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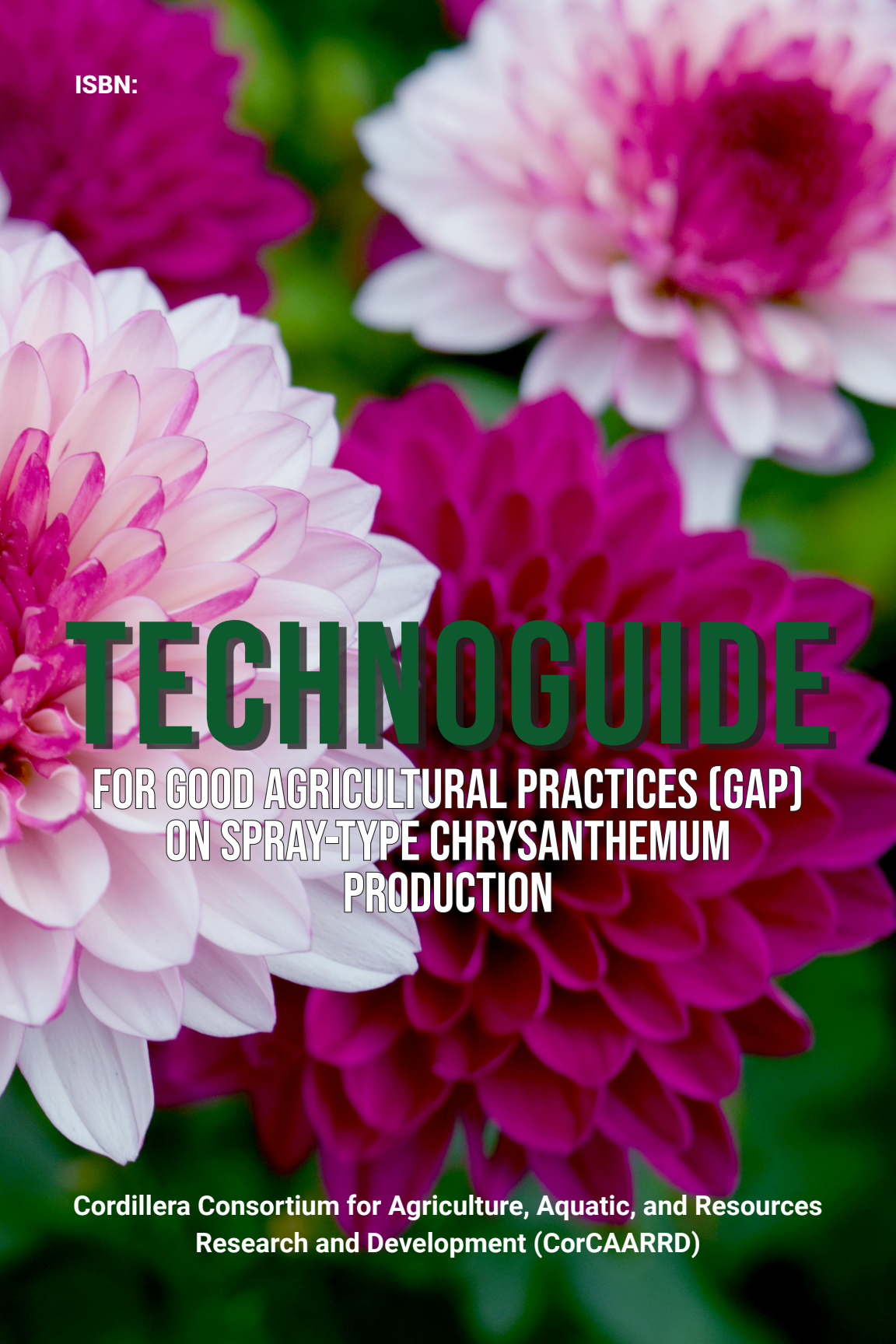

TECHNOGUIDE

FOR GOOD AGRICULTURAL PRACTICES (GAP) ON SPRAY-TYPE CHRYSANTHEMUM PRODUCTION

Cordillera Consortium for Agriculture, Aquatic, and Resources Research and Development (CorCAARRD)

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Preface

The Benguet State University (BSU) is continuing its effort to improve productivity and quality of ornamentals specifically the spray-type chrysanthemum through Good Agricultural Practices (GAP) and promotion of technologies through the Science and Technology Community Based-Farm (STCBF) modality developed by Philippine Council for Agriculture, Aquatic and Natural Resources Research and Development of the Department of Science and Technology (DOST-PCAARRD).

The technoguide is intended to assist the chrysanthemum growers, researchers, extension workers who are involved in the promotion of small scale spray-type chrysanthemum production through the Science and technology interventions. This does not simply concern producing quality and profitable chrysanthemum cutflower production but also reduction of pesticide application, cost of production and environmental pollution and less exposure of farmers to pesticide risks.

The outputs primarily focused on management of soil through adequate application of BSU organic compost, management of soil-borne disease through biocontrol agent Trichoderma koningii and application of wood vinegar "Mokusako" to suppress insect pests. These technology interventions increased productivity and quality cutflower thereby increasing farm income to ensure profitable farm operations.

This publication serves as information material for chrysanthemum growers, students, researchers, extension workers and chrysanthemum enthusiast. Grateful acknowledgment is here made to DOST-PCAARRD and the project team for their invaluable efforts in producing this publication, which provides valuable information and encouragement to our farmer partners in the production of quality spray-type chrysanthemum through enhanced GAP.

FELICIANO G. CALORA, Jr.
PRESIDENT
BSU

Introduction

Floriculture is fast emerging in the agriculture sector, continues to grow and has set an important agricultural activity especially for small-scale cutflower growers. The lucrative cultivation of cutflowers specifically spray-type chrysanthemum gives higher returns per unit area and time, and has attracted a selected group of farmers to take up flower cultivation on commercial scale. The floriculture industry in our country is growing at a modest rate, which has attributed particularly increase in income, number of hotels and tourists have increased every year (Ticbaen, 2016). The favorable environmental conditions of mid and high hills are ideally suited for flower cultivation on commercial scale in naturally ventilated greenhouses.

Report shows that Benguet ranks second after Laguna in Chrysanthemum production specifically the spray-type. La Trinidad, Benguet is the number one cutflower producer in the Cordillera Administrative Region (CAR) with the highest volume of harvest of 11.42 million dozens in 2015 (Municipal Agriculture, La Trinidad, 2015). Further, the volume and demand among chrysanthemum in CAR and in the national market are increasing. This is substantiated by the information from the La Trinidad Cutflowers and Ornamental Growers Association (LaTCOGA, 2016). This is due to the varied colors and shapes of the flowers that suit many special occasions and festivities that sustain the industry.

As a common practice, most cutflower growers, specifically those who are planting chrysanthemum, apply high amounts of inorganic fertilizers. They also apply pesticides exorbitantly to combat insect pests and diseases. According to LaTCOGA (personal interview, 2017), farmers normally practice mixing of 2-3 pesticides at one spray application against major insect pests and diseases. The farmers believe that mixing pesticides will increase the efficacy in solving the pest problem.

