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Research Article

Integrated Management of Cotton Flea Beetle, *Podagrica puncticollis* Weise in Major Cotton Growing-Belt of Northwestern Ethiopia

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Abstract

Background and Objective: Cotton flea beetle poses a serious menace to cotton cultivation in Northwestern Ethiopia. Comprehensive pest management plays a sustainable role in reducing pest risk and pesticide use in cotton. This study aims to assess the occurrence and severity of cotton flea beetle infestation and evaluate effective management practices for controlling cotton flea beetle in Northwestern Ethiopia to improve cotton production and minimize yield losses. **Materials and Methods:** A field trial was conducted to evaluate the integrated use of insecticide, sowing date and seed rate against cotton flea beetle on cotton during 2020/21 cropping seasons. The treatments consisted of three levels of insecticide (Cruiser 350 FS, Carbaryl 85% WP, untreated control), sowing date (early, mid and late) and seed rate (15, 20 and 25 kg/ha) laid out in randomized complete block design with three replications. Two-year data were analyzed using ANOVA (Steel & Torrie) and means were compared using LSD at 5% significance. **Results:** The significant differences among treatments and the highest incidence (4.1 beetles/plant), leaf injury (47.5 shot-holes/leaf) and total plant damage (56.66%) were recorded from early sown untreated plots plus received low seed rate. On the other hand, the least results of 0.75 beetle, 17.5 shot-holes and 8.33% plant damage were noted in late sown plots with seeds treated with Cruiser plus received high seed rate. Pest infestation and damage levels on cotton plants decreased with the increase in the age of the plants and delayed sowing. Generally, treatment combinations with insecticides exhibited good performance in reducing pest threats with resultant increase boll and seed cotton yields than others. **Conclusion:** The study demonstrated that integrated use of seeds treated with Cruiser, early sowing time and high seeding rate is the best strategy against this pest and for achieving better cotton yield.

Key words: Cotton growth stages, insect number, shot-hole, seed treatment, foliar spray

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Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Cotton (*Gossypium hirsutum* L.) is an essential fiber crop and contributes a lot in the overall economic development of Ethiopia as well as it provides income to many people engaged in cotton related sectors[1]. It is widely cultivated in the lowland areas using extensive irrigation systems and also in limited level under rain fed farming[2]. However, the amount of cotton produced in the country is small and the current domestic cotton production is much lower than the potential[3]. Biotic factors coupled with climatic and edaphic factors are hindering normal growth, boll formation and productivity of the crop[4]. Insect pests have been reported as one of the major productivity limiting factors in most Malvaceae crop fields[5]. Insect attacks on cotton starts early in the season and continues until the pulling of the cotton sticks and inflicts 30-40% yield losses[6].

Among the insect pests that cause economic injury on the cotton crop, the cotton flea beetle *Podagrica puncticollis* Weise (Coleoptera: Chrysomelidae) is the most serious in the recent times. It is among the main destructive and economically important cotton pest species reported in Ethiopia and the nearby countries[7]. In Ethiopia, 75.51% yield loss caused by adult cotton flea beetle was reported in no insecticide treated cotton plot[8]. Ekoja and Pitan[9] stated that flea beetles (*Podagrica* spp.) are the most serious early season insect pests that might cause economic damage where it is not managed properly in several Malvaceae crops in Africa. Frequently early planted cotton is more expose to substantial attack by cotton flea beetles than later planted cotton[10]. Mostly, flea beetles feed on young seedlings especially on cotyledons and leaves of growing plants by disrupting the upper parts of leaf tissue thereby seriously hampering crop physiological processes and ultimately causing retarded growth[11] and yield drop or total loss in heavy infestations[12].

