EFFECT OF CHLORONICOTINYL AND CARBENDAZIM COMBINATIONS ON THE GROWTH AND YIELD OF WATERMELON (*Citrulus lunatus*) IN ENUGU AREA SOUTHEASTERN NIGERIA.

Awere, S.U. and Egekwu, B.O.
Department of Agronomy and Ecological Management, Enugu State University of Science and Technology Enugu, Enugu State Nigeria
Corresponding author: aweresu@yahoo.com.

ABSTRACT
A field experiment to evaluate the effect of insecticide (chloronicotinyl) and fungicide (carbendazim) combinations on the growth and yield of watermelon (*Critullus lunatus*) was carried out at the Teaching and Research farm of Faculty of Agriculture and Natural Resources Management, Enugu State University of Science and Technology, Enugu Southeastern Nigeria, using 3x2 factorial in a randomized complete block design (RCBD) replicated three times. Parameters assessed were days to 50% flowering, vine length (cm) number of fruits per plant, number of rotten fruits per plants, number of marketable fruits per plant and fruit yield (ton/ha). The result of the experiment showed a significant (P = 0.05) interaction effect of chloronicotinyl and cardbendazim combinations on all the parameters assessed. The application of insecticide to watermelon induced early flowering which lead to early maturity whereas the application of fungicide increased the number of days to 50% flowering thereby prolonging its maturity period. 1.5Lha^{-1} of insecticide and 1kgha^{-1} of fungicide combination recorded the highest vine length of 89.43 cm, whereas 1Lha^{-1} of insecticide and 1kgha^{-1} of fungicide combination recorded the highest mean number of 2.33 fruits per plant. The highest mean number of 1.00 rotten fruits per plants was recorded from 1Lha^{-1} of insecticide and 0kgha^{-1} of fungicide combination. 1Lha^{-1} of insecticide and 1kgha^{-1} of fungicide combination had the highest yield of 50.70tonha^{-1}

Keywords: Watermelon (*Citrulus lunatus*), insecticide (chloronicotinyl), fungicide (carbendazim), Interaction.

INTRODUCTION
Watermelon (*Citrullu lunatus*) belongs to the cucurbit family (cucurbitaceae). It is one of the most common types of melons and a vine like (*climber and creeper*) flowering plant that originated from south Africa. Its fruit is a special kind referred to by botanists as a pepo which may be either round or cylindrical and up to 600 mm long. It has a smooth rind, usually green, yellow and sometimes white with thickness of 10 mm to 40 mm and a juicy sweet interior usually red but sometimes yellow, orange or pink and even green if not ripe.

Watermelon plays significant role in the preparation of different kinds of food items such as salad. Watermelon is often served fresh as slices, chunks often in fruit salads, as juice, candy and as edible seeds. Watermelon is an economically important fruit crop and valuable alternative source of water in desert area. Watermelon fruits contain 93% water, with small amount of protein, fats, minerals and vitamins. It can also be cultivated for its vegetative parts (Schipper, 2000). The importance of watermelon as part of human food cannot be over emphasized. It was even mentioned in the bible as a food eaten by the ancient Isrealites while they were in bondage in Egypt. When the Isrealites going to the promise land became hungry in the wilderness, they complained to their leader Moses saying "In Egypt, we used to eat all the fish we wanted, and it cost us nothing. Remember the cucumbers, the watermelon, the leek, the onions and the garlic we had" (Good news Bible). The flavour of watermelon is best enjoyed raw because heating diminishes the flavour and softens the texture (FAOSTAT, 2010). Watermelon is a crop of high nutritional and commercial value but production in the southeastern Nigeria has been low. The most important factors that cause poor yield of watermelon are the incidence of insect pests and fungal diseases (Webb. 2010).

Watermelon is a good source of lycopene, carotnoid, fibre, citrulline and has antioxidant properties which improves health. It also contains potassium which helps in controlling blood pressure and probably stroke (Edelson *et al.* 2013).

In Nigeria, *Citrullus lunatus* is a crop of commercial importance. It is not only produced to overcome nutritional deficiency but is also good sources of income for farmers. The largest production of the crop in Nigeria comes from the northern part where suitable agro-ecology is found. The potentials of watermelon as cash crop are enormous for farmers, especially those residing near urban areas (Gore *et al.* 2007).

