthivanan *et al.*, 2006). Past studies have shown that there is a positive effect of panchagavya on plant growth and pest/disease management (Pramod *et al*., 2018). This study attempted to use it as an alternative nutrient source and pesticide in cultivating Capsicum variety Muria 358 F1. Here, the ordinary Panchagavya preparation used in India was slightly modified by adding dry yeast as a fermenting agent and nutrient source which accelerates the fermentation process. Therefore, this study was designed to study the effects of "Newly Modified Panchagavya" on

growth, yield and pest incidence of *Capsicum annuum* in an open field cultivation.

METHODOLOGY

Location and Experimental Design

This experiment was conducted in the open field in Banadarawela (IU_3), with maximum and minimum temperature that are ranged between 19-29^oC and 8-19^oC respectively and with an average annual precipitation of 1729 mm. Randomized Complete Block Design (RCBD) was used with three replicates and each replicate contained 25 plants.

Seed sowing and Nursery management

C. annum (variety: Muria 358 F1) seeds were sown in the nursery trays containing sterilized mixture of top soil: partially burned paddy husk at the rate of 1:1 as the nursery media. Prepared nursery trays were kept in the polytunnel and practiced daily watering.

Pot preparation and Transplanting

Poly bags (30 cm x 35 cm, Gauge 300) were filled using the mixture of top soil: compost: partially burned paddy husk at the rate of 3:2:1. The compost used for the study was bought from a private seller. Planting pots were arranged in 40 cm * 40 cm spacing in an open field. Potting media was sterilized using 2g/L captan solution. Basal inorganic fertilizer mixture was applied to planting pots according to the Department of Agriculture. The seedlings were transplanted in the polybags.

Preparation of NMP

Cow dung (1 kg) and cow ghee (142 g) were added into a wide mouthed plastic barrel and stirred using a wooden stick. After, covered using an insect-proof net and it was kept in shade for 3 days. Then, cow urine (1 l) and water (1 l) were added and mixed properly. It was kept in shade for 15 days after covering it. The prepared mixture was stirred daily to facilitate fermentation. After another 15 days, milk (430 ml), curd (285 ml), young coconut water (200 ml), two ripen bananas and yeast (10 g) were added, kept in shade and practiced daily stirring. Prepared mixture was strained after 15 days. Finally, NMP Mixture was stored in a plastic bottle. Nutrient status, pH and EC of Newly Modified Panchagavya were analyzed at the soil and plant laboratory of Tea Research Institute (TRI), Thalawakale.

Preparation of Neem Seed Kernel Extract

Well dried neem seeds (1 kg) were ground to make fine powder. The water (2 L) were added and kept for overnight after closed. Then, the mixture was strained.

Application of Treatments

Following four treatments were used for the experiment with three replicates. Each replicate consisted of 25 plants.
T1 – Water
T2 – NMP 3% solution
T3 – NMP 5% solution
T4 – Neem Seed Kernel Extract
The application concentration of newly modified panchagavya as 3%, 5% was decided based on the pre-trials. The 2.5 L of any treatment were applied for 25 plants as foliar application in first month after planting. Then, the application amount was increased up to 5 L from two months after planting.

Management practices

All management practices were done according to the recommendation of Department of Agriculture.

Data collection

The total number of leaves and the number of leaves damaged by pest such as trips, aphids, mites and white flies were counted. Number of leaves and numbers of pest damaged leaves per plant was counted and recorded manually. Data collection was done once a week starting from 2 WAP to 8WAP. Plant height was measured weekly starting from one WAP and recorded. Yield was measured using electronic scale and recorded.

Data analysis

The data were statistically analyzed using the Analysis of Variance (ANOVA) to detect the significance at the treatment level. The difference between treatments was compared by the Tukey test at 95% confidence using Minitab17.

RESULTS AND DISCUSSION

Nutrient composition of NMP

According to the analysis of NMP in the soil and plant laboratory of Tea Research Institute (TRI), Thalawakale, NMP comprises 2.76% N, 0.25% P, 2.41% K, 0.22% Mg, 0.0027% Fe and 0.003% ppm Cu. A past research on panchagvaya has shown that, it contained 1000 ppm total nitrogen, 175. 40 ppm total phosphorous, 194. 10 ppm total potassium, 1.27 ppm total zinc, 0.38 ppm total

copper, 29.71 ppm total iron and magnesium (Rawat *et al.*, 2020). The effect of different treatments on growth, yield and pest damage were given below (Table 1)

Table 1: Effects of different treatments on number of leaves, Number of damage leaves, Plant height and Yield