Cotton flea beetle, *P. puncticollis* is most commonly managed by the use of foliage, soil and seed treatments. Lamb[13] stated that most flea beetle adults are managed with insecticide as foliar dusts or sprays or seed treatment. Neonicotinoids have been the most commonly applied insecticides in seed treatments in the last three decades global and these seed dressing insecticides are active against a broad spectrum of economically important crop pests[14]. Among these insect pests, Chrysomelidae (leaf beetles) family was included[15]. The efficacy of various synthetic organic insecticides has been reported in the management of flea beetles. Carbaryl was reported to be effective in controlling the flea beetles in okra[16] and canola[17]. According to a study by Dosdall *et al.*[18], seeding rates can influence degree of flea beetle injury and higher seeding rates and plant populations are expected to decline damage to individual plants via dilution effect. Also, proper planting date can play a significant role in decreasing flea beetle prevalence and damage[19].

Currently in the major cotton production areas in northwestern parts of Ethiopia, the extent of cotton flea beetle infestation, abundance and damage has been increasing due to lack of scientific based interventions and cotton growers still continue to suffer considerably from the pest attack. Pest management is a major factor in the culture of cotton for increased production. Over the years, management measures for *Podagrica* spp. have received tremendous attention. Hence, the prevention and management of pests of crops must be comprehensive, especially that of cotton, because the plant diseases and insect pests of cotton are severe and the dosage of pesticide is great[20]. The effectiveness of an IPM strategy comprising cultural, mechanical and chemical methods against flea beetle was reported by Raghavendra *et al.*[21]. This study was conducted to determine the effect of integrated use of insecticide, sowing date and seed rate on infestation level of cotton flea beetle and cotton yield.

MATERIALS AND METHODS

Study area and duration: The study was conducted in Metema district in North Gondar Zone of the Amhara National Regional State during cotton main cropping seasons of 2020 and 2021. Metema is located at about 900 km Northwest of Addis Ababa and about 180 km west of Gondar Town. It is situated at 12°58' N and 36°12' E. The district has a long international boundary of more than 60 km with the Sudan. The altitude of Metema ranges from 550 to1608 meter above sea level. The daily maximum temperature can reach as high as 43°C during the months of March to May, while the mean annual temperature is about 31°C. The district has unimodal rainfall and the rainy period extends from June to the end of September. The total annual rainfall ranges from about 850 to 1100 mm as well as the soil type is predominantly black with vertic properties[22,23].

Experimental treatments and design: The treatments consisted of two synthetic insecticides (Cruiser 350 FS for seed treatment and Carbaryl 85% WP as foliar spray) and untreated check (control); three sowing dates (early, mid and late); and three seed rates (low = 15 kg per hectare, medium = 20 kg per hectare and high = 25 kg per hectare). Time of planting cotton was at the onset of rains (early) and two (mid) and four (late) weeks later. A total of 27 treatment combinations were arranged in a Randomized Complete Block Design (RCBD) with three replications. Cotton flea beetle infestations and cotton crop damage were evaluated in an open field experiment.

Plot layout and agronomic practices: Each plot consisted of 4 rows of 5 m length and 3.6 m width. The area of each plot was 18 m^2. The cotton variety Deltapine-90 was used for this trial. Sowing date was adjusted according to the onset of rainfall. The recommended seed rates for the variety were considered as medium seed rate and 5 kg lower and higher seed rates than the optimum one. Spacing between plants and rows were 20 and 90 cm, respectively. Spacing between plots and blocks were 0.5 and 1.5 m, respectively. All other agronomic practices were kept uniform to all plots and applied as and when needed.

Insecticide application: The insecticides Cruiser 350 FS and Carbaryl 85% WP were applied based on the recommended rates of 350 mL per 100 kg seeds and 1.5 kg per hectare, respectively. A weighed lot of cotton seeds were mixed in a plastic bag, with a carefully weighed amount of the chemical. To facilitate adherence of the toxicant, the seeds were first moistened and allowed to stand until the surface of the seed felt only slightly moist. The foliar insecticide Carbaryl was sprayed using knapsack sprayer two times at five and ten days after seedling emergence.

Sampling of cotton flea beetle: The adult cotton flea beetles were collected and counted by using a 25.4×12.7 cm sized sampling tray painted with white color. Cotton flea beetles were sampled from young field crops by enclosing the base of the plant in a hinged metal tray. The plant was then tapped (jarred) and beetles from it were counted as they fall onto the tray[10]. The number of adult cotton flea beetles per plant was recorded at 15, 21 and 30 days after sowing (DAS) through randomly selected ten plants from each plot.