Further, pesticides application is most often more than the recommended rates and at the closer interval application specially during warm weather (Personal interview, 2016). Ultimately, the practice increases production cost, makes the soil acidic, reduces income and increases health risk due to exposure to pesticides not only to the farmer but also the handlers and consumers. Hence, this underlines the need to reduce the application of pesticides to reduced health risk while the quality of cutflower is improved and income of farmers is increased.

Under the Philippine Good Agricultural Practices (GAP) Program 2006 and the ASEAN GAP Guideline of 2005, the GAP approach aims at applying available knowledge to addressing environmental, economic and social sustainability dimensions for on-farm production and post-production processes, resulting in safe and quality food including non-food agricultural production. Hence, chrysanthemum production is not exempted from the application of GAP. While the GAP certification has its place in the vegetable & fruit industry in the region, there is a need to institute the same in the cutflower industry sector. One way to address the problem is through the GAP, which is through the S&T interventions.

GAP is important not only for economic importance but also for social conditions since it encompasses environmental issues for commercialization and market value of horticultural and agricultural products. Prior to the three-year project funded by DOST-PCAARRD on "Science and Technology Community-Based Farm (STCBF) on Spray-Type Chrysanthemum Production following GAP options, farmer partners practically used inorganic fertilizers. In addition, pesticide application to control insect pests and diseases is done at spray interval of 3 to 4 days. Moreover, chrysanthemum growers mix 2 to 3 kinds of pesticides at one spray application (Personal interview 2014). With the S&T interventions using BSU organic compost, BPI Trichoderma and LGU-wood vinegar "*Mokusako*", the chemical inputs were reduced to about 50% and replaced by organic inputs.

Variety

Selection of spray-type chrysanthemum for production is determined by the adaptability, consumers' preference and demand in the market. In Benguet, the top most preferred varieties are Radost white, Radost yellow, Japanese red and Remix. The latter two are use as highlights to give aesthetic and color in flower arrangements (Fig 1).

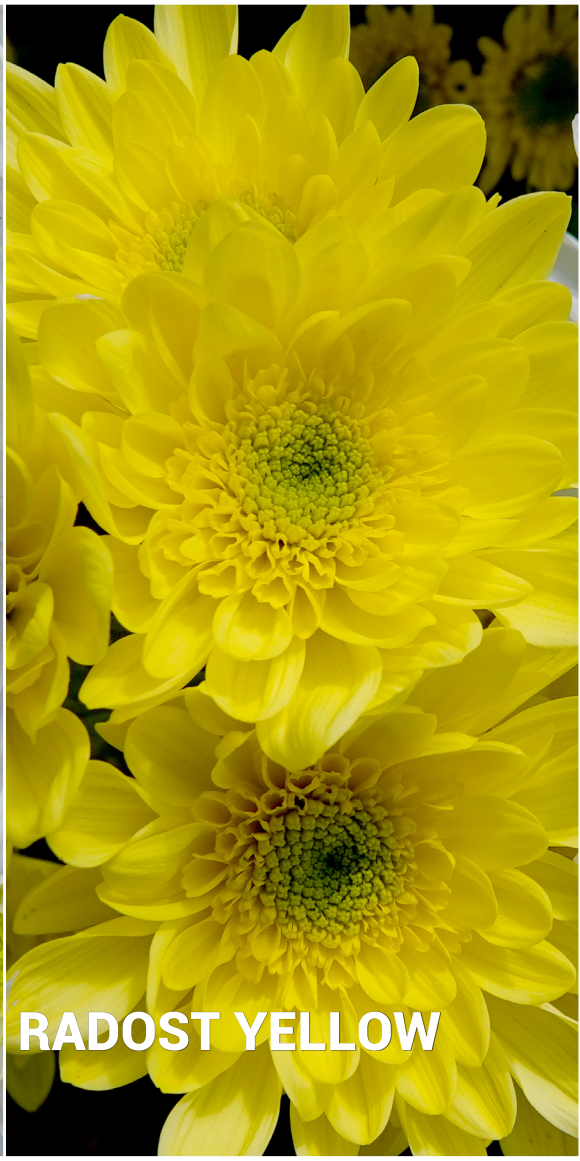
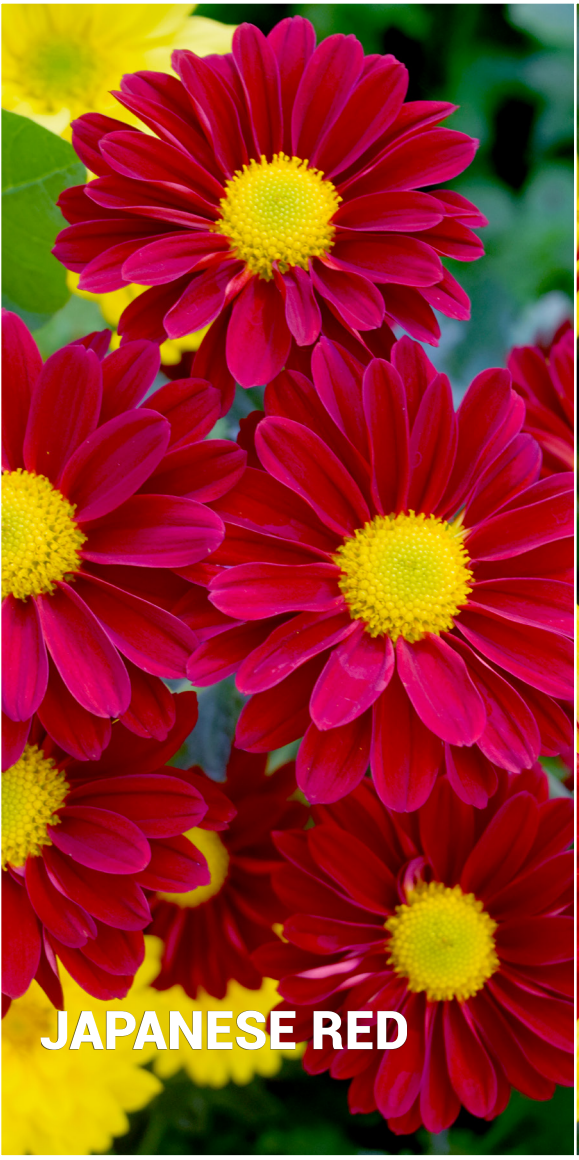
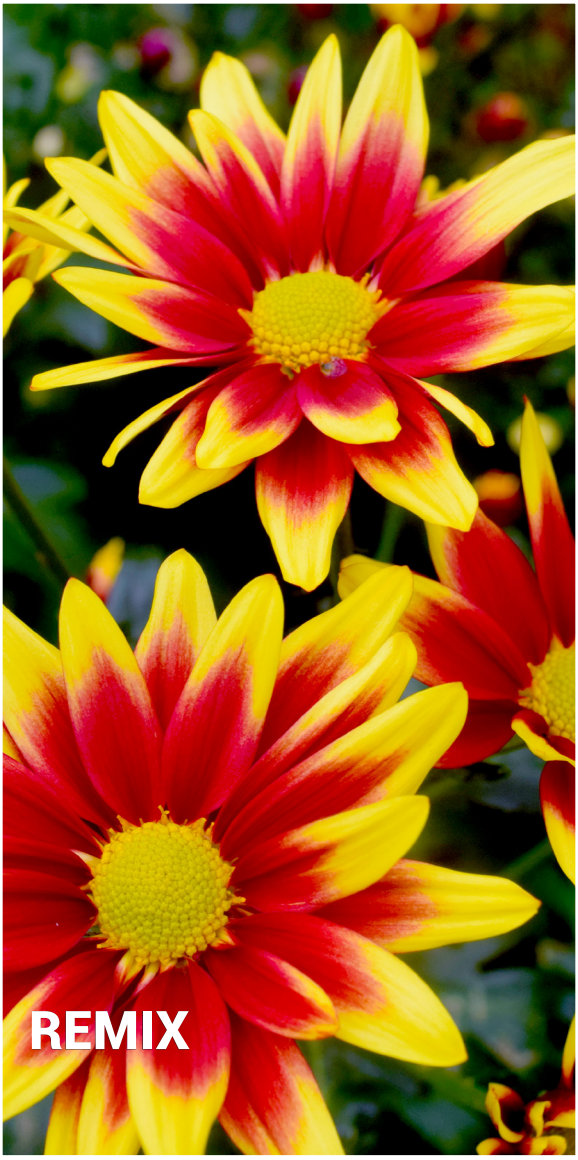


