World Journal of Innovative Research (WJIR)
ISSN: 2454-8236, Volume-8, Issue-6, June 2020 Pages 73-77

Poly Film Cover and Calcium Foliar Application Affect Occurrence and Prevalence of Two-Spotted Spider Mites in Rose Flower

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Abstract— **Spider mite is a major constraint in rose flower production. Though flower producers have not quantified the magnitude of the losses incurred, the quantity of the miticides used on their control is enormous. This experiment was designed to investigate the effect of UV spectrum through different poly-films on the occurrence of two spotted red spider mite a common rose flower pest. The study was carried out at Egerton University Horticulture Research and Teaching field. The experiment was split- split plot laid down in a Randomized Complete Block Design (RCBD) with polyfilms forming the main plot treatments. Two rose cultivars were tested for tolerance and calcium foliar feed was applied at four different concentration levels. Rose cultivars and calcium concentrations formed the sub and sub-sub plot treatments respectively. Poly-film samples were scanned through UV- 1800 shimadzu spectrophotometer to assess light transmission properties at different wavelengths. Data collection involved measuring of light transmission through Poly-films, the temperature and relative humidity in the tunnels was also monitored. The data was subjected to analysis of variance at 5% probability level and mean separation was performed using Tukey's Studentized Range (HSD) Test.Poly films modified the tunnel microclimate and this impact on prevalence and population of two spotted red spider mite. Mean temperature values of 41°C, 35.2°C and 32.8 °Cwere recorded under UV-A clear, IR 504 and UV-A 205/N poly films respectively. It was observedthat the number of spider mites increased with increase in temperature.A mean spider mite population of 5 mites/cm2 was recorded under the clear poly-film compared to 3 mites/cm2 under the UV-A 205/N. Changes in greenhouse microclimate influenced the population and prevalence of spider mite. Clear poly film that transmitted high light recorded high temperature and subsequently high number of mites.**

Index Terms— **Spider mite, Poly film, microclimate, Light transmission.**

I. Introduction

Two spotted spider mites (*Tetranychusurticae*) is a major constraint to greenhouse rose flower production. Two spotted mites attack up to 1200 host plant species (Takeshi *et al*., 2009). The pest is currently considered to be one of the most aggressive and invasive in the world (Boubou *et al*., 2012). The mites usually inhabit the underside of the leaf mostly alongside the veins (Takeshi *et al*., 2009) which is deemed a survival strategy to avoid the injurious effect of UV-B radiation. Under suitable conditionsof high temperature and low relative humidity, spider mites multiply rapidly and can cause significant crop loss of up to 90% (Sibanda*et al*, 2000). One female spider mite has potential to lay up to 20 eggs per day and they have the capability to leave for 2-4 weeks thus laying hundreds of eggs (Kasap, 2002). Economic threshold levels however, differ with host plant specificity and the prevailing weather at the time of crop management. Mites have been reported to increase linearly as temperature increases fron 15 °C -37 °C (Pakyari and Enkegaard, 2012). Studies with different crops have also shown differences in fecundity for example in case of Gerbera, mites laid an average of 2-10eggs/day (Krips, 1998), Strawberry varieties 3-40 eggs were laid over their life time (Elsawi, 2006) and in rose flower 48 eggs (Kasap, 2002).

Several methods have been applied for control of red spider mite without much success. Chemical control using different molecules of active ingredients has become inefficient with time because the mites detoxify a wide range of chemical compounds (Grbic*et al*., 2011) hence lowering their efficacy. Additionally, at the time of control, the spider mite exists at all developmental stages (egg, larvae, first and second nymph stages and adult) making it difficult for a single active ingredient to control the pest. Mite population is also influenced by environmental conditions which have direct or indirect effect on host plant physiological changes.

Net photosynthetic rate, total chlorophyll content, and greenness of the leaf are significantly affected by the feeding of mites, regardless of the developmental stages (park and Lee, 2002). Exponentiationof red spider mite is accelerated by the prevailing micro-environment like elevated temperature, (stavrinides*et al*., 2010). Multiplication of predator mites *Phytoseiulus persimilis*for instance has been established to be effective within a temperature range of 20°C-30°C and 60 ±10% relative humidity (Pakyari and Enkegaard, 2012).