Assessment of leaf damage: The extent of leaf damage was estimated by counting the number of shot-holes through ten randomly taken plants from each plot after applied treatments. Number of shot-holes per damaged leaf on plants was recorded at first true leaf, first several true leaves and second true leaf growth stages. Percentage of damage per ten plants at cotyledon, first true leaf, first several true leaves and second true leaf stages was recorded and the following formula was used to calculate percentages of plant damage[24].

$$\text{Perent damage} = \frac{\text{Total number of plants damaged}}{\text{Total number of plants in a sample}} \times 100$$

Yield assessment: The number of bolls per plant was counted randomly by taking ten plants from each plot when more than 50% of plants in a plot initiated bolls. Seed cotton yield was harvested by randomly taken and tagged ten plants from the central two rows of each plot. Cotton harvesting was made twice by hand picking and seed cotton yield per plants was changed into yield/ha.

Statistical analysis: Combined Analysis of Variance (ANOVA) for the two-year data was performed according to the procedure indicated by Steel and Torrie[24]. Mean separation was done using the Least Significant Difference (LSD) test at 5% level of significance.

RESULTS

Effect of integrated management tactics on the incidence of cotton flea beetle: There were significant ($p \leq 0.05$) differences among treatments in the number of cotton flea beetles per plant recorded at 15, 21 and 30 days after sowing (DAS) as shown in the Table 1. At 15 DAS, the highest (4.1) number of flea beetle per plant was recorded from untreated early sown plus received low seed rate, followed by medium (3.8) and high (3.61) seed rates. However, significantly least number of 0.75, 1 and 1.2 cotton flea beetles per plant were recorded in seeds treated with Cruiser and late sown plus received high, medium and low seed rates, respectively (Table 1).

In 21 DAS, the insecticide treated plots were most active and significantly effective against cotton flea beetles when compared with the untreated plots. Seeds treated with Cruiser late sown plus that received high seed rate hosted least (0.7) number of cotton flea beetle per plant, followed by those received medium (0.8) and low (1) seed rates. The least (1.2 to 1.36) number of flea beetles per plant was also recorded in seeds dressed with Cruiser mid sown, which was statistically similar (1.2 to 1.5) with beetle population counted in the plots sprayed with Carbaryl late sown. The highest (4) number of flea beetles per plant was counted from untreated early sown plus received low seed rate, followed by medium seed rate (3.71) and high seed rate (3.5). Likewise at 30 DAS and plots sown with seeds treated with Cruiser late sown plus received high seed rate were effective and recorded least (0.6) number of cotton flea beetle per plant, followed by those that received medium (0.7) seed rate. But, the highest (3.6) number of flea beetles per plant was observed from untreated early sown plots plus received low seed rate (Table 1).

Number of shot-holes per damage leaf at different growth stages of cotton plant: The results (Table 2) on number of shot-holes per damage leaf did vary significantly among treatments at first true leaf, first several true leaves and second true leaf growth stages of cotton plant. At first true leaf, the highest (47.5) number of shot-holes per damaged leaf was

Table 1: Effect of integrated use of insecticides, sowing dates and seed rates on number of cotton flea beetle days after sowing (DAS) at Metema in 2020/21 crop seasons