Figure 1. Chrysanthemum Varieties in La Trinidad, Benguet.


JAPANESE RED


REMIX

Planting and Acclimatization of In-vitro Plantlets

Chrysanthemum plantlets as source of mother plants are propagated in the laboratory using meristem culture. This is to ensure the health standard of planting materials. The shoot- tips are cut from the apical shoots of healthy chrysanthemum plants and inoculated into sterilized bottles containing the culture media. When shoots have developed into plantlets, these are taken out from the laboratory into the greenhouse for acclimatization and hardening. In-vitro grown plantlets for propagation of mother plants should be acclimatized in order to ensure vigorous growth, increase rate of survival and reduce mortality before these are transplanted (Fig 2).

Fig. 2a. In-vitro grown plantlets acclimatized by BSU-Horticultural Research and Training Institute (HORTI).

Fig. 2b. Acclimatized spray-type chrysanthemum planted in plastic tray/s with carbonized rice hull.

This should be done in greenhouse or under protected structure to prevent exposure to adverse weather conditions. The plantlets can be planted in plastic trays for easy handling at a depth of 0.5 to 1.0 inch. Plantlets can be grown in a planting media consisting of 1 part carbonized rice hull, 1 part sand and 1 part coco coir. The trays are filled with the media and distributed evenly. The media should be disinfected with fungicide which is done by drenching to prevent infection by soil-borne diseases. The plantlets are removed from the test tube bottles and the rootlets are washed with sterile water before transplanting. For production of mother plants, the plantlets can be transplanted within 2 to 3 weeks.

Fig. 2c. Acclimatized spray-type chrysanthemum planted in plastic pray/s with carbonized rice hull under protected structure.

Fig. 2b. Farmer Partner, Carlos Binay-an inspects the BSU-HORTI in-vitro grown spray-type chrysanthemum plantlets prior to Nursery Management.

Establishment and Management of Nursery

This will minimize the incidence of insect pests and diseases and protection against adverse weather conditions. The structure can be made of bamboo, wood or GI pipes with concrete foundation. The roof should be provided with polyethylene plastic sheet to prevent plantlets from transplanting shock. All sides should be enclosed with fine mesh or fine nylon net to minimize the entrance of insect pests and to provide ample aeration during seedling growth (Fig. 3). Temperatures ranging from 16 to 26°C should be maintained inside the greenhouse for optimum plant growth. Temperature below 16°C, will delay the flowers to bloom, while temperature above 26°C render the flowers to bloom early but easily wilts due to the heat.

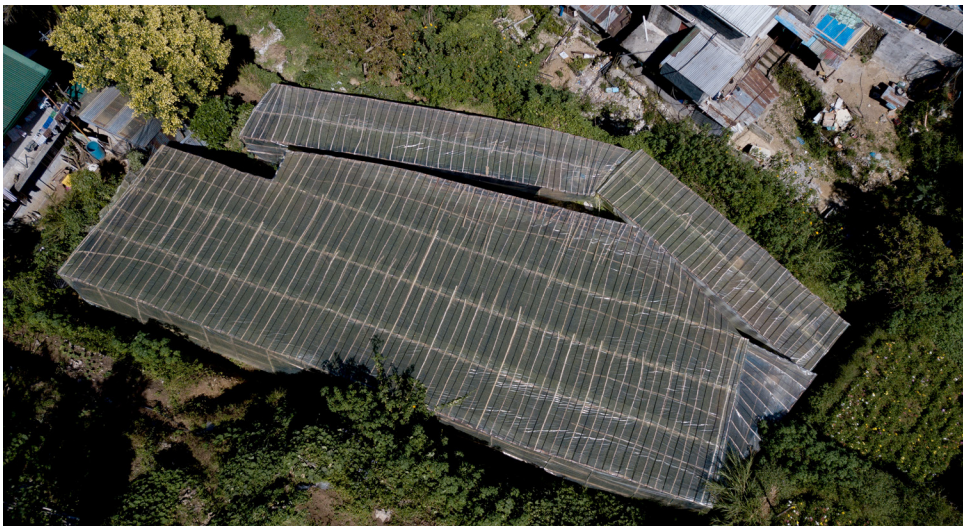


Fig. 3b. Aerial view of Chrysanthemum Greenhouse-type made of bamboo poles in Tawang, La Trinidad, Benguet.

Fig. 3a. Aerial view of Chrysanthemum Greenhouse-type made of GI pipes in Bineng, La Trinidad, Benguet.

Propagation and Management of Mother Plants

Acclimatized in-vitro derived plantlets for mother plants are grown in the greenhouse to minimize infestation of insect pests and disease infection. Plantlets can be grown in polyethylene black plastic pots measuring 12x24 inches. This will ensure the survival and uniform crop stand, and faster growth and root development. For potting media, mix 8 parts garden soil, 3 parts compost and 1 part carbonized rice hull. A mixture of 1 part garden soil and 1 part coco peat or coco coir is also recommended. While mixing, wet the media with just enough moisture using watering can with fine mist. This allows the stem of plantlets to be in contact with the media to ensure growth. Irrigate the media after planting, but do not over irrigate as this can cause rotting of stems. Approximately 2 to 3 weeks after transplanting or when plantlets have developed roots, spray foliar fertilizer to keep the plants completely vegetative to promote rapid growth and for maximum production of young shoots. When plants are established, cut the shoot tip just above the node using a sterilized sharp blade dipped in 70% isopropyl alcohol, to stimulate and promote growth of auxiliary buds and increase source of cuttings. After 3 to 4 weeks or when 3 to 4 leaves appeared, cut the shoots and continue every 2 weeks to produce mother plants rapidly. This is also to maintain succulent shoots which favor rapid root development.

Fig. 4. Propagation of mother plants for rooted cutting production.