Recent technologies in greenhouse production have impressed cladding of poly-film which alters light transmission within the greenhouses. This advancement targets achievement of ideal greenhouse conditions for crop production, however it has been observed to alter the greenhouse microclimate that may have positive or negative impact on the plants. Temperature, photosynthetic active radiation and relative humidity are among the affected microclimate elements (Peetz*et al*., 2009).Spider mite prevalence is affectedsignificantly by changes in microclimate. The objective of this study was to assess the effect of growth environment on population of

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two-spottedspider mite in rose production. Two spotted spider mites is serious pest in rose production, yet growers are no aware of the effect of greenhouse covers and spider mite prevalence.

II. MATERIALS AND METHODS

Experimental Site; the study was conducted at, Egerton University, Njoro Kenya at an altitude of 0º 23' South, longitudes 35º 35' East in the Lower Highland III Agro Ecological Zone (LH3) at an altitude of approximately 2,238 meters above sea level. The experimental site had an average maximum and minimum temperatures range from 19 ºC to 22 ºC and 5 ºC to 8 ºC respectively, with a total annual rainfall ranging from 1200 to 1400 mm.

A. Planting material, experimental design, treatment application and crop establishment

Top grafted plants of two rose cultivars were purchased from the commercial propagator (Stokman Rozen limited) in Naivasha. The research was carried out under a split- split plot experiment laid down in a randomized complete block design. The main treatment involved poly-film covers with different colours denoted as; G_0 = UV-A clear, G_1= IR 504 (green tint) and G_2 = UV- A 205/N (Yellow tint) both with similar gauge 200 µ. The growth tunnel was divided into three sections of $44M^2$. Each section was covered with a different poly-film cover as described above. The sub-plot treatment included two rose cultivars and calcium foliar feed at four levels of concentration was applied to the sub-sub plot treatments. Calcium concentrations included:T_0 =Distilled water, T_1 =CalMax® 1.25 ml/L, T_2 =CalMax® 2.5 ml/L, T_3 =CalMax® at the rate of 3.75 ml/L and T_4= CalMax® at the rate of 5.00 ml/LSoil treatment was done using Metham sodium® at the rate of $0.12ml/m^2$ (the application rates as per the product specification) through drip lines.

The experimental plots that were covered prior to treatment application were left undisturbed for three weeks, before aeration. The experimental plots were uncovered and aeration was done by digging and turning the soil. Germination test was performed to ascertain depletion of chemical residues in the soil. The plants were established in double rows spaced at 30cm x 20cm to accommodate 10 plants per square metre. Management activities involved fertigation, bending, weeding, de-suckering and general plant cleaning.

B. Data collection and analysis

A strip of the transparent poly-film was cut from the extra ends of growth tunnel. The strip was carefully locked in a jig before insertion in the cuvette holder to ensure an upright position of the polyfilm. The polyfilm was then scanned at different wavelengths (190-280nm, 280-315nm, 315-400nm and 400-700nm)using UV- 1800 Shimadzu spectrophotometer. Transmission data was recorded at intervals of one month over two flushes one in June-August 2018 and the second one after one year in June-August 2019.

Microclimate. Relative humidity and temperature were monitored using watch dog® mini data logger weather station. The machine was plugged into software that automatically calculates the wavelength received. The PAR sensor was plugged into the port on the watch dog® while in the field for data collection. Relative humidity and temperature were recorded and stored. Although data was collected for the entire day, 0800h, 1200h and 1600h sampling times were used as a baseline for comparison among the three poly films.

Spider mite prevalence, Spider mite infestation was determined by quantifying the number of adult mites on small discs of leaves measuring 1cm in diameter with the aid of a magnifying lens.

C. Data analysis

The collected data was transformation using logarithm and subjected to analysis of variance (ANOVA) using SAS statistical package (SAS Inst., Inc., Cary, NC). Difference among treatment means were compared using Tukey's studentized range test at $P \leq 5\%$. Where there were treatment differences, mean separation was done using Tukey's Studentized Range (HSD) Test.

III. RESULTS AND DISCUSSION

A. Microclimate and spider mite occurrence

The poly films affected the microclimate and it was observed that relative humidity was significantly high under UV-A clear poly film during the night while the lowest values were recorded under the same cover during the day (Figures 1 and 2). Mean relative humidity of 69.2%, 76.1% and 71% with temperatures of 31.2 °C, 31.1°C and 30.9 °C was recorded under UV-A 205/N, UV-A clear and IR504 poly films respectively at 1200hrs. UV-A clear recorded 2.5°C and 1.3°C higher than UV-A 205/N and IR504 covers. Higher values of RH 93.1%, 96.5% and 93.3% and low temperature of 8.5°C, 8.9°C and 9.2°C was recorded at 0400hrs under the UV-A 205/N, UV-A clear and IR504 respectively.