Treatments			Number of flea beetles per plant		
Insecticide types	Sowing dates	Seed rates	15 DAS	21 DAS	30 DAS
Cruiser	Early	Low	1.7^{i}	1.5^{gh}	1.23^{jk}
	Early	Medium	1.6^{ij}	1.46^{gh}	1.2^{jk}
	Early	High	1.53^{ij}	1.4^{h}	1.18^{ij}
	Mid	Low	1.5^{ij}	1.36^{h}	1.16^{ij}
	Mid	Medium	1.4^{ijk}	1.3^{hi}	1^{jk}
	Mid	High	1.33^{ijk}	1.2^{hij}	0.95^{jkl}
	Late	Low	1.2^{jkl}	1^{hij}	0.9^{jkl}
	Late	Medium	1^{kl}	0.8^{ij}	0.7^{kl}
	Late	High	0.75^{l}	0.7^{j}	0.6^{l}
Carbaryl	Early	Low	2.6^{fgh}	2.36^{def}	1.96^{f}
	Early	Medium	2.5^{gh}	2.21^{ef}	1.93^{fg}
	Early	High	2.46^{gh}	2.15^{ef}	1.86^{fg}
	Mid	Low	2.43^{gh}	2.13^{ef}	1.75^{fgh}
	Mid	Medium	2.4^{gh}	2^{fg}	1.6^{gh}
	Mid	High	2.2^{h}	1.53^{gh}	1.4^{hi}
	Late	Low	1.7^{i}	1.5^{gh}	1.18^{ij}
	Late	Medium	1.5^{ij}	1.33^{hi}	1.15^{ij}
	Late	High	1.4^{ijk}	1.2^{hij}	1^{jk}
Untreated	Early	Low	4.1^{a}	4^{a}	3.6^{a}
	Early	Medium	3.8^{ab}	3.71^{ab}	3.3^{ab}
	Early	High	3.61^{abc}	3.5^{ab}	3.26^{ab}
	Mid	Low	3.48^{bcd}	3.46^{ab}	3.1^{bc}
	Mid	Medium	3.41^{bcd}	3.4^{b}	3.03^{bc}
	Mid	High	3.2^{cde}	3.2^{bc}	2.81^{cd}
	Late	Low	3.08^{def}	2.8^{cd}	2.53^{de}
	Late	Medium	3^{def}	2.76^{cd}	2.48^{de}
	Late	High	2.8^{efg}	2.66^{cde}	2.35^{e}
CV (%)			18.67	22.80	17.47

Means sharing the same superscript letter(s) are not significantly different according to Least Significant Difference (LSD) test at 5% level of significance

recorded from untreated early sown plot plus received low seed rate, followed by medium seed rate (44.5). But, least numbers of 17.5, 18 and 19.5 shot-holes per damaged leaf was recorded in seeds treated with Cruiser late sown plus received high, medium and low seed rates, respectively. In first several true leaves, the highest (46.9) number of shot-holes per damaged leaf resulted from untreated early sown plots plus received low seed rate, which was not significantly different from plots received medium seed rate (43.9). But, least (16.8) number of shot-holes per damaged leaf was recorded in seeds treated with Cruiser late sown plus received high seed rate, statistically at par with plots received medium (17) and low (18) seed rates. Those treatments showed better performance against this beetle on the first earlier two crop stages also repeated their ability in similar fashion at second true leaf stage of the crop. However, this last assessed cotton stage scored relatively a bit lower shot-holes number compared to previous ones. See Fig. 1 for identifying the typical cotton flea beetle leaf feeding damage on cotton crop.

Percent of plant damage at different growth stages of cotton plant: The result showed that there were significant ($p \leq 0.05$) differences in percent damage per ten plants among treatments at early four growth stages of cotton plant, such as cotyledon, first true leaf, first several true leaves and second true leaf stages (Table 3). At cotyledon stage, the maximum (56.66) percentage of damage was observed on untreated early sown plots plus received low seed rate, followed by medium (51.66) and high (48.33) seed rates. However, the minimum (8.33) percent damage was recorded in seeds treated with Cruiser late sown plus received high seed rate, which was statistically similar with plots received medium (10) and low (10) seed rates. In first true leaf stage, the maximum (50) percent damage was observed on untreated early sown plots plus received low seed rate, followed by medium (45) and high (41.33) seed rates. But, significantly minimum (6.66) percent damage was recorded in seeds treated with Cruiser late sown plus received high seed rate. In case of first several true leaves stage, the maximum (46.66) percent damage was observed on untreated early sown plots plus received low seed rate, followed by medium (43.33) seed rate. Conversely, significantly minimum (3.33) percent damage was observed on seeds treated with Cruiser late sown plus received high seed rate. On the other hand, at second true leaf stage, the maximum (40) percent damage was observed on untreated early sown plots plus received low seed rate, which was