Propagation and Management of Rooted Cuttings

Elevated beds in the nursery should be used for rooting of cuttings (Fig 5 a&b). This is to establish well-developed shoots and roots prior to transplanting. Beddings can be made of galvanized iron flat sheet. The ideal height of beds is 2.50 feet above the ground. For rooting media, mix 1 part garden soil and 1 part coco peat, or 1 part fine river sand and 1 part coco peat (Fig. 6). The mixtures provide sufficient aeration and also permit good drainage suitable for chrysanthemum which enhance the growth of root hairs. A pH ranging from 6.0 to 6.5 is recommended. The ideal planting distance is 1.0 to 2.0 inches apart at a depth of 0.70 to 1.0 inches. After planting, make the soil firm around the plant base to allow contact with the soil for easy rooting. Irrigate newly planted cuttings by misting 1-2 times a day, preferably early in the morning. Three-week-old cuttings should be given less water to avoid soaking and rotting. Do not overwater, as too much moisture may cause the cuttings to rot. Avoid watering late in the afternoon because it can enhance disease development. Root development occurs within 14-20 days, after which cuttings are ready for transplanting.

In order to have vigorous and healthy plants, select rooted cuttings with numerous root hairs without galls and with at least 3-4 leaves (Fig 7). During cool months or rainy season, rooting hormone is recommended for faster root development. Before planting, dip the terminal end of each cutting in rooting hormone powder to a depth of about 0.5 inch on the cut-end and remove excess by slightly shaking. The media should be sterilized or disinfected with 5.25% Chloro bleach (1:12 L water) solution. Apply the solution by drenching before planting to minimize the presence of soil-borne diseases and nematodes. Materials such as cutters, blades or scissors should be disinfected by dipping them in 70% ethyl alcohol before using. Strict sanitation during cutting of apical shoots should be observed to prevent the spread of diseases or contamination. It is recommended that workers should wear gloves. Cut shoots early in the morning while the plant is well-hydrated. Trim excess foliage and retain 3-4 leaves. Cuttings should be at least 2-3 inches in length (three fingers). Dip cut stems in fungicide solution following recommended rates for 5 minutes as protectant to fungal diseases.

Fig. 5a. Elevated bed with media composed of river sand mixed with coco coir.

Fig. 5b. Preparing stem-cutting for nursery establishment.

Fig. 6. Stem-cuttings planted in media mixture composed of river sand and coco peat/coir.

Fig. 7. Spray-type chrysanthemum rooted cuttings for cutflower production.

Cutflower Production in Greenhouse

There is no standard design for greenhouse cultivation for spray-type chrysanthemum production (Fig. 8). However, the greenhouse should establish the climatic condition suitable for plant growth at different stages. It protects the plants from the adverse weather conditions by providing optimum conditions of light, temperature, humidity and aeration for the best growth of plants to achieve maximum yield and better quality. Likewise, incidence of insect pests and diseases including weeds is minimized, hence, pesticide application and labor cost is reduced. Planting of spray-type chrysanthemum for cutflower production under protected structure provides opportunity for growers to plant twice a year. The greenhouse can be alternately planted to off-season vegetable crops for more efficient use of productive resources which could provide additional income.

Climatic Requirement. Spray-type chrysanthemum can be grown two times a year with ideal temperature ranging from 20-28°C during the day and 15-20°C at night. Rotate crops every after one cropping with short season crops such as vegetables or fallow the soil to prevent or discourage the growth of soil-borne diseases. The relative humidity of 70-90% is favorable for spray-type chrysanthemum.

Soil Requirement. Spray-type chrysanthemum grows in a well-drained soil with good texture and a pH of 6.0-6.5. It is best grown in soil containing high amount of organic compost, which provides a well-developed root system.

Land Preparation. Before planting, prepare the area by removing the grasses and other rubbish. Till the soil by using either a grab hoe or a small farm implement. For ease of planting, pulverize the soil to make it friable (Fig 9 a&b). cultivation, prepare the area by removing the grasses and other rubbish. Till the soil by using either grab hoe or small farm implement. For ease of planting, pulverize the soil to make it friable (Figure 9).

Planting. A nylon net with a mesh of 4x4 inches is needed to serve as a guide in planting and at the same time will serve as support to the plants as they grow to prevent logging. The nylon net should be placed in the plot before transplanting and after application of fertilizer. Dig a small hole at the middle of the mesh and plant the chrysanthemum seedlings (Fig. 10 a&b).

Fertilizer Management

Soil analysis should be done before planting. The amount of fertilizers to be applied should be based on soil fertility and organic matter content of the soil. Generally, spray-type chrysanthemum requires 210 ppm of N, 210 ppm of P2O4 and 220 ppm of K2O (Laurean et. al., 2014). Apply organic fertilizer (BSU Growers' Compost) at the rate of 20 t/ha or 1.81 kg/sqm basally into the plot and mix with soil manually using a grab hoe or a small farm implement (Fig 9a). Fertigate the plants by mixing 1kg complete fertilizer (16-16-16) to be mixed with 0.50 kg nitrogen source such as Urea (46-0-0) in 200 liters water. Apply the solution 7 days after transplanting and every 2 weeks thereafter up to 80 days. This will increase the efficiency of water and nutrient delivery directly into the root zone, where they are most needed. This will reduce also the application of synthetic fertilizers thereby reducing its cost and save labor costs as well. Disease incidence is also reduced because the crop foliage remains dry.

Fig. 8. Tunnel type greenhouse in Bineng, La Trinidad, Benguet owned and managed by Cutlower *Magsasaka Siyentista*, Andy Colte.

Fig. 9a. Land preparation and application of BSU Growers' Compost before planting.

Fig. 9b. Rooted cuttings ready for transplanting for cutflower production.

Fig. 10a. Installation of nylon net as guide for planting distance at 4x4 inches between hills.

Fig. 10b. Transplanting of rooted cuttings.

Water Management

It is necessary to keep the soil moist throughout the growing period. Water requirement increases as vegetative growth progresses, however, water requirement should be reduced as plants approach the flowering stage since they need less water. At planting, apply irrigation water just enough to prevent wilting of the seedlings. This is determined by getting a handful of soil from the plots and squeezing it. If excess water is present, the field is over-irrigated. During the early growth stages, plants need smaller amounts of water. Irrigate the field every day during the first week after transplanting, preferably early in the morning. Two weeks after transplanting, the plants can be irrigated every after 2 days and every after 4 days thereafter until the flowers are ready for harvest. Irrigate the plants the day before harvest to prevent wilting of plants during harvesting. Overhead irrigation or sprinkle method can be applied for the first and a half months. Thereafter, flooding or watering at the base of the stem can be done (Fig 11). This is to keep the foliage dry to minimize disease incidence.

Fig. 11. Sprinkle method irrigation is applied to maintain soil moisture.

Support/Staking

Spray-type chrysanthemums are tall and can grow as high as 60cm to more than 80cm, hence, it is necessary to support the stems as the crop matures. Generally, spray-type chrysanthemums are tied to bamboo stakes, metal hog wire or sturdy sticks to properly hold flowers to keep them erect. Nylon nets can also be used as support to the plants. These are attached to guide poles and are installed in each plot before transplanting. It also serve as trellis or support to the plants from bending and to maintain and keep the stem straight up to harvesting. The netted nylon is adjusted as the plants grow taller (Fig. 12).