In the southeastern part of Nigeria and in the rainforest regions, the production of this crop has been low despite its nutritional and commercial value. This low production is due to susceptibility of the crop to several foliar and fruit diseases and insect pests whose severity is encouraged by high humidity, temperature and rainfall that leads to reduced crop quality and yield. The insect pests infestation does not only reduce growth and yield of the crop, but transmit pathogenic diseases which included fungal, viral and bacterial diseases. Such diseases can reduce or completely eliminate the ability of the plant cells and tissues to perform their normal physiological functions which may lead to reduced yield or death of the plant. Due to huge losses encountered in the southeast and other rain forest regions in Nigeria where weather conditions favour their development, most farmers are discouraged from continuous production of the crop. If disease control practices are not followed, some losses can be obtained yearly from foliage, stem, bud, flower and fruit diseases.

Studies have shown that in South Carolina (USA), the number and weight of marketable watermelon was increased by 61% with full season fungicide programs. Richardson (2011) has also shown that using insecticide and fungicide combination is an effective way to prevent yield losses to foliar diseases and insect pests.

Due to the fact that watermelon has become a cash crop of great importance in Nigeria today, the need for the use of yield improving factors such as insecticide and fungicide should not be neglected. Thus, effect of insecticide (chloronicotinyl) and fungicide (carbendazim) combinations to improve the growth and yield of watermelon was evaluated. This would definitely help to provide useful information on how to reduce or completely eliminate yield loses due to insect pests and fungal diseases attacks prevalent in the rainforest regions particularly in southeastern Nigeria.

Materials and methods.

A field experiment to evaluate the efficacy of insecticide (chloronicotinyl) and fungicide (carbendazim) combination on the growth and yield of watermelon was carried out at the teaching and research farm of faculty of Agriculture and Natural Resources Management, Enugu State University of Science and Technology Enugu, southeastern Nigeria during the 2015 cropping season.

Treatments.

The treatments were; three (3) rates of insecticide (chloronicotinyl) viz; 0 Litreha^{-1}, 1 Litreha^{-1} and 1.5 Litreha^{-1} (Factor 'A') and two (2) rates of fungicide (carbendazim) viz; 0Kgha^{-1} and 1kgha^{-1} (Factor 'B') giving a total of six (6) treatment combinations.

Treatment combinations.

Treatment combinations involved all the possible combinations of the rates of the factors in the experiment such as factor 'A' (chloronicotinyl) and factor 'B' (carbendazim) viz; A_1B_1, A_1B_2, A_2B_1, A_2B_2, A_3B_1,A_3B_2.

Experiment Design.

The experiment was carried out using 3 x 2 factorial in a randomized complete block design (RCBD) replicated three (3) times. The experimental area measured 14.6m by 6.8m (99.28m^2). The experimental units (plots) measured 1.6m x 1.6m and were separated by 1m pathway. Three seeds were sown per hole at a spacing of 50cm x 50cm and later thinned down to two plants per hole at 7days after germination.

Treatment schedule.

Spraying of chloronicotinyl and carbendazim combinations started at one week after germination and repeated weekly until final harvest.

Data Collection.

Data were collected on;

- Days to 50% flowering
- Vine length (cm)
- Number of fruits per plant
- Number of marketable fruits per plant
- Number of rottened fruits per plant
- Fruit yield (tonha^{-1})

Statistical Analyses.

The data collected were analyzed using the Genstat Release (2012) and analysis of variance outlined by Obi, (2001).

Results.

Effects of chloronicotinyl and carbendazim combinations on days to 50% flowering, vine length (cm) and number of fruits per plant.