Fig. 1: Typical cotton flea beetle leaf feeding damage on cotton crop
This original photo was generated by authors during conducting the present field research work

Table 2: Effect of integrated use of insecticides, sowing dates and seed rates on number of shot-hole per damaged leaf caused by cotton flea beetle at different cotton growth stages at Metema in 2020/21 crop seasons

Treatments			Number of shot-holes per damaged leaf		
Insecticide types	Sowing dates	Seed rates	First true leaf	First several true leaves	Seed rates
Cruiser	Early	Low	22^{ij}	21^{hi}	18.5^{jk}
	Early	Medium	21.8^{ij}	20.9^{hi}	18.3^{jk}
	Early	High	21^{j}	20.6^{hi}	18^{jkl}
	Mid	Low	21^{j}	20.5^{hi}	17.78^{jkl}
	Mid	Medium	20.5^{jk}	19.5^{ij}	17.5^{jkl}
	Mid	High	20^{jkl}	19^{ij}	16.9^{jkl}
	Late	Low	19.5^{jkl}	18^{ij}	15.87^{jkl}
	Late	Medium	18^{kl}	17^{j}	15.35^{kl}
	Late	High	17.5^{l}	16.8^{j}	14.85^{l}
Carbaryl	Early	Low	26.6^{gh}	25.9^{fg}	24.55^{gh}
	Early	Medium	26.3^{gh}	25.78^{fg}	24.5^{gh}
	Early	High	26^{h}	25.6^{g}	24^{gh}
	Mid	Low	26^{h}	25.5^{g}	23.1^{gh}
	Mid	Medium	25.8^{h}	25^{g}	23^{gh}
	Mid	High	24.5^{hi}	23.3^{gh}	22^{hi}
	Late	Low	24.3^{hi}	23.1^{gh}	19^{ij}
	Late	Medium	24^{hi}	23^{gh}	18.5^{jk}
	Late	High	22^{ij}	20.9^{hi}	17^{jkl}
Untreated	Early	Low	47.5^{a}	46.9^{a}	40^{a}
	Early	Medium	44.5^{b}	43.9^{a}	38.41^{a}
	Early	High	40.98^{c}	40.6^{b}	35^{b}
	Mid	Low	40.15^{c}	39.86^{b}	34^{bc}
	Mid	Medium	33.93^{d}	33.6^{c}	31.45^{cd}
	Mid	High	32.5^{de}	32.23^{cd}	30de
	Late	Low	30.3^{ef}	30de	28^{ef}
	Late	Medium	30^{ef}	29.7^{de}	26^{fg}
	Late	High	29^{fg}	28.7^{ef}	24.6^{gh}
CV (%)			9.33	9.91	12.06

Means sharing the same letter(s) are not significantly different according to Least Significant Difference (LSD) test at 5% level of significance

Table 3: Effect of integrated use of insecticides, sowing dates and seed rates against cotton flea beetle on percent of damage plant at different growth stages of cotton at Metema in 2020/21 crop seasons