Parameter	Treatment	1 WAP	2 WAP	3 WAP	4 WAP	5 WAP	6 WAP	7 WAP	8 WAP
NOL	Water	4.30^{a}	9.50^{a}	13.40^{c}	17.70^{c}	22.20^{c}	25.70^{c}	29.60^{c}	34.20^{c}
	3% NMP	4.30^{a}	10.26^{a}	17.50^{b}	25.00^{b}	33.10^{b}	44.00^{b}	55.40^{b}	68.40^{b}
	5% NMP	4.46^{a}	10.40^{a}	22.00^{a}	33.10^{a}	45.70^{a}	60.23^{a}	76.70^{a}	95.60^{a}
	NSKE	4.50^{a}	10.20^{a}	16.9^{bc}	22.70^{bc}	29.30^{bc}	35.40^{bc}	41.60^{bc}	48.10^{bc}
	P	0.407	0.091	0.001	0.001	0.000	0.000	0.000	0.000
NDL	Water	-	2.40^{a}	11.20^{a}	15.60^{a}	20.40^{a}	24.40^{a}	28.50^{b}	33.00^{c}
	3% NMP	-	2.34^{a}	9.00^{a}	13.90^{a}	22.10^{a}	31.30^{a}	41.46^{a}	53.50^{a}
	5%NMP	-	2.54^{a}	10.10^{a}	17.50^{a}	26.60^{a}	32.30^{a}	37.60^{ab}	43.20^{b}
	NSKE	-	2.30^{a}	11.40^{a}	18.50^{a}	25.30^{a}	31.30^{a}	38.60^{ab}	45.33^{b}
	P	-	0.498	0.427	0.232	0.419	0.226	0.048	0.000
PH	Water	6.36^{a}	9.96^{a}	11.24^{b}	12.63^{b}	14.04^{b}	15.46^{b}	16.73^{b}	18.01^{b}
	3% NMP	6.15^{a}	10.72^{a}	14.03^{ab}	17.21^{a}	20.57^{a}	23.91^{a}	27.07^{a}	30.37^{a}
	5% NMP	6.21^{a}	10.78^{a}	14.96^{a}	18.77^{a}	22.61^{a}	26.19^{a}	30.01^{a}	33.56^{a}
	NSKE	6.40^{a}	10.61^{a}	13.28^{ab}	15.89^{ab}	18.44^{ab}	21.00^{ab}	23.72^{ab}	26.21^{ab}
	P	0.395	0.681	0.018	0.004	0.004	0.003	0.0003	0.004
Yield	Water					7.20^{b}	10.09^{b}	6.70^{b}	5.80^{b}
	3% NMP					16.20^{b}	22.40^{ab}	24.80^{a}	15.80^{ab}
	5% NMP					36.90^{a}	38.40^{a}	36.50^{a}	14.90^{ab}
	NSKE					22.90^{ab}	21.80^{ab}	22.40^{ab}	24.70^{a}
	P					0.008	0.023	0.006	0.034

Means followed by the same superscripts are not significantly different (P<0.05) according to Tukeys test, WAP – Weeks After Planting; NMP –Newly Modified Panchagawya; NSKE – Neem Seed Kernel Extract; NOL-number of leaves; NDL-Number of damage leaves; PH-Plant height; Y-yield

Effects of different treatments on the total number of leaves

The highest number of leaves per plant was recorded with 5% NMP (T3) followed by 3% NMP (T2) in this experiment (Table 1). There was no significant difference (P>0.05) among treatments on the number of leaves of *Capsicum annum* plants in 1 and 2 WAP. There were significant differences (P<0.05) among treatments in 3 WAP to 8 WAP. T3 (5% NMP) had a higher performance on number of leaves of plants than other treatments. This may be due to the micro and macro nutrients and plant growth hormones present in NMP. The panchagavya contains macro and micronutrients such as nitrogen, potassium, sodium. molybdenum, magnesium, iron and phytohormone such as auxins, cytokinin, gibberellin (Uthirapandi *et al*., 2018). Ashwagandha plant sprayed with panchagavya, produced higher number of leaves per plant (Mohanlakshmi *et al.*, 2008). The total number of leaves and nodules of panchagavya applied Sounthern sunnhemp plants increased than the control plants (Vallimayil and Sekar., 2012).

Effect of different treatments on number of pest damaged leaves

There was no significant difference on leaves damaged by pest such as trips, aphids, mites and white flies of this experiment in 2 WAP to 6 WAP (Table 1). There was a significant difference among treatments on 7 WAP and 8 WAP. Although, the lowest number of damaged leaves recorded from T1 (33) at 8th week, the highest pest damaged was recorded from T1 considering the total number of leaves presence at 8th week. When comparing T3 (5% NMP) with the no. of leaves at 8thweek, it showed better results on pest control. The past studies showed, the panchgavya increased the immunity of plants and gave resistance against the pest and diseases (Raghavendra *et al*., 2014). The application of panchagavya reduced the shoot and fruit borer (*Earias vittella*) population *in vitro* condition (Pazhanisamy and Archunan., 2019)

Effect of different treatments on number of plant height

Plant height was not significantly differed at 1 WAP and 2 WAP in this experiment. After 3 WAP

to 8WAP there was a significant difference among treatments. The highest plant height was recorded as 33.565 cm in T3 (5% NMP) followed by T2 (3% NMP). It showed that NMP can accelerate the growth of plants. The application of panchagavya recorded higher plant height which facilitates rapid cell division and multiplication due to the growth enzymes present in it might be the possible reason for the high growth characters (Sanjutha *et al*., 2008). The application of panchagavya increases the plant height, number of fruits, number of branches and weight of single fruit of *Solanum melongena* (Swarnam *et al*., 2016).

Effects of different treatments on plant yield

According to this experiment, there were significant differences among treatments (Table 1). The highest yield found that plants treated with 5% NMP (T3) and the lowest yield found from T1 (water) in 5WAP to 7 WAP. This might be due to the nutrition, growth promoting hormones and pest controlling ability included in NMP. Past researchers investigated that the influence of liquid organic manures such as Panchagavya, Jeevamruth, and Beejamruth on the growth, nutrient content and yield of tomato and found that the panchagavya is an efficient plant growth stimulant that enhances the biological efficiency of crops (Gore and Sreenivasa., 2011). It is used to activate biological reactions in the soil and to protect the plants from disease incidence.

CONCLUSIONS

Results revealed that Newly Modified Panchagawya at 5% concentration increased plant growth and reduced pest damage. Neem Seed Kernel Extract (NSKE) has a proven efficacy as a pesticide and the present study showed NMP is equally performed as NSKE against pests. Therefore, it can be concluded that NMP is a good alternative nutrient source and a pesticide which can replace certain amount of synthetic chemicals in agriculture.