This observation concurs with Holcman and Sentelhas, (2012) who evaluated microclimate under shading screens of assorted colours red, blue, black and reflective. The reflective shade screen used as the control transmitted 56.3%, red 27% while black recorded the least transmission of 10.4%.According to AlHelal and Abdel-Ghany, (2011) they observed that colourful screens have the capacity to alter the spectral properties which in turn influence the microclimate by lowering temperature and the darker the colour the less the amount of light transmitted Shahak, (2008). Additionally, besides the prevailing climate, greenhouse design, size and height affects the internal microclimate (Holcman and Sentelhas, 2012). This explains why the control poly film (UV-A clear) recorded the highest light transmission and the highest temperature at 1200hrs compared to IR504 and UV-A 205/N.

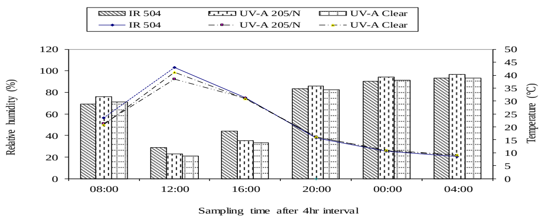

Fig. 1: Effect of selected poly film covers on percent relative humidityand air temperature(flush 1). Bar graphs and line graphs represent relative humidity and temperature respectively. Values presented are means over a growth period of 42 days at different sampling time; 0800 hrs, 1200 hrs and 1600 hrs

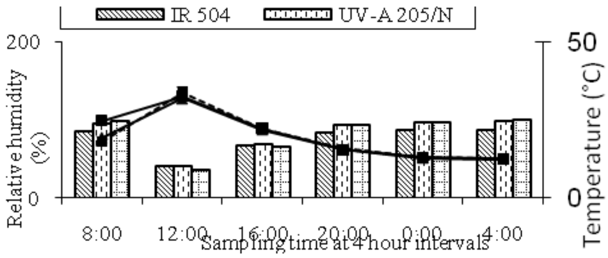

Fig. 2: Effect of selected poly film covers on percent relative humidity and air temperature (Flush 1I). Bar graphs and line graphs represent relative humidity and temperature respectively. Values presented are means over a growth period of 42 days at different sampling time; 0800hrs, 1200hrs and 1600hrs

B. Effect of cover and cultivars on spider mite's population

Spider mite occurrence and population was dependent on the type of poly-film used. In the first flush mites recorded under the IR504 poly film were significantly higher compared to the population under UV-A clear and UV-A 205/N. IR 504 poly film recorded a temperature of 0.7°C higher than UV treated poly films. It is therefore possible that the IR 504 poly film had higher temperature and therefore supported higher population of mites. Average relative humidity was 81% under the IR504, with temperature of 30.9°C during the day and 9.2°C during the night. Mites are also sensitive to higher temperature (greater than 22.7–32.6°C) and low relative humidity. Mites escape such temperatures by hiding under the leaf surface (Villanueva and Childers, 2005).

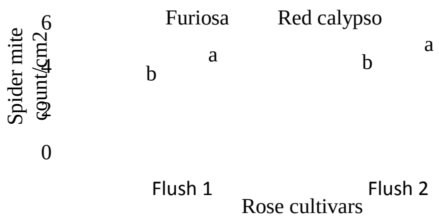

Fig. 3: Spider mite occurrence on different rose cultivars per cm² flushes 1 and 2