Fig. 12. Nylon net is adjusted as plants increase in height to maintain erect crop stand.

Blacking out

Blacking out starts when plants are about to initiate flowering (Fig. 13). This is done by installing black polyethylene plastic above the plants at a height of at least 6.0 ft. for at least three hours in the afternoon from 4:00-7:00pm or in the morning from 4:00-7:00am for a period of 6 weeks or until the flowers begin to show colors depending on the variety. Blacking out is only done during long-day during the months of March to May or when day length exceeds 12 hours.

Fig. 13. Blacking out being demonstrated by Carlos Binay-an, Farmer Partner.

Light Requirement

Chrysanthemums are short-day plants and they are very much influenced by light, and as such require short days or long nights to flower. The critical day length is 14-15 hours for flower initiation and 13-14 hours for development. Supplemental lighting is necessary during short days specifically during the months of August to February. Lighting is necessary during short days because this will prevent the plants from blooming early before they have attained their best stem length. Supplemental lighting should be installed at least 5.0 ft. above the ground at a distance of 2 meters using >18-watt light bulbs or 40-watt fluorescent lights.

Lights should be on for 28-35 consecutive days for fast growing varieties, while 40 consecutive days for slow growing varieties for at least 3-4 hours a day from 6:00-10:00 pm to delay bolting which could result to early flower initiation and production of short stems. Supplemental lighting is stopped when the plants have reached a height of more than 12 inches (Fig. 14).

Fig. 14. Installation of 40-watt light bulbs at a height of 5.0 ft. above ground at distance of 2 meters.

Disbudding

Pinching the growing tip of the plant is done to induce branching and increase the number of flowering stems per plant (Fig. 15 a&b). In spray-type chrysanthemum varieties, only the large apical or terminal bud is removed and the lateral buds are retained. Disbudding is done when plants have developed terminal buds. It is done by removing the terminal buds by snapping with the thumb and forefinger to allow lateral buds to develop. This will enhance the flowers to bloom evenly and develop a spray of large uniform flowers from lateral buds. Delayed disbudding can result to production of smaller flower buds and longer duration of flower bud opening.

Fig. 15. Disbudding of terminal buds by Wilfredo Padio, Farmer Partner.

PESTS MANAGEMENT

The best way to combat insect pests and diseases affecting ornamental crops such as spray-type chrysanthemum is through integrated crop management (ICM). For best result of pests management, it is important to use disease-free planting materials to minimize pesticide application. Likewise, sanitation should be practiced at all times in the greenhouse in order to prevent the presence of insect pests and diseases.

A. Insect Pest and their Management

LEAFMINER

Phytomyza spp. attack the spray-type chrysanthemum at all stages. It is a small fly that has larvae that feed by tunneling in the leaves of its host plants. Flies are small dark colored flies 2-3 mm in length. The female fly makes small puncture marks usually around the edges of plant leaves in order to feed and lay eggs. Eggs hatch into maggots that burrow under the leaf surface creating tunnels as they feed and grow. At the end of their mining, the maggots will turn into small dark brown pupae at the end of their tunnels.

Symptoms

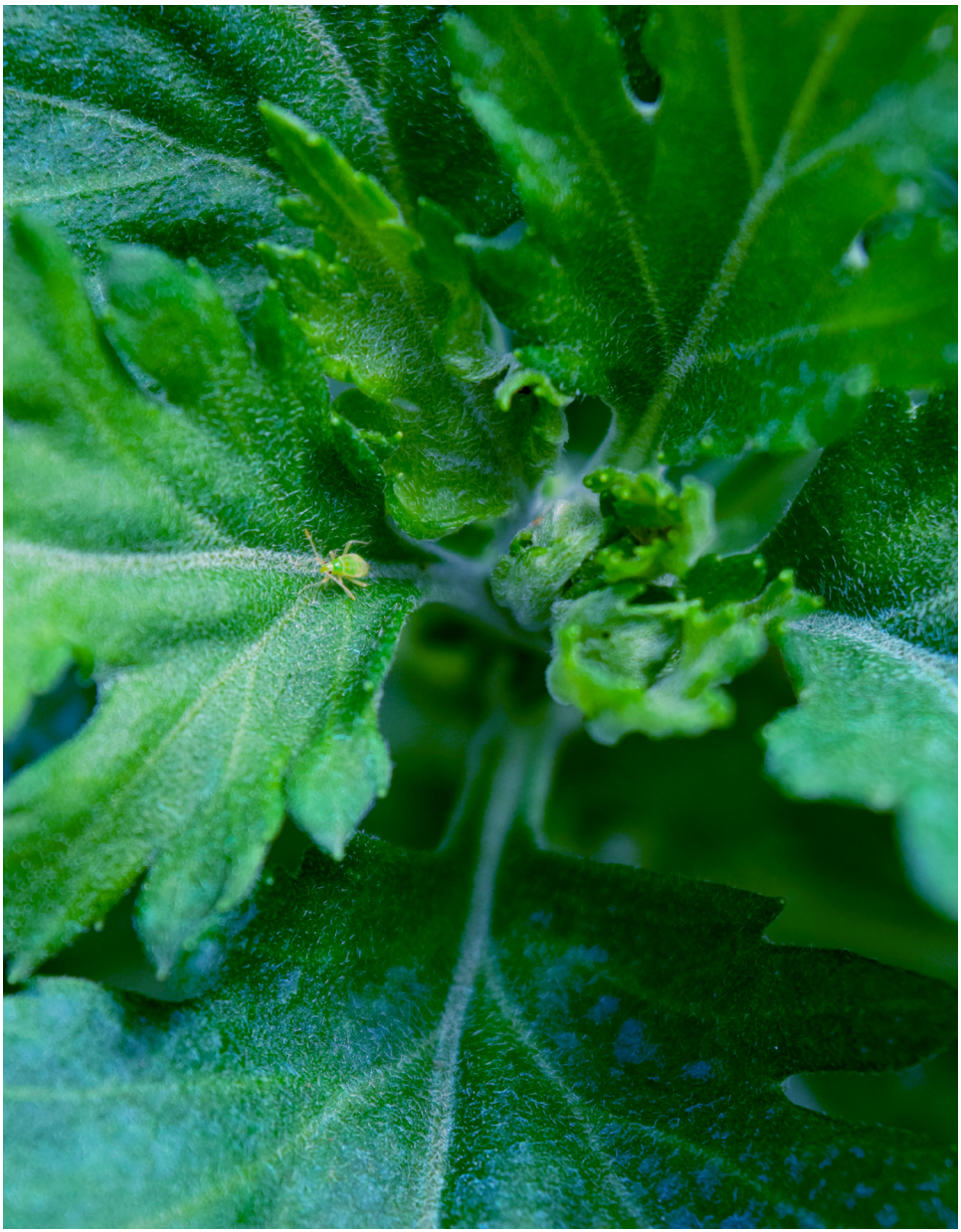
The adult female lays eggs on the undersurfaces of leaves. The eggs hatch and the larvae enter the leaves causing mining and tunneling while feeding. Larvae feed on the cells within the leaves of the host and create silvery lines across the leaves. The larvae live between the upper and lower surfaces of the leaves. As they move through the leaf feeding, they create winding trails that are pale green to brown in color. Dots of black waste products are visible in some of the trails (Blake et. al., 2018). Severely infested leaves dry up and eventually die.