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GROWTH AND YIELD RESPONSE OF CHILLI (*Capsicum annum* L) FOR THE COMBINED ORGANIC AND INORGANIC FERTILIZER APPLICATION

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ABSTRACT

It is well known that the overuse of inorganic fertilizers has catastrophic impacts on forms of life and the environment. In chemical fertilizers, Nitrogen is one of the main elements that has a high leaching potency which leads to pollute both surface and groundwater resources. This study was carried out to identify the best organic and inorganic fertilizer combination that gives the highest yield in MI-Green. The treatments are 3 kg/pot cow dung (control 1), (T1), 2 kg/pot cow dung (control 2) (T2), 2 kg/pot cow dung + foliar urea spray (T3), 2 kg/pot cow dung + urea soil application (T4), 3 kg/pot cow dung+ foliar spray (T5) and 3 kg/pot cow dung + Urea soil application (T6). Results disclosed a significant effect ($p<0.05$) on growth and yield in T5. Hence, it can be concluded that 3kg/pot cow dung+ foliar spray combination can be used to improve the growth and yield of MI-Green chilli.

Keywords: Cow dung, Growth and yield parameters, Urea foliar spray

INTRODUCTION

The Sri Lankan government banned the import of synthetic fertilizers and agrochemicals recently (Beillard et al., 2021). Hence there is a growing trend for organic farming within the country. Organic farming recycles and mineralizes nutrients from organic matter to ensure sustainable production and reclaiming the degraded soil (Are et al., 2017). There was low soil fertility is in a large part of the lands in Sri Lanka too; mainly because of the high yielding varieties, the application of excessive inorganic fertilizers and inadequate nutrient replacement; while over-fertilization results in the accumulation and leaching of nitrate residuals that directly contribute to the pollution of ground water apart from the low soil fertility (Biosci et al., 2012). Consequently, the application of inorganic fertilizers to the soil should be shifted to the application of inorganic compounds in liquid form which is known as foliar-feeding. The foliar spray is absorbed through the plant leaf surface (Manasa et al., 2015). In foliar fertilization, urea is the most broadly used nitrogen source due to its non-polar nature. Hence, foliar-feeding is needed to introduce in every possible vascular plant which has a reasonable leaf area with appropriate concentrations and timing. There is a high probability of reducing the arable lands due to soil infertility and soil degradation in the distant future if current fertilizer practices are not changed in an environment-friendly way. The importance of foliar spraying of water-soluble fertilizers to overcome micro and macronutrient deficiencies in the soil is immensely felt these days because of the adaptation to high chemical inputs (Garhwal et al., 2007). Beneficial activities of soil microbes can be improved by organic manure through the supply of carbon-rich organic compounds (Knapp et al. 2010). The organic matter added to the soil is a favourable remedy to enhance soil fertility and reclamation of the already degraded soil. Considering the above facts; the objectives of this study were meant to identify the best combination of urea and soil application of cow dung as an amendment on MI-Green chilli growth and yield indices, as well as the best combination to produce a better yield.

METHODOLOGY

The experiment was carried out at Aquinas farm in Ragama which belongs to the WL3agro-ecological zone. The experiment was conducted during the period from September 2019 to January 2020 in the Maha season. The MI-Green variety was used in this study which performs well in all chilli growing areas and it has broad and long leaves. The soil media for the pots has a pH of 6.3 and available Na, Ca, K and Mg are 86, 1260, 1520 and 484 mg/Kg respectively which were determined according to AOAC 2006.03., (2009) and the official analysis method (Hall William., 2006). For the potting mixture of topsoil, sand, coir dust and compost, 5 parts from each were applied for all treatments (Mudalagiriyappa et al., 2016). The cow

dung sample was analyzed by wet oxidation by nitric–sulphuric-perchloric acid and then the filtrate was used to determine N, P, K Ca and Mg. Nitrogen was determined by the Micro-Kjeldahl method, Potassium was determined by flame photometer while calcium and magnesium were determined by AAS (Atomic absorption spectroscopy).

The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications with the total number of unit pots was 18 in a block. There were 6 treatment combinations as follows. 3kg/pot cow dung (control 1)(T1), 2kg/pot cow dung(control 2)(T2), 2 kg/pot cow dung + foliar urea spray (T3), 2 kg/pot cow dung + urea soil application (T4), 3 kg/pot cow dung+ foliar spray (T5) and 3 kg/pot cow dung + Urea soil application (T6).According to (Biosci et al., 2012); (3 kg/pot), organic manure with NPK exhibited a significant effect on growth parameters in chilli.The dimension of each pot was approximately 23 cm (diameter) × 38 cm (height). Spraying was carried out every 15 days of the interval as it was the standard foliar treatment practice (Deore et al., 2010). In this study, 2% (v/v) urea solution (Venkatesh et al., 2011), was applied and it was prepared by using 20g of urea dissolved in one-litre water (2g urea/100 ml). In treatments 4 and 6, fertilizer was applied to the soil as urea 35kg/ha as basal dressing before sowing seeds and as top dressing urea, 30 kg/ha applied at flowering (Mudalagiriyappa et al., 2016). Two plants/pots were maintained 2 weeks after sowing. In this study, Glycerin was used as the surfactant and applied before applying foliar treatments (Fernandez et al., 2013). Water/glycerin spray was prepared by mixing water with glycerin in a 10:1 ratio. The growth parameters, yield and yield-related parameters were taken as response variables in this study. The canopy size was taken by measuring the diameter of the plant which was taken from north to south and east to west directions of the above-ground part of plants at 90 DAS. Plant volume (cm^3) was measured using the formula (V) = 1/6× π × height × D2) where, D was the average value of north-south and east-west spreading of the canopy at 90 DAS (Mandal et al., 1984). The data obtained on these various parameters were analyzed by using ANOVA at $p<0.05$. The significance of the difference between pairs of means was tested by the Least Significant Difference Test (LSD) at the level of 0.05 whereas Pearson correlation and R-sq were also calculated to identify the degree of relationship among the specified variables.

RESULTS AND DISCUSSION

Cow dung sample

Nutritional composition of cow dung was used in this study had 18.6% organic matter, 2.8% Nitrogen, 0.34% Phosphorus, 0.48% Potassium, 0.21% Calcium and 0.26% Magnesium.