Generally, the UV-A clear poly-film transmitted higher percentage of UV-B radiation that is lethal for survival of mites (Data not presented). According to Ohtsuka and Osakabe, (2009) who studied the effect of artificial and natural UV-B radiation on mites they observed that the survival of mites and egg production reduced with increased UV-B. They also reported that natural UV-radiation reduced hatchability and development of spider mites.When mites sense unfavourable environmental conditions they diapause to increase resistance to stress. This finding was further confirmed by Sakai and Osakabe, (2010) who studied the solar specific damage of ultraviolet radiation and confirmed that UV-B (280-315nm) radiation was deleterious to spider mites compared to UV-A (315-400nm) radiation.Exposure of Phytoseiid species of mites to UV-B radiation resulted to loss of egg viability and high mortality reducing spider mite population.The effect explains why mites avoid the radiation by hiding under the leaf surface (Onzo*et al*., 2010) a strategy that has made their control difficult in most crops.During the second flush, the occurrence was higher under the UV-A clear while UV-A205/N and IR504 were statistically similar (Figure 3). The number of mites recorded in second flush was higher compared to the first flush especially under the UV-A clear poly film (Figure 3).During the first flush, the temperatures were extremely high and UV-A clear poly film transmitted more light which probably had more of UV-B radiation hence low mite population. During the second fllush UV-A clear poly film had higher mite population because during this time the prevailing weather condition was cool and temperatures were higher under this poly film thus suitable for spider mites.

Mites prevalence was also dependent on the rose cultivar. The highest number of mites were recorded on the cultivar Red calypso compared toFuriosa(Figure 4). The results in flush1 were consistent with those recorded in the second flush (Figure 4). Although the plants in the study were of similar species the results show that the spider mites had preference of one cultivar over the other. The two cultivars differed in physiological and morphological characteristics (data not shown) which could have contributed to spider mite preference. The two cultivars differed in their chlorophyll concentrations a factor that may have affected the reception of UV-B radiation hence differences in spider mite infestation.

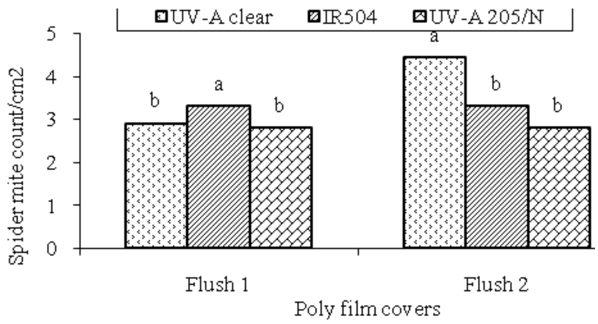

Fig. 4: Effect of poly film covers on the spider mite population per cm²flushes 1 and 2

C. Effect of calcium foliar feed on spider mite's population

The number of spider mites was dependent on the concentrationof calcium foliar feed. Treatments with concentration of 1.25ml/L and 2.5ml/L were not significantly different from the control and recorded the highest number of mites/cm^2. The lowest number of mites were recorded under higher concentration of calcium foliar feed 3.75ml/L and 5ml/L at 5% level of significance. Increase of calcium in the foliar feed could have strengthened the leaf cuticle and made it difficult for mites to suck sap leading to lower population on plants sprayed with 3.75ml/L and 5ml/L calcium concentration. Fertilizer application improves plant physiological performance which attracts pest infestation in some incidences while on the contrary because of changes in nutrient content it may influence feeding sites selection by mites (Chen *et al*., 2007). Mites damage was studied in Ivy and geraniums in relation to phosphorus and nitrogen fertilizer application, at the rates of N (8 or 24 Mm) and P (0.32, 0.64 and 1.28 Mm). It was established that different rates of nitrogen had no effect on the population of mites while over a period of 8 weeks phosphorus level 0.64Mm had more mites (Chen *et al*., 2007). The implication is that fertilizer/plant nutrition cause physiological and biochemical changes within the plant that leads to insect pest feeding preferences.

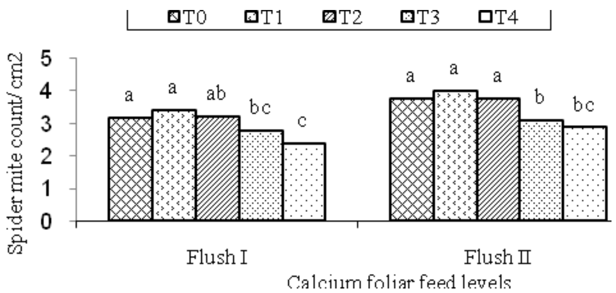

Fig. 5: Effect of calcium foliar feed application on spider mite count per cm^{2}in two field flushesI and II. T_0 =Distilled water, T_1 =CalMax® 1.25 ml/L, T_2 =CalMax® 2.5 ml/L, T_3 =CalMax® at the rate of 3.75 ml/L and T_4= CalMax® at the rate of 5.00 ml/L. Bars followed by the same letter were not significantly different at P<0.05.