MANAGEMENT

Practice sanitation by pruning and removing infested leaves, including those that fall to the ground, and destroy them by burning or burying deep under the ground. Leaves that fall to the ground should be picked up and disposed properly to prevent re-infestation. Installation of yellow sticky traps in greenhouses at 10 traps per 100sqm just after transplanting will help reduce population of the leafminers. Use overhead sprinkler once in a while to minimize infestation by the insect. Any plant debris should be removed and destroyed after harvest. Spray with wood vinegar "*Mokusako*" (LGU, La Trinidad) at 20 tablespoons per 16L water. Green-label insecticides can be sprayed when the insect is present. If damage is severe, spray with effective green-labeled insecticide such as Cyromazine-based, acephate or spinosad.

APHIDS

There are many species of aphids that attack chrysanthemum plants but the most common species are the chrysanthemum aphid *Macrosiphoniella sanborni*, green peach aphid *Myzus persicae* and the melon/cotton aphid *Aphis gossypii*. The species are green in color but can vary from light to dark green, from light green to nearly pink (green peach aphid), and brown to black (*M. sanborni*). Aphids have small soft bodies with piercing-sucking mouth parts.



Symptoms

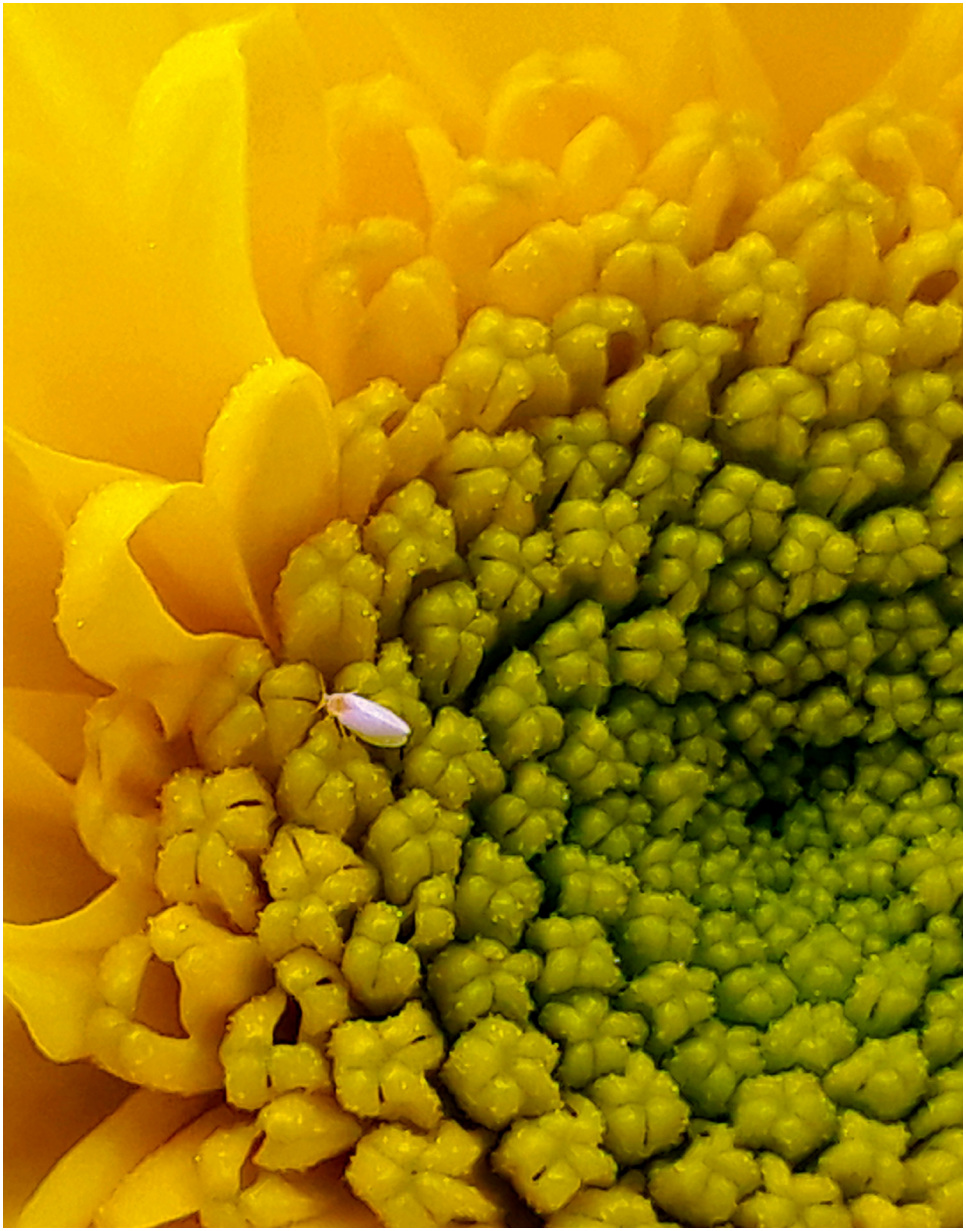
Aphids cause injury by feeding on plant shoots, undersides of leaves, buds and flowers. They can also transmit viral diseases (Moran, 1994). The feeding results in distortion/ wrinkling of plant leaves, distorted growth, stunting and sometimes death of the entire plant (Blake et. al., 2018).

MANAGEMENT

Use healthy planting materials. Chrome yellow sticky traps can be installed to suppress population of winged adult aphids. The population can also be suppressed by overhead irrigation method/sprinkling. At harvest, remove all plant debris to prevent the insect from breeding. Spray with wood vinegar "*Mokusako*" (LGU, La Trinidad) at 20 tablespoons per 16L water. Green-label insecticides can be sprayed when the insect is present. If damage persists, apply Methomyl-based insecticide following the recommended rates.

WHITE FLIES

Adult white flies are moth-like and covered with white, waxy powder. Adult female white-flies are about 0.16 cm or 1.59 mm in length. They can deposit about fifty eggs in cool environments and up to four hundred eggs at higher temperature. They feed exclusive-ly on leaves, nearly always occurring on the undersurface. They suck juices from the plants and also excrete large quantities of honeydew in which sooty mold grows.



Symptoms

The insect feed on plant phloem by injecting enzymes and removing the sap, reducing the vigor of the plant. Honeydew secretions from whiteflies promote the growth of sooty mold, which significantly reduces plant quality. Infested stems show symptom of stem blanching, chlorotic spots, leaf yellowing and shedding.

MANAGEMENT

Use disease-free planting material. Practice sanitation by removing sources of infestation that might carry over populations from one season to the next. Practice crop rotation by planting with non-host crops or keep the area fallow in between chrysanthemum planting. Install yellow sticky traps a few inches above the plants at 10 traps per 100 sqm. Apply insecticide if necessary such as imadacloprid following the recommended rate.