Plant height

The highest average plant height 18.6 cm at 30 DAS was recorded in T5 whereas the least average plant height 9.7cm was in T2. There is a significant ($P < 0.05$) difference in plant height at 30 DAS between T2 and T4 (Difference between two different treatment mean (τ_1-τ_2) = 6.5> LSD = 3.2). Ahmed et al., (2007) stated that nitrogen application resulted in maximum plant height which was identified in the present study too. The highest average plant height of 53.5cm at 90 DAS was recorded in T5 whereas the least average plant height 36.7cm was in T2. There is a significant ($P< .05$) difference in plant height at 90 DAS between T5 and T6 (τ_1-τ_2 =13.2 >LSD =7.1) (*Table 1*). When applying urea as a foliage application it can facilitate the good provision of nitrogen to soil while minimizing nitrogen leached to the environment (Witte et al. 2002). Therefore a significant difference can be identified among T5 and T6.

Number of branches

The highest number of branches (4) at 30 DAS was recorded in T3, T4 and T5 whereas the least number of branches (2) was in T1 and T2. There is no significant ($p>0.05$) difference among treatments on 30 DAS. The highest number of branches (7) at 60 DAS was recorded in T5 whereas the least number of branches (4) was in T1 and the highest number of branches at 90 DAS was recorded in T5 whereas the least number of branches was in T1.There is a significant ($p< 0.05$) difference in plant height at 90 DAS between T5 and T1 (τ_1-τ_2 =8>LSD =3.6) (*Table 1*).Nitrogen has a considerable effect on the number of branches/plants during the vegetative stage where, these findings were agreed with the findings of (Sarker et al., 2018).

Plant volume (cm^3)

The highest plant volume (1309 cm^3) was recorded in T5 where the lowest spreading (693.2 cm^3) was in T2. There was a significant ($p <0.05$) difference in plant volume in T5 and control 1(τ_1-τ_2 =555.9 >LSD = 223.7) whereas T3 and control 2 (τ_1-τ_2

=304.3>LSD = 223.7)(*Table 2*).Nitrogen increases the vegetative growth of the plants (Baloch, 2008). As stated by Aliyu et al. (2000); plants with a wider crown yielded more than those with a smaller crown whereas wider canopy diameter could produce more pods, due to the increased number of secondary and tertiary branches which result in high plant volume at last.

Days to 50% of flowering

The earliest number of days (51 days) to reach 50% flowering was observed in T5. While the longest days (83 days) to attain 50% flowering was recorded in T2 which is statistically different ($p < 0.05$) from T3 (τ_1-τ_2 = 2.1> LSD = 8.1)(*Table 2*). This might be due to the improvement in soil physical condition for the plant growth along with the increased availability of nitrogen.

The number of flowers / plant

The highest number of flowers at 60 DAS (19 flowers) was recorded in T5 whereas the least (7 flowers) was in T2. There was a significant ($p < 0.05$) difference in T5 and T1 (τ_1-τ_2 =9> LSD =4.7)(*Table 2*). These results were inagreement with those of (Natesh et al ., 2010)who reported that the number of fruit per plantincreased when organic manure was combined with nitrogen application.

The number of pods/ plants

The highest number of pods (15 fruits) at 90 DAS was in (T5) whereas the least (4fruits) was in T2. There was a significant ($p < 0.05$) difference in T5 and T1 (τ_1-τ_2 = 9> LSD = 3.4) (*Table 2*). Abid et al.,(2014), stated the highest number of fruits per plant might be due to the vigour of the plant and more number of leaves per plant.

Seed numbers/pod

The highest seed numbers (87 seeds) per pod were in T5 and the least (51 seeds) seeds number per pod was in T1. There was a significant ($p < 0.05$) difference in T5 and T6(τ_1-τ_2 = 30 > LSD = 14.9)(*Table2*).

Pod weight (g)

Among the treatments, T5 recorded the highest average pod weight (12.5g) and the lowest (6.2 g) was in T1. There was a significant ($p < 0.05$) difference in T5 and T6 (τ_1-τ_2 = 3.2 > LSD = 1.2) and also there was a significant ($p < 0.05$) difference in T1 and T6 (τ_1-τ_2 =3.1 > LSD = 1.2)(*Table 3*). Similarly, the highest pod weight was obtained by (Abid et al. 2014) inchilli plants treated with organic fertilizers.

Pod length (cm)

The highest pod length (6.8 cm) was in T5 and the least diameter (4.4cm) was in T4. There was a significant ($p < 0.05$) difference in T4 and T5 (τ_1-τ_2 =2.4 > LSD = 1.1) (*Table 3*).Correspondingly (Roychaudhury et al. 1997) observed an improvement in fruit size with increasing nitrogen contents in organic fertilizer.

Pod girth (cm)

The highest grith (2.6 cm) was in T5 and the least grith (1.5 cm) was in T1. There was a significant ($P<.05$) difference in T1 and T5 (τ_1-τ_2 =1.1 > LSD = 0.8) (*Table 3*). The effect of organic manure with various levels of inorganic fertilizer had a significant impact on fruit girth (Akanbi et al., 2007).

Pod pericarp weight (g)

The highest pod pericarp weight (4.7 g) was in T5 and the least pericarp weight (1.6g) was in T2. There was a significant ($p < 0.05$) difference in T1 and T5 *(τ_1-τ_2 =1.4> LSD = 0.2) (Table 3).*

Yield / Plant (g)

The highest yield per plant (3.1g) was in (T5) whereas the least (1.9g) was in (T2). There was a significant ($p < 0.05$) difference in T1 (control 1) and T5 (τ_1-τ_2 =0.9 > LSD = 0.6) and control 2 treatment *with T3(τ_1-τ_2 =0.8> LSD = 0.6) (Table 3).*

Final yield (t/ha)

The highest final yield (15. 2 t/ha) was in T5 whereas the least (9.7 t/ha) was in T2 and there was a significant difference ($p < 0.05$) in the final yield of control 1 treatment with T5 (τ_1-τ_2 =4< LSD = 3.8) and control 2 treatment with T3 (τ_1-τ_2 =4.1< LSD = 3.8)(*Table 3*). Hence it was obvious that urea foliar application combined with cow dung treatment had a significant effect on final yield.