The result of the experiment showed a significant (P =0.05) interaction effect of chloronicotinyl and carbendazim combinations on the number of days to 50% flowering, vine length and number of fruits per plant. On the number of days to 50% flowering, plots treated with 0Lha^{-1} of chloronicotinyl and 0kgha^{-1} of carbendazim recorded the highest mean number of 45days to 50% flowering followed by plots treated with 0Lha^{-1} of chloronicotinyl and 1kgha^{-1} of carbendazim that recorded mean number of 41.67days to 50% flowering, plots treated with 1Lha^{-1} of chloronicotinyl and 0kgha^{-1} of carbendazim with mean number of 39.67 day to 50% flowering, plots treated with 1Lha^{-1} of chloronicotinyl and Ikgha^{-1} of carbendazim with mean number of 38.33 days to 50% flowering, plots treated with 1.5Lha^{-1} of chloronicotinyl and 1kgha^{-1} of carbendazim that recorded mean number of 37.33 days to 50% flowering and plots treated with 1.5Lha^{-1} of chloronicotinyl and 0 kgha^{-1} of carbendazim that had mean number of 37.00 days to 50% flowering respectively. (Table 1). On the vine length (cm), 1.5Lha^{-1} of chloronicotinyl and 1kgha^{-1} of carbendazim combination had the highest mean vine length of 89.43 cm, followed by 1.5 Lha^{-1} of chloronicotinyl and 0kgha^{-1} of carbendazim, 1Lha^{-1}

of chloronicotinyl and 1kgah^{-1} of carbendazim, 0Lha^{-1} of chloronicotinyl and 1kgha^{-1} of carbendazim, 0Lha^{-1} of chloronicotinyl and 1kgha^{-1} of carbendazim and 0Lha^{-1} of chloroncotinyl and 0kgha of carbendzim combinations with vine lengths of 88.47cm, 81.50cm, 78.57cm, 75.33cm and 50.40cm respectively (Table 1). On the number of fruits per plant, 1Lha^{-1} of chloronicotinyl and Ikgah^{-1} of carbendazim combination recorded the highest mean number of 1.67 fruit per plant which differed statistically from 0 Lha^{-1} of chloronicotinyl and 0kgha^{-1} of carbendazim combination that had mean number of 0.47 fruit per plant whereas other treatments recorded mean number of fruits per plant that were statistically the same (Table 1).

Table 1. Effect of chloronicotinyl and carbendazim combinations on days to 50% flowering, vine length (cm) and number of fruits per plant.

Chloronicotinyl (Lha^{-1}) + Carbendazim (kgha^{-1})	mean days to 50% flowering	mean vine length(cm)	mean number of fruits Per plant
0 chloronicotinyl + 0 carbendazim	45	50.40	0.47
1 chloronicotinyl + 0 carbendazim	39.67	81.50	1.20
1.5 chloronicotinyl + 0 carbendazim	37.00	88.47	1.00
0 chloronicotinyl + 1 carbendazim	41.67	75.33	0.80
1 chloronicotinyl + 1carbendazim	38.33	78.57	1.67
1.5 chloronicotinyl + 1 carbendazim	37.33	89.43	1.40
F – LSD 0.05	5.95	5.40	0.88

Effect of chloronicotinyl and carbendazim combinations on the number of marketable fruits per plant, number of rotten fruits per plant and fruit yield (tonha^{-1}).

The result of the experiment showed a significant (P = 0.05) interaction effect of chloronicotinyl and carbendzim combinations on the number of marketable fruits per plant, which followed the same trend as the number of fruits per plant. Also the result of the experiment showed a significant (P = 0.05) interaction effect of chloronicotinyl and carbendazim combinations on the number of rotten fruits per plant with plots treated with 1Lha^{-1} of chloronicotinyl and 1kgha^{-1} of carbendazim combination recording the least mean number of 0.07 rotten fruit per plant, whereas plots treated with no chloronicotinyl and no carbendazim had the highest mean number of 1.20 rotten fruits per plant, followed by plots treated with 1Lha^{-1} of chloronicotinyl and 0kgha^{-1} of carbendazim which had mean number of 1.00 rotten fruit per plant. Furthermore, there was a significant (P = 0.05) interaction effect of chloronicotinyl and carbendazim combinations on the fruit yield (tonha^{-1}), with plots treated with no chloronicotinyl and no carbendazim recording 0.00 tonha^{-1}, whereas plots treated with 1Lha^{-1} of chloronicotinyl and 1kgha^{-1} of carbendazim combination recorded the highest mean fruit yield of 50.7 tonsha^{-1} (Table 2).