THRIPS

Thrips (*Frankliniella occidentalis/ Thrips tabaci*) are small, slender insects that are less than 2 mm long, have two pairs of wings fringed with fine hairs. Color varies from pale yellow to light or dark brown. Adult males are usually smaller and paler in color than females. Color can vary depending on temperature, being darker when development occurs at cooler temperatures. Eggs are ovoid, translucent and are laid in soft plant tissue. Larvae resemble the shape of adults but are smaller, paler in color and lack wings. The pupa is similar to adults and can be recognized by the presence of wing buds. Thrips have piercing sucking mouth parts and feed by puncturing the surface of flowers and young leaves and sucking up the plant juices. Both adults and nymphs cause damage.

Symptoms

The insect feed on plant phloem by injecting enzymes and removing the sap, reducing the vigor of the plant. Honeydew secretions from whiteflies promote the growth of sooty mold, which significantly reduces plant quality. Infested stems show symptom of stem blanching, chlorotic spots, leaf yellowing and shedding.

MANAGEMENT

Use chrysanthemum that have flowers as trap plants when the spray-type chrysanthemum crop is in the non-flowering stage. Install yellow sticky traps just above the chrysanthemum bearing flowers to attract the adults to fly towards the flowering mums. Chrysanthemum used as traps should be arranged at all sides of the plots and preferably planted in pots for easy handling. Ensure that all plants introduced to the greenhouse are free of pests. Remove all crop remains and weeds after harvest. Use insect-proof netting in the greenhouse to prevent entries of insects. Cover doors of greenhouses with insect-proof netting. Install yellow sticky traps in greenhouses at 10traps/100sqm to help monitor potential problems and to reduce population. If damage is severe, spray with effective green-labeled insecticides such Abamectin-based or Fipronil following the recommended rates.

TWO-SPOTTED SPIDER MITES

Spider mites (*Tetranychus urtica*) and other mite species are pests of spray-type chrysanthemums. Mites are not insects but are classified as arthropods. They are a problem during hot and dry periods. Mites are extremely small and can barely be seen without a magnifying lens. They have piercing mouthparts with which they puncture plant tissue and suck plant sap. With a light infestation, leaves develop stipples (tiny yellow spots) and appear dusty (Blake et. al., 2018).

Symptoms

Leaves are distorted and withered and blooms are discolored. In addition, fine webbing can be seen on flower buds, between stems and on the undersides of leaves.

MANAGEMENT

Practice sanitation by collecting and destroying severely infested plants or portions of plants by burying or burning. Miticides such as Bifenthrin are sprayed to the leaf surface following the recommended rates.

B. Diseases and their Management

FUSARIUM WILT

This is the most common disease problem among the spray-type chrysanthemum growers in Benguet. The disease is caused by a fungus, *Fusarium oxysporum f. sp. chrysanthemi.* The pathogen lives in the soil and can be transmitted through planting materials and farm tools.

Symptoms

Disease symptoms vary with the spray-type chrysanthemum variety. The fungus infects the plant roots and colonize the internal vascular tissue. The affected plants show different symptoms such as leaf chlorosis, necrosis, decay and discoloration of internal portion of the stem. When the flower buds are about to open, small dark streaks are seen at the base of the stem. Root decay is noticed only in advanced stages of infection. In many cases, the infection is devoid of any external symptoms and roots also look healthy. In some varieties, stem and root trotting are confined to one side of the stem and the leaves turn yellow with discoloration.

MANAGEMENT

Use disease-free planting materials. The disease can further be minimized by following strict sanitation, periodic monitoring, crop rotation and rouging of infected plants. To protect the plants from infection, application of Trichoderma koningii (Mangili et. al., 2011 & 2014) 1 to 2 weeks before planting can reduce infection by about 30 to 50% during first application and about 75 to 90 % during second application on the following cropping season (Laurean et al., 2014).

Dilute 1 to 2 packs of the Trichoderma (a beneficial microorganism grown in 3 parts rice hull and 1 part rice grits) in 16 li water. Dissolve the media with the Trichoderma and strain the debris to prevent clogging of the nozzle spray. Apply as drench on the plots prepared and turn the soil after application. Maintain soil pH between 6.5 and 7.0 (Blake et. al., 2018). Use nitrate rather than ammonium forms of fertilizer. Cuttings should be taken from healthy plants. Following strict field sanitation, rouging of infected plants and crop rotation help to minimize disease incidence.

DAMPING-OFF

The disease is caused by a soil borne fungus Pythium spp. The pathogens are a water mold (fungus-like, but not fungi) that favors cool, wet conditions. It causes rotting of the stem and root in many seedlings. Fungal spores live in the soil and are primarily a problem in seed beds. They can be transported by garden tools and in garden soils or greenhouse. Water molds produce swimming spores that move freely in water and moist soil, increasing risk of infection when water puddles underneath seed beds. Infected plants are not curable.

Symptoms

Diseased seedlings may first exhibit a wet, black-brown basal-stem rot that can extend several inches above the media surface. The stem and root wilts show blackening and rotting. Decaying roots turn black and the root cortex may droop. Pythium spp. infects the tip of the roots and colonize the root system, causing roots to rot. In the early stages of the disease, seedlings may wilt during the day but recover overnight but within a few days, they become water-soaked and fall over at the base and die.

MANAGEMENT

Use appropriate soil media with good aeration. Sterilize soil media before planting by drenching with systemic fungicide following the recommended rate or by soil sterilization. Do not over-crowd the planting of cuttings, which can lead to humid, moist conditions. Water only in the morning so that the soil surface and the plants are dry by evening. This will prevent the accumulation of water in the evening which will enhance the presence of the fungus. Irrigate the seedlings by misting. Avoid overwatering the seedlings. Cultural practices, including proper soil drainage and sanitation, must be practiced.

WHITE RUST

Chrysanthemum white rust (*Puccinia horiana)* is a serious fungal disease of spray-type chrysanthemum. Rust infection initially appear as white to yellow spots on the leaves. As infection progresses, it produces powdery spots directly on the underside of the leaves. Severely infected plants can affect the quality of chrysanthemum flowers. Pustules become white with age and are most common on young leaves and flower bracts but may form on any green tissue or the petals. Symptoms usually occur during cool, wet weather.

Symptoms

Plants infected with white rust exhibit spots on the upper surfaces of leaves. The growth of the fungus on the leaves appears as powdery coating. The spots are initially pale-green to yellow in color and up to 5mm in diameter (Callahan, 2015) but may turn brown as the tissue becomes necrotic. On the underside of the leaf, the spots develop into pink or white pustules ,which burst open releasing masses of white, powdery spores. Severely infected plants become weak and fail to bloom properly (Blake et. al., 2018). Small, yellow to tan spots are also observed on the upper surface of leaves. Symptoms vary with the cultivar infected. Young leaves are light green and very upright. Plants are stunted to half their normal height at maturity. Infected plants flower prematurely and flower size is reduced. Some cultivars exhibit small dead spots or flecks on the leaves.

MANAGEMENT

Early removal of infected leaves by handpicking and burning as soon as possible help prevent further spread of the disease. Water the soil but keep the foliage dry and ensure that plants are well spaced. Do not water the plants late in the afternoon. If possible, avoid water splash and spreading the disease via overhead irrigation. Practice sanitation especially in the greenhouse and rotate crop with non-host. Use contact or systemic fungicides following the recommended rates. Set new plants farther apart and provide better aeration. Water the soil without wetting the plants. If disease is severe enough to warrant chemical control, apply fungicides oxycarboxin, triforine, benodanil, triadimefon, diclobutrazol, propiconazole.