According to the DOA, the average yield of the MI-Green variety during the Maha season was 15 t/ha. Laxman *et al.*, (2000), indicated that yield attributes of chilli were highly influenced by the foliar spray of urea. Similar to the present study; Chopra et al., (2005) observed that combining organic and inorganic nutrients increased the production of chilli genotypes. Azad (2000) claimed that using a combination of manures and chemical fertilizers resulted in the highest cabbage

plant height. In a similar study, Ashrafi et al. (2010) discovered that adding organic manure and NPKS to rice plants enhanced growth and yield parameters. Moreover, the results of this study also revealed the beneficial effect when combined organic manure with foliar urea application because organic fertilizers improve soil structure while increasing the performance of beneficial soil organisms (Ouda et al., 2008).

Table 1: Effect of different treatments on the plant height and number of branches at 30, 60, 90 (DAS) in MI-Green chilli.

Treatments	Plant height (cm)			The number of branches per plant		
	30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS
$T1_{(Control\ l)}$	10.8	24.7	39.6	2	4	7
$T2_{(Control\ 2)}$	9.7	22.2	36.7	3	6	9
T3	14.5	29.9*	39.5*	4*	6*	10*
T4	16.2	31.6	41.3*	4*	6*	9*
T5	18.6	37.2	53.5	4*	7*	15
T6	11.7*	30.5*	40.3*	2*	6*	9*
$LSD_{(0.05)}$	3.2	8.4	7.1	2.9	4.7	3.6

**Value followed by the asterisk in the same columns is not significantly different with the respective control treatment at LSD test (p<0.05)*

Table 2: Effect of different treatments onplant volume, days to 50% flowering, flowers/plant, pods/plant and seeds/pod in MI-Green chilli.

Treatments	Plant Vol (cm^3)	Days to 50% of flowering	Flowers /plant	Pods/ plant	Seeds/ pod
$T1_{(Control\ l)}$	753.1	67	10	6	68
$T2_{(Control\ 2)}$	693.2	83	7	4	52
T3	997.5	62	8*	5*	80
T4	793.9*	72	17	10	60*
T5	1309	51	19	15	87
T6	787.1*	82	14*	8*	57*
LSD	223.7	8.1	4.7	3.4	14.9

**Value followed by the asterisk in the same columns is not significantly different with the respective control treatment at LSD test (p<0.05)*

Table 3: Effect of different treatments on, pod weight, pod grith and pod pericarp weight, yield/plant and final yield in MI-Green chilli.

Treatments	Pod Weight (g)	Pod Grith (cm)	Pod pericarp weight (g)	Yield/ plant (g)	Final Yield (t/ha)
$T1_{(Control\ l)}$	9.9	2.1	3.3	2.2	11.2
$T2_{(Control\ 2)}$	6.2	1.5	1.6	1.9	9.7
T3	8.8	2.4	2.7	2.7	13.8
T4	8.2	2*	2.8	2.4*	12.4*
T5	12.5	2.6	4.7	3.1	15.2
T6	9.3*	1.8*	3.0*	2.6*	12.8*
$LSD_{(0.05)}$	1.2	0.8	0.2	0.6	3.8

**Value followed by the asterisk in the same columns is not significantly different with the respective control treatment at LSD test (p<0.05)*

Control 1 = 3kg /pot Cow Dung, Control 2 =2 kg/pot cow dung,T3= 2 kg/pot cow dung + foliar urea spray, T4= 2 kg/pot cow dung + urea soil application, T5= 3 kg/pot cow dung+ foliar spray, T6= 3 kg/pot cow dung + Urea soil application. DAS= Days after sowing.

A positive correlation between plant volume (cm^3) and Yield (t/ha) was observed (*Figure1*). The relationship between plant volume (cm^3) and Yield (t/ha) was expressed by the regression equation Yield = 11.24 + 0.0025 Plant Volume. Pearson correlation of yield and plant volume = 0.249 and

P-Value = 0.142; therefore, there was no correlation between yield and plant volume (p> 0.05).

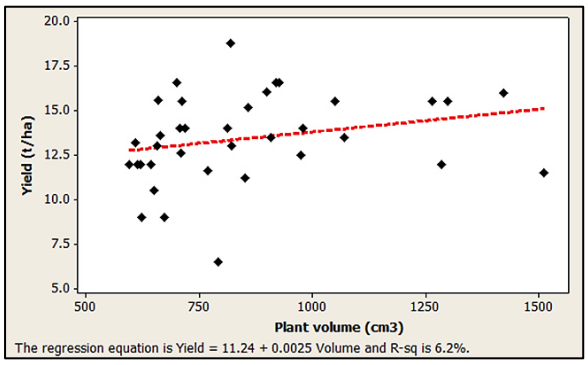

Figure 1: Relationship between plant volume with the average yield.

CONCLUSIONS

When considering growth parameters, the highest plant height, plant volume, the number of branches/ plant and early days to 50% flowering was reported in 3 kg/pot cow dung+ foliar spray (T5). Among yield and yield-related parameters, the highest number of pods/plant, pod weight, the highest yield/plant (g) and final yield (t/ha) were in 3 kg/pot cow dung+ foliar spray (T5). The highest pod length, pericarp weight, pod grith and the number of seeds per pod were also recorded in (T5).

Results disclosed that the best treatment combination to gain a high yield was 3 kg/pot cow dung+ foliar spray (T5). From the above results, it can be concluded that the tested 3 kg/pot cow dung+ foliar spray combination can be used to improve the growth and yield of MI-Greenchilli.