Treatments			Percent damage due to flea beetle per 10 plants			
Insecticide types	Sowing dates	Seed rates	Cotyledon stage	First true leaf	First several true leaves	Second true leaf
Cruiser	Early	Low	18.33^{mn}	16.66^{ij}	15^{gh}	11.66^{gh}
	Early	Medium	16.66^{no}	13.33^{ijk}	11.66^{ghi}	8.33^{ghi}
	Early	High	16.66^{no}	11.66jkl	11.66^{ghi}	8.33^{ghi}
	Mid	Low	13.33^{op}	10^{kl}	10^{hi}	8.33^{ghi}
	Mid	Medium	11.66^{pq}	10^{kl}	8.33^{ij}	6.66^{hi}
	Mid	High	11.66^{pq}	10^{kl}	8.33^{ij}	5^{i}
	Late	Low	10^{pq}	8.33^{kl}	6.66^{ij}	5^{i}
	Late	Medium	10^{pq}	8.33^{kl}	6.66^{ij}	5^{i}
	Late	High	8.33^{q}	6.66^{l}	3.33^{j}	3.33^{i}
Carbaryl	Early	Low	31.66^{hi}	28.33^{fg}	26.66^{ef}	21.66^{ef}
	Early	Medium	31.66^{hi}	26.66^{g}	25^{ef}	21.66^{ef}
	Early	High	30^{ij}	25^{g}	23.33^{f}	20^{f}
	Mid	Low	26.66^{jk}	23.33^{gh}	23.33^{f}	20^{f}
	Mid	Medium	25^{kl}	18.33^{hi}	16.66^{g}	13.33^{g}
	Mid	High	25^{kl}	18.33^{hi}	15^{gh}	11.66^{gh}
	Late	Low	23.33^{kl}	16.66^{ij}	15^{gh}	11.66^{gh}
	Late	Medium	21.66^{lm}	13.33^{ijk}	11.66^{ghi}	8.33^{ghi}
	Late	High	18.33^{mn}	11.66^{jkl}	10^{hi}	8.33^{ghi}
Untreated	Early	Low	56.66^{a}	50^{a}	46.66^{a}	40^{a}
	Early	Medium	51.66^{b}	45^{ab}	43.33^{ab}	36.66^{ab}
	Early	High	48.33^{bc}	41.66^{bc}	38.33^{bc}	35^{ab}
	Mid	Low	46.66^{cd}	40^{bcd}	38.33^{bc}	33.33^{bc}
	Mid	Medium	43.33^{de}	38.33^{cde}	36.66^{c}	33.33^{bc}
	Mid	High	40^{ef}	36.66^{cde}	35^{cd}	28.33^{cd}
	Late	Low	38.33^{fg}	35de	35^{cd}	28.33^{cd}
	Late	Medium	36.66^{fg}	33.33^{ef}	30de	26.66^{de}
	Late	High	35^{gh}	28.33^{fg}	26.66^{ef}	25^{def}
CV (%)			15.71	24.65	24.53	26.83

Means sharing the same letter(s) are not significantly different according to Least Significant Difference (LSD) test at 5% level of significance

statistically similar with medium (36.66) and high (35) seed rates. However, the minimum (3.33) percent damage was observed on seeds treated with Cruiser late sown plus received high seed rate.

Effect of integrated management tactics applied against cotton flea beetle on cotton productivity: There were significant ($p \leq 0.05$) differences among treatments in number of bolls per plant and seed cotton yield per hectare (Table 4). The highest (35) number of bolls per plant was obtained from seeds treated with Cruiser early sown plus received high seed rate. While, significantly least number of 11, 15 and 16 bolls per plant was obtained from untreated late sown plots plus received low, medium and high seed rates, respectively. In seed cotton yield, the highest (2451 kg) seed cotton yield/ha was obtained from seeds treated with Cruiser early sown plots plus received high seed rate. But, the lowest seed cotton yield of 914.67, 999.5 and 1046.83 kg/ha was obtained from untreated late sown plots plus received low, medium and high seed rates, respectively. See Fig. 2 for perceiving cotton plants growth variation among those grown from plots sown with seeds dressed with Cruiser insecticide and plots received no insecticide treated seeds.

DISCUSSION

The results of this study revealed that treatments grouped with insecticides showed their better effectiveness against cotton flea beetle incidence than the untreated ones across all sowing dates and seed rates in two year combined analysis of this study. On the other hand, those untreated treatments received high seed rate across all sowing dates relatively showed good performance against cotton flea beetle incidence as compared to others untreated treatment groups. Consequently, the insecticide treatments induced reduction of the cotton flea beetle population on treated plots. Especially, high effectiveness of Cruiser seed dressing insecticide was also observed in the present study compared to Carbaryl foliar spraying insecticide. The seedling stage is the most susceptible period and insecticides often need to be applied as a seed treatment or as a foliar insecticide to protect the crop from flea beetle feeding injury[25]. Seed dressings with insecticide are the most effective and main measures against flea beetle[17,26]. The most commonly used Neonicotinoid seed dressing insecticide Thiamethoxam reported as a preventive management measure against cotton flea beetle, early season