D. Effect of cover and cultivar interaction on the spider mite occurrence flushes 1 and 2

The mite population was significantly higher under treatment combination of IR504 + Furiosa in flush 1(Table 1). Cultivar Furiosa under the UV-A clear control cover recorded a significantly higher population compared to Red calypso under the control UV-A clear and IR504. Mite population was however insignificantly different on both cultivars under UV-A 205/N. The observations made were inconsistent between flushes 1 and 2. Higher mite population was recorded under the control poly film on both cultivars Red calypso and Furiosa under UV-A clear poly film in flush 2 unlike in flush 1. The second flush was characterized by calm weather and overcasts with limited solar radiation. UV-A clear was observed to transmit more light that raised temperatures in the tunnel making the conditions suitable for mites compared to the other poly films. The least population was recorded under poly film cover UV-A205/N with both cultivars (Table 1). Mite population between the two flushes occurred because of differences in prevailing weather conditions. The first flush was characterized by high solar radiation and the UV-A clear poly film transmitted the highest amount of light resulting to lower population of mites under this cover.

Table 1: ***Effect of cover and cultivar interaction on the spider mite occurrence flushes1and 2.***

Cover/Cultivar	Flush I	Flush II
UV-A clear + Red calypso	2.6 cd	4.67a
UV-A clear + Furiosa	3.2b	4.33ab
IR504 + Red calypso	2.27d	4.20ab
IR504 + Furiosa	4.33a	2.8bc
UV-A 205/N +Red calypso	2.8bc	2.8bc
UV-A 205/N + Furiosa	2.8bc	2.27c

[1]Values in the column followed by different letter are significantly different at 5% level of significance for poly films and cover interactions according to Tukey's Studentized Range (HSD) Test. Values are the means of the treatments (n = 3)

Table 2: ***Effect of cultivar and calcium foliar feed on spider mite count flushes 1 and 2***

Cultivar/Calcium foliar feed	Flush I	Flush II
Red calypso +Distilled water	2.89c	3.67b
Red calypso + Ca 1.25ml/L	2.89c	3.44b c
Red calypso + Ca 2.5ml/L	2.11d	2.67d
Red calypso + Ca 3.75ml/L	2.89c	3.11c
Red calypso + Ca 5.0 ml/L	2.00d	2.56d
Furiosa +Distilled water	3.44b	3.89b
Furiosa + Ca 1.25ml/L	4.00a	4.56a
Furiosa + Ca 2.5ml/L	4.33a	4.89a
Furiosa + Ca 3.75ml/L	2.67c	3.11c
Furiosa + Ca 5.0 ml/L	2.78c	3.22c

[1]Values in the column followed by different letter are significantly different at 5% level of significance for the different calcium and cultivar interactions according to Tukey's Studentized Range (HSD) Test. Values are the means of the treatments (n = 3)

IV. CONCLUSION

The lethal effects of solar radiation affect the population of spider mites. Generally, spider mite occurrence increasedwith increase in temperature and decline in relative humidity. Spider mites prefer host plant occupancy and subsequent oviposition even within plant species.Proper choice of greenhouse cover, cultivar selection and foliar nutrient application can contribute significantly to integratedpest management programmes leading to reduction in agrochemical usage.

V. Acknowledgment

We wish to thank Egerton University, Stokman Rozen Limited Kenya and National Commission of Science, Technology and Innovation (NACOSTI) for facilitating this work.

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Biography of author

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She is a Horticulture professional specialized in Horticulture from Undergraduate degree to her Ph.D. degree level at Egerton University, Kenya. She has the passion for research in Floriculture and Ornamental Horticulture. She has worked in supervisory position in different Floriculture enterprises for three years. She has also acquired training in Food Safety and Sustainable Agriculture. With this knowledge, she enthusiastically works with farmers in Horticulture to encourage them embrace safe methods of Food production and minimize use of pesticides. She has served for six years as Agricultural extensionists, for the Government of Kenya. Audited farmers on implementation of Sustainable Agriculture Standards and capacity built farmers on various concepts in Horticulture. She joined Chuka University in 2013 as a lecturer. She integrates teaching and research. She has published seven (7) papers from her own research work with emphasis on Crop physiology. She is currently serving as the chairperson Plant Sciences Department Chuka University. Currently she is a member of the American Phytopathological Association.