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EFFECT OF GAMMA IRRADIATION ON SURVIVABILITY, GROWTH PERFORMANCES AND FLORAL CHARACTERS OF *Jasminum officinale* (Samanpichcha)

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ABSTRACT

Physical mutagenesis is an effective mutational breeding method for improving various growth and floral characteristics of ornamental plants. The experiment was undertaken with an objective to investigate the effect of various dosages of gamma irradiation on survivability, growth and floral characteristics of Jasminum officinale plants raised by rooted cuttings. The ^{60}CO Gamma irradiation source at Horticultural Crop Research and Developmental Institute, Gannoruwa was used to expose rooted plants to different dosages such as 0Gy, 17Gy, 21Gy, 25Gy, 29Gy and 33Gy. A Complete Randomized Design with four replicates having 10 plants for each replicate was practiced. The results revealed that gamma irradiation dosage from 25Gy to 33Gy significantly decreased the survivability of J. officinale plants ($P<0.05$). LD_{50} of gamma radiation on J. officinale was occurred around 33Gy at maturity stage. Plant height and shoot length were significantly reduced by gamma irradiation dosages of 17Gy to 33Gy compared to the control and significant reduction of shoot number was observed at 33Gy. Gamma irradiation with 17Gy dosage, it showed a significant reduction in petal width (0.82 cm) of flowers. None of the other dosages were able to develop a change in the floral characteristics of J. officinale. The study showed that 33Gy gamma irradiated plant, it is having significant reduction of plant height, number of shoots and shoot length hence it could be domesticated as a dwarf and potted plant.

Keywords: Dosage, Gamma irradiation, Jasminum officinale, Rooted cuttings, Survivability

INTRODUCTION

Jasminum officinale (Samanpichcha) is one of the most demanding indigenous flower species in Sri Lanka which is belonging to the family Oleaceae. The genus consists with around 200 species. This plant is used for perfume industry as a flavoring agent and various cosmetics and medicinal purposes.

When considering this plant as a floriculture crop, it has a limited variation of plant and flower characteristics as this plant is a vegetatively propagated plant. Therefore, creating a variation through induced mutagenesis is more important to promote this plant as a home gardening plant around Sri LankaGenerally, physical and chemical mutagen were used to produce new varieties with better characteristics of their genetic variation (Kaushik., et. al., 2015). Properties of mutagens, treatment duration, pre and post treatments, and temperature are the several influencing factors for effectiveness of mutagens. In any mutagenesis method, the dose of applying the mutagen is an important factor. It was noticed that the greater biological damage observed at higher concentration of mutagens (Rajib and Jagatpati, 2011).

Therefore, the present experiment was carried out to study the effect of different dosages of gamma irradiation on survivability, growth performances and floral characteristics of *Jasminum officinale*.

METHODOLOGY

Experimental Site

The experiment was conducted during the period of June 2020 to October 2020 at the Institute for Agro- technology and Rural Science, University of Colombo, Weligatta, Hambantota located in Dry Zone of Sri Lanka where the mean annual rain fall is 1250mm-1500mm and mean annual temperature

is 29 ºC-33ºC. Soil types of the area are Reddish Brown Earth and Low Humic Gley soil.

Planting materials

Four months old healthy, 8cm height Jasmin plants, were used for the study. All plants were raised as shoot tip derived cuttings in 5cm height × 4cm width poly bag containers filled with sand: compost 1:1 (v/v) media.

Gamma irradiation

Jasminum officinale potted plants were treated with gamma radiation at Horticultural Crops Research and Development Institute (HORDI), Gannoruwa, Sri Lanka. ^{60}Cobalt Gamma irradiator source was used to treat the plants and five gamma ray doses (17Gy, 21Gy, 25Gy, 29Gy and 33Gy) were selected as treatments.

Post treatment cultural practices

Treated plants were established in 12.5cm height × 10cm width black poly bag containers with 250-gauge and filled with sand: compost 1:1 (v/v) media. Plants were kept under a shade house and maintained under uniform conditions provided with equal irrigation using a measuring can. Subsequently, the growing plants were transferred to 30cm diameter pots with topsoil: sand: compost 1:1:1 (v/v) media at 8 weeks after the treatment as they were starting to produce new shoots and not enough the small pot for further growth and development.

Evaluation of survivability, growth, and yield performances of treated plants

The data recorded were used to calculate the percentage of survival at six months that is at their maturity. It was calculated for each treatment as the ratio of alive (survived) plants to the total number of plants treated and established.

Survival % = (No. of survived plants/ No. of gamma irradiated plants) ×100

The plant growth parameters: plant height and shoot length were recorded using the measuring tape in cm and number of shoots were recorded by counting. Petal length, petal width, flower diameter and stalk length all in cm were recorded using a foot ruler and a vernier caliper at the flowering stage as flower characters.

Experimental design and Statistical analysis

The experimental design was Completely Randomized Design (CRD) with 5 treatments excluding non-treated plants as the control. Four replicates per treatment were maintained with 10 plants per each replicate accounting total of 40 plants per treatment. The data were statistically analyzed using Minitab 17 software. One- way ANOVA general linier model test was performed while Dunnett and Tukey tests were used to ascertain the significant differences among treatments at 0.05 significant level.

RESULTS AND DISCUSSION

Survivability of gamma irradiated plants

Table 1: Effects of Gamma irradiation on survivability of *Jasminum officinale* plants

Treatments	Survival % at 6th month after the treatment
0 Gy (T0)	97.5^{a}
17 Gy (T1)	97.5^{a}
21 Gy (T2)	90.0^{a}
25 Gy (T3)	67.5^{b}
29 Gy (T4)	60.0 ^{b}
33 Gy (T5)	50.0 ^{b}

Column having same letter are not significantly difference at p< 0.05

After six months from treatment application, no significant difference was observed in the percentage of survival of plants in gamma irradiated dosages at 17Gy and 21Gy with compared to the control (Table 1). But survival percentage was significantly decreased when increased the gamma irradiation rate at 25Gy, 29Gy and 33Gy. LD_{50} value was calculated according to the 50 percent survival rate in maturity stage of J. *officinale* after exposing the gamma irradiation as 33Gy. The reduction of the survivability after the gamma irradiation may be due to the drop of auxin level resulting the poor establishment and chromosome aberrations created by mutagenic treatments. A study of Broerjest et. al., (2013), explained the substantial damage of meristematic cells and essential plant cell components at the physiological level of plants exposed to higher doses of gamma rays. The study carried out by Ghosh et. al., in 2018 reported that survival percentage of gamma treated cuttings ranging from 5Gy to 40Gy of different *Jusminum* species is varied with the species and recorded that LD50 value as 17.8Gy in *J. grandiflorum*, 28Gy in *J. multiflorum* and 25.1Gy in *J. nitidum*.