Table 2. Effect of chloronicotinyl and carbendazim combinations on the number of marketable fruits per plant, number of rotten fruits per plant and fruit yield (tonha^{-1})

Chloronicotinyl (Lha^{-1}) + Carbendazim (kgha^{-1})	mean days to 50% flowering	mean vine length(cm)	mean number of fruits Per plant
0 chloronicotinyl + 0 carbendazim	0.00	0.47	0.00
1 chloronicotinyl + 0 carbendazim	1.00	1.00	20.90
1.5 chloronicotinyl + 0 carbendazim	1.00	0.47	21.60
0 chloronicotinyl + 1 carbendazim	0.60	0.60	10.40
1 chloronicotinyl + 1carbendazim	2.33	0.07	50.70
1.5 chloronicotinyl + 1 carbendazim	2.20	0.13	36.70
F – LSD 0.05	0.61	0.58	16.0

DISCUSSION

The result of the experiment showing a significant (P = 0.05) decrease from 45 to 37 days to 50% flowering when the highest rate of 1.5 Lha^{-1} of insecticide (chloronicotinyl) was used without fungicide (carbendazim) may therefore suggest that early application of insecticide to watermelon is important in order to induce early flowering which may lead to early maturity of the crop. The result of the experiment may also suggest that insecticide (chloronicotinyl) application to watermelon helped in flower bud initiation. Furthermore, this result indicated that fungicide (carbendazim) application to watermelon did not promote flower bud initiation and did not interact with insecticide (chloronicotinyl) to reduce the number of days to 50% flowering, but rather negatively affects the efficacy of insecticide in reducing the number of days to 50% flowering. This was obvious as the number of days to 50% flowering increased from 37.00 days to 37.33 days when no fungicide was combine with the highest rate of 1.5Lha^{-1} of insecticide (Table 1). This result may also suggest that fungicide application at early stage of the crop growth could prolong its maturity period. A significant (P=0.05) interaction effect of insecticide and fungicide combinations on the vine length may therefore suggest that watermelon producers in Enugu area whose emphasis is on the production of forage should apply both insecticide and fungicide on the crop in order to obtain a higher leaf yield because the higher the vine length, the higher the number of leaves that will be produced from it .

A decrease in the number of fruits per plant when the rate of insecticide was increased from 1Lha^{-1} to 1.5Lah^{-1} in combination with fungicide may suggest that it will be a waste of resources to increase the rate of insecticide application to watermelon beyond 1Lha^{-1} if a farmer aims at obtaining a maximum number of fruits per plant. The same result was obtained when the rate of insecticide was increase from 1Lha^{-1} to 1.5Lah^{-1} without fungicide (Table 1), so also with the number of marketable fruits per plant (Table 2)

A significant (P=0.05) interaction effect of insecticide and fungicide combinations on the number of rotten fruits per plant may also suggest the possibility of insects (fruit borers/worms) contributing to fruit rot of this crop. This is because; sugary exudates produced at points of attack of the fruit borers/worms could serve as substrate to fungal pathogens that rotten fruits (Table 2). So the application of insecticide and fungicide combinations is an effective way to prevent yield losses to foliar and fruit diseases of watermelon. This is in line with the observation of Richardson (2011) who stated that using insecticide and fungicide combination is an effective way to prevent yield losses to foliar diseases of watermelon. A significant (P = 0.05) interaction effect of insecticide and fungicide combinations on fruit yield showed that both insecticide and fungicide should be applied to watermelon in order to achieve a maximum fruit yield but the rate of application should not exceed $1Lha^{-1}$ of insecticide and $1kgha^{-1}$ of fungicide, as this brought about a non significant decrease in fruit yield (Table 2).

Conclusion and Recommendation

To achieve a reduction in the maturity period of watermelon in Enugu Southeastern Nigeria, farmers should not apply a combination of insecticide and fungicide but insecticide only.

To achieve a maximum fruit yield, a combination of insecticide and fungicide application is necessary in watermelon production in Enugu Southeastern Nigeria, but the rate of application should not exceed $1Lha^{-1}$ of insecticide and $1kgha^{-1}$ of fungicide. To reduce fruit decay in the farm, watermelon farmers in Enugu Area Southeastern Nigeria should apply a combination of insecticide and fungicide from one week after germination until final harvest.

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