LEAF SPOT

The disease is caused by the fungus *Septoria chrysanthemi, S. chrysanthemella, Alternaria spp. and Cercospora spp.* (Fig. 16). Fungal spores are spread by splashing rain, overhead irrigation water, and air currents. Leaf spot occurs during cool-wet periods of the rainy season.

Symptoms

Disease spread is by infected plant material, splashing water, and air movement. Spots on the leaves can be found which are at first yellowish, and then brown and black, increasing from 2.03 to 2.54 cm or more in diameter. Leaves may wither prematurely. The lower leaves are infected first, and white masses of spores may be seen on the leaf spots. The edges of the leaves and petals and are brown to blackish, rounded to oval, sometimes leaves are entirely yellow.

Fig. 16. Disease caused by *Septoria chrysanthemi*.

MANAGEMENT

Hand pick and destroy infected leaves and dispose properly. Practice sanitation and destroy dead plant debris in the farm to reduce spore populations. Prevent the spread of spores by watering directly to the soil. Avoid splashing water onto plant foliage, and water early in the day to allow foliage to dry quickly. Avoid wetting foliage, opt for drip irrigation instead of overhead irrigation. Use fungicides as protectants. If infection is severe, fungicides containing Chlorothalonil, Mancozeb, or Thiophanate methyl may be used following the recommended rates.

POWDERY MILDEW

The fungal disease is caused by (*Erysiphe cichoracearm*). The spores require a very moist atmosphere in which to germinate and spread the infection. Its name implies is characterized by a white to ash-gray powdery growth on leaves and occasionally stems.

Symptoms

The growth of the fungus on the leaves appears as powdery coating. The disease appears as ash-gray powdery growth on leaves and occasionally on the stems and buds as the lesions develop, the leaf may become puckered or distorted and severely infected leaves will shrivel and drop from the plant. The disease is most serious during hot, humid weather. Leaves have white, dry fungal growth on their surfaces. Infection is more severe in older plants under humid conditions. Infected leaves turn yellow and dry out sometimes with whitish-gray powdery growth on the leaves, stems, and buds. In severe cases, Infected plants remain stunted and fail to flower.

MANAGEMENT

Powdery mildew can be avoided by proper plant spacing, good air circulation, low relative humidity, and adequate light levels. Remove diseased plant material. Good ventilation and proper spacing for free circulation of air is recommended. If disease infection persists, spray with copper based, propiconazole, sulfur, potassium bicarbonate and thiophanate methyl fungicides.

BACTERIAL BLIGHT

The disease is caused by a soft rot pathogen (*Erwinia chrysanthemi*). It is a vascular wilt that colonizes the xylem. The disease survives in crop debris and is favored by surface moisture, high temperatures, and high relative humidity.

Symptoms

Affected areas turn dark brown to black, collapsed and become dry. When the stem is pressed firmly with the fingers, they easily flatten due to hallow pith region. Rooting will occur although dark necrotic areas are visible on both stem and leaves. Cuttings of highly susceptible cultivars develop brown to black stem decay resulting in stunting or death. In other cultivars, the pathogen may invade the vascular system and pith while cuttings appear symptomless. As plants become established, infection spreads and plants may wilt during sunny days but recover at night. As the disease progresses, terminal shoots collapse and darken. In cuttings, stems show water-soaked lesions followed by the darkening and death of stems. Buds turn black at the terminals and cause wilting and collapse of the upper portions of the plants. Infected cuttings may have brown to black decay at the stem base. The pathogen survives in crop debris and is easily spread by infested tools and hands. Visually symptomless cuttings and stock plants can serve as sources for transmission.

MANAGEMENT

Avoid wetting foliage and use drip irrigation instead of overhead irrigation. Inspect plants and discard infected plant material and plant debris. Replace nursery soil media and disinfect propagation beds between crops. Space plants for increased air circulation; this promotes rapid drying and reduces relative humidity. To prevent the disease, dilute 1 to 2 packs of the beneficial microorganism (grown in 3 parts rice hull and 1 part rice grits) in 16L water. Dissolve the media with the *Trichoderma* and strain the substrate to prevent clogging of the nozzle spray. Apply by drenching on the plots prepared and turn the soil after application.

VIRUS DISEASES

Spray-type chrysanthemums are subject to a large number of virus diseases, including mosaic, chrysanthemum smut virus, tomato spotted wilt virus, and aster yellows. Virus diseases are spread by sucking insects such as aphids and leafhoppers.

Symptoms

Virus-infected plants generally have spindly, stunted shoots and yellowing of foliage. Leaves may be marked with ring spots, lines, pale areas, or mottling. Infected plants are either stunted, form dense "rosettes", and have small flowers (Blake et. al., 2018).

MANAGEMENT

If symptomatic virus-infected plants are visible, remove and dispose properly by burning or burying them (Fig. 18). To control the insects that transmit these viruses, see the insect portion of this fact sheet. Remove weeds that may harbor the viruses. Wash tools used around infected plants. Pruning tools should be disinfected before moving from plant to plant. Sodium hypochlorite and sodium hydroxide plus formaldehyde have been reported to be effective in disinfecting tools contaminated with virus.

HARVESTING AND POSTHARVEST OPERATIONS

Harvesting

The correct stage of harvesting depends upon the cultivar, marketing and purpose. Nonetheless, harvesting is optimum when the top 3 or 4 lateral flower buds are open. It is done by uprooting the plants and cutting the stem just above the roots, or cutting the stems just above the ground using a pruning shear. About 5-6 leaves are removed above the stem. Plants with a height of more than 80 cm stem length (Extra Class) are first harvested. Flowers to be shipped for long distances should be harvested when approximately flowers are half open. Flowers must be harvested late in the afternoon or early in the morning to prevent wilting. Spray-type chrysanthemums are generally harvested at the two-thirds to three-fourths open flower, however, according to the chrysanthemum growers harvesting depends on the cultivar, market and purpose.

Sorting and grading

Spray-type chrysanthemum is sorted based on the color and graded according to stem length which is the basis for pricing. This is done immediately after harvesting to prevent wilting of the flowers. Harvested chrysanthemum cutflowers are bundled by the dozen using clean rubber bands, and the base of stem is soaked in water immediately to avoid wilting. Cutflowers are classified as follows based on the Philippine National Standards (2003):

CLASSIFICATION	STEM LENGTH (cm)
Extra Class	80
Class I	70
Class II	60

Packaging

The packing area should be in a cold room or the coolest part of the building. Cutflowers are wrapped by dozens using newspapers packed in containers made of corrugated plastic or cartons measuring 100cm x 33cm x 60cm (LWH) for transport to market outlets. One container can accommodate 45 to 50 dozens. The cartons are labeled with the following information: name of product, cultivar and color, quality classification, name and address of supplier and/or exporter. Cutflowers that are to be delivered the next day are bundled and soaked in water at 1-2 inches' deep to prevent wilting.

• **100cm x 33cm x 60cm (LWH) corrugated box will be used for nationwide transport (left), while the ordinary brown box is being used for local transport (right).**

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