According to Rifnas et. al., (2020) a higher survival rate of *Allamanda cathartica* was observed in first few months of treated plants and when the plants are matured the dead plant number was increased. He also has explained that it is due to the damage of plant tissues and breakdown of meristem cells in the plants.

Growth performances of gamma irradiated plants

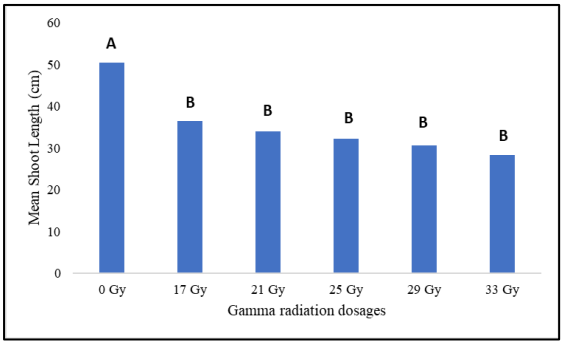

Figure 1: Effect of Gamma irradiation on plant height

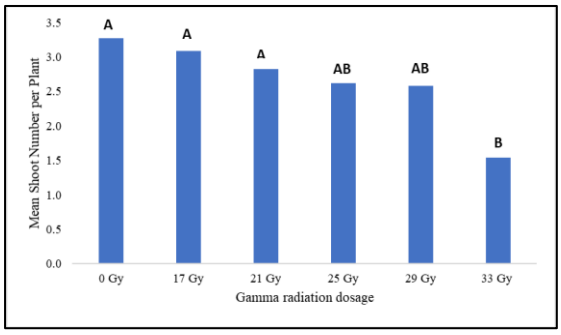

Figure 2: Effect of Gamma irradiation on number of shoots per plant

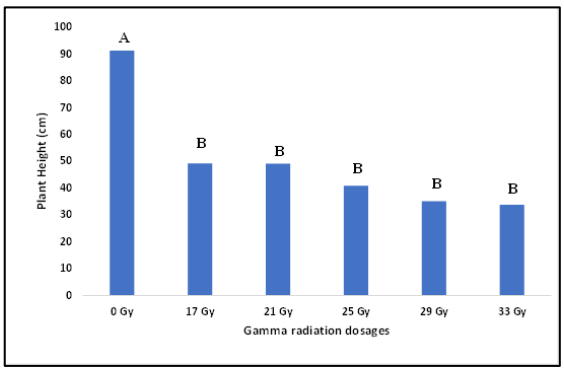

Figure 3: Effect of Gamma irradiation on shoot length

The results of effect of gamma radiation dosages on different growth parameters of *J. officinale* are represented in the Fig. 1, Fig. 2 and Fig. 3. These results showed that plant height (Figure 1), number of shoots (Figure 2) and shoot length (Figure 3) were significantly responded to the various irradiation treatments. It is interesting to note that the irradiation treatments have significantly reduced the plant height compared to the control plants ($P<0.05$) but among the treated plants, no significant difference was observed. The results revealed that the mean plant height ranged from 49.27cm (17Gy) to 33.79cm (33Gy) and the control recorded the maximum plant height as 91.2cm. Accordingly, 33Gy gamma irradiated plant has a considerable difference of its plant height with the control plant (Plate 1 to 6). Reduction of plant height is an advantageous character for an ornamental plant regardless of the gamma dosage. This retardation of plant height could be due to the effect of radiation on cells in apical buds and it may cause to decrease or inhibit the auxin content produced by those cells which restricts the elongation.

Ghosh et. al., (2020) has reported that, exposing the terminal cuttings of *Jasminum grandiflorum* to the gamma radiation doses ranging from 10-25 Gy has responded in plant growth parameters such as plant height, number of primary branches and leaf area. The variation was reduced with increase in gamma radiation dosage from 10Gy to 25Gy. According to their study the highest mean plant height (51.99cm) was recorded in the lower gamma dosage of 10Gy and the lowest mean plant height (47.77Gy) was recorded in 25Gy gamma dosage. Further they mentioned that the reason for progressive reduction of plant height is inactivating of auxin and decrease its content with the increasing of gamma ray dosages.

Previous studies showed that majority of the species which poses a reduction of plant height with gamma ray irradiations have been subjected to seed treatments rather than rooted cuttings/ plants. As stated by Pallavi et. al., (2017), decrease in the activity of meristematic tissue mitotic division as well as a decrease in the moisture content of the seeds develops dwarf plants. Therefore, we can suggest that the reduction of plant height depends on the planting material (seeds or rooted cuttings) used for irradiation.

Mean number of shoots per plant (Figure 2) also significantly affected by gamma irradiation treatments. The results shown that the mean shoot number (3.1) was recorded in 17Gy treatment, and the lowest mean shoot number (1.5) was recorded in 33Gy treatment while control having the highest mean shoot number (3.3). Significant reduction of shoot number per plant was observed only in 33Gy treatment when compared to the control and all other treatments in the experiment.

Plate 1: Vegetative growth of control plant (MPH:91.2cm)

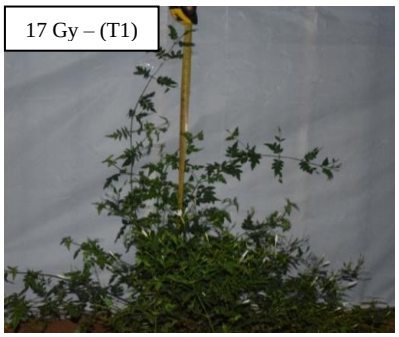

Plate 2: Vegetative growth of 17Gy (T1) plant (MPH:49.27cm)

Plate 3: Vegetative growth of 21Gy (T2) plant (MPH:49.08cm)

Plate 4: Vegetative growth of 25Gy (T3) plant (MPH:40.86cm)

Plate 5: Vegetative growth of 29Gy (T4) plant (MPH:35.17cm)

Plate 6: Vegetative growth of 33Gy (T5) plant (MPH:33.79cm)

Note: MPH – Mean Plant Height

This difference may be due to the restriction of multiplication of active cells that suppress the shoots development in 33Gy plants. A study of Gosh et. al., (2020) reported that the mean number of primary branches lower (2.78) in 25Gy and higher (3.98) in 15Gy when exposure *Jusminum grandiflorum* cuttings for gamma irradiation. According to the findings of Aisyah et. al., in 2005, survival rate, plant height and shoot number were reduced when exposures the rooted cutting plants of different *Jasminum* species to the gamma irradiation dosages of 50Gy and 55Gy. With the present study, It could be suggested that, lower plant height and less ability to initiate the higher number of shoots, 33Gy plant is appeared as a dwarf plant and it is better to domesticated as a potted plant in home gardening.

Further, gamma irradiation has significantly affected on shoot length (Figure 3) of *J. officinale* rooted cutting plants ($P<0.05$). Shoot length of all gamma irradiated plants was significantly decreased when compared to the control plants. Mean shoot length was recorded as 36.4cm in 17Gy and the lowest mean shoot length was 28.4cm in 33Gy gamma dosage while control having the highest mean shoot length of 50.4cm. There was no any significant difference observed among the treatments from 17Gy to 33Gy. The mean shoot length per plant shows a decreasing pattern parallel to the plant height. The explanation from Ghosh et. al., in 2018 supported to prove these results the influencing of mutagenic agent as an inhibitor for vegetative growth performances such as shoot length, number of leaves and leaf length can be shown a decreasing pattern with the increasing of gamma irradiation dosage (5Gy to 40Gy) on *Jasminum* spp and Kannan, (1994) mentioned that J. *sambac* is a woody perennial plant which is inhibitory influence of ionizing radiation was well established. .

However, when considering all above three parameters such as plant height, number of shoots per plant and shoot length, there is a high potential to domesticate 33Gy gamma irradiated plant as a dwarf potted plant as an value addition for traditional *Jasminum officinale* in home gardening.

Lack of information availability of previous studies could not find much similar or various results

regarding the gamma irradiation on J. *officinale* or on family Oleaceae. But some cases were reported on other crops in gamma irradiation. In 2004, Toker and Cagirgan reported that higher dosages of gamma irradiation in between 200Gy to 400Gy are affected to reduce the shoot length of seed germinated plants in chickpea. Tocker et. al., (2005) concluded that critical dosage for shoot and root elongation is varying among the species and in different genotypes in same species.

Flower yield and flower characteristics of gamma irradiated plants

Mean flower yield was not significantly affected by used gamma irradiation dosages ranging from 17Gy to 33Gy in *J. officinale* ($P>0.05$). Ghosh et. al., (2020) reported that in gamma irradiated J. *grandiflorum* plants ranging from 10Gy to 25Gy had not observed a significant change in flower yield and no increasing or decreasing trend followed by flower yield with the gamma ray dosages.

The results revealed that none of the used gamma irradiation doses for the experiment from 17Gy to 33Gy were enough to develop a significant change in considered floral characteristics (stalk length, bud length, petal length and flower diameter) of *J. officinale* ($P>0.05$) except the petal width. The petal width of flowers in 17Gy gamma irradiated plants showed a significant reduction ($P<0.05$) of their petal width (0.83 cm) when compared to the control (1cm). This reduction of petal width caused by lower concentration of gamma ray dosage (17Gy) may be due to the inhibitory influence on cell division and elongation. The used gamma irradiation range from 17Gy to 33Gy may be not strong enough to produce any mutagenetic change on floral characters in J. *officinale* rooted cutting plants. A study on *Jasminum* spp. Aisyah et al., (2005) has indicated that, when exposing the rooted cutting plants to gamma radiation dosages with 50 and 55Gy, it was affected the flowering period, reduced flower size, petiole length, stalk length, petal number and calyx number but did not observe any change in flower colour and aroma in all tested *Jasminum* species. Further he concluded that, 50Gy gamma ray dosage can create much frequent mutant than 55Gy gamma ray dosage in different *Jasminum* species.

CONCLUSIONS

It can be concluded that the higher dosages of gamma irradiations significantly decrease the survivability of *Jasminum officinale* rooted cuttings. LD_{50} of gamma radiation on *J. officinale* occurred as 33Gy at maturity stage. Vegetative growth on plant height and shoot length of *J. officinale* are significantly reduced with the gamma irradiation dosages of 17Gy, 25Gy, 29Gy, 33Gy and significant reduction of number of shoots was occurred at 33Gy. Gamma irradiation dosages from 17Gy to 33Gy were not enough to develop a change in the floral characteristics of stalk length, bud length, petal length, flower diameter of *J. officinale* and only the 17Gy gamma dosage was significantly affected for the reduction of petal width. Gamma irradiated plants in 33Gy have potential to develop as a domesticated dwarf potted plant of *J. officinale* since this dosage induced the smaller number of shoots, less plant height and less shoot length when compared to the control plants.

Hence it could be recommended that exposing the *Jasminum officinale* plants to the gamma irradiation dosages above 33Gy has the potential to generate attractive mutants but with reducing the mortality rate.

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