Fig. 2: Growth variances among cotton plants grown from the seeds treated with insecticide (vigorous and outsized) and untreated one (stunted) sown at the same time during the onset of rainfall in the hot spot area of cotton flea beetle at Metema District, Northwestern Ethiopia

This original photo was generated by authors during conducting the present field research work

pest of cotton in Ethiopia[8]. On the other hand, other researchers reported that Carbaryl as a foliar insecticide was very effective in the suppression of flea beetles in okra[16] and canola[17] crops. Adult cotton flea beetle peak emergence usually coincided with the emergence of the early sown cotton both years and this resulted in greater infestation level in the early sown cotton than later sown cotton. Results of the study indicate that the incidence of cotton flea beetle significantly declined with late sowing. In previous research study by Zeiss and Pedigo[27] recommended late planting to alleviate bean leaf beetle risk. Also, in the present study, treatment combinations of seeds treated with Cruiser, late sowing and high seed rate performed well and effectively suppressed cotton flea beetle prevalence related to other treatments. Similar research finding was reported[28]. Further, according to Dosdall *et al.*[18], flea beetle damage to individual plants was lower with high seeding rate than with lower one and higher seeding rates are also believed to dilute and decline injury of plants.

The current study revealed that insecticide treated plants exhibited significantly lower number of shot-holes per damage leaf across all sowing dates and seed rates than the untreated treatments that suffered heavy leaf damage. Especially, the highest number of shot-holes per damaged leaf was recorded from untreated early sown plots when compared with other sowing dates. In similar manner, Dosdall and Stevenson[29] observed lesser flea beetle damage to plants grown from seeds treated with insecticide than to plants grown from no insecticide treated seeds. Likewise, Knodel *et al.*[30] also indicated that canola flea beetles are generally managed with systemic insecticides, like Imidacloprid applied as a seed treatment. This study results also established that the extent of cotton leaf injury and number of shot-holes created by cotton flea beetle declined with late sowing and the cotton plant escapes first several true leaves growth stage. In this regard, Witkowski and Echtenkamp[31] reported that delayed planting is an essential cultural practice against bean leaf beetle in soybean. Ulmer and Dosdall[32] observed canola plants that have reached the four to six leaves vegetative growth stages or beyond can tolerate more feeding damage, unless flea beetles are damaging the growing point.

Table 4: Effect of integrated use of insecticides, sowing dates and seed rates against cotton flea beetle on number of bolls and yield of cotton at Metema in 2020/21 crop seasons

Treatments				
Insecticide types	Sowing dates	Seed rates	Number of bolls per plant	Yield (kg/ha)
Cruiser	Early	Low	32.33b	2313.67b
	Early	Medium	33b	2360.5b
	Early	High	35a	2451a
	Mid	Low	27.33fg	1861.5g
	Mid	Medium	28.16ef	1948.83f
	Mid	High	29de	1999.67ef
	Late	Low	21m	1400l
	Late	Medium	22.5l	1428.5kl
	Late	High	22.6kl	1450.17jkl
Carbaryl	Early	Low	29.56de	2012.33e
	Early	Medium	30.16cd	2125.17d
	Early	High	31.6bc	2253.5c
	Mid	Low	24.5ij	1600.67i
	Mid	Medium	25.16hi	1650.67hi
	Mid	High	26gh	1690.5h
	Late	Low	19.2no	1199.33n
	Late	Medium	20mn	1293m
	Late	High	22.5l	1399.67l
Untreated	Early	Low	23.5jkl	1455.33jkl
	Early	Medium	23.5jkl	1459.67jk
	Early	High	24ijk	1500j
	Mid	Low	18o	1050.67op
	Mid	Medium	18.66no	1092o
	Mid	High	19no	1196.33n
	Late	Low	11q	914.67q
	Late	Medium	15p	999.5p
	Late	High	16p	1046.83op
CV (%)			5.43	3.16

Means sharing the same letter(s) are not significantly different according to Least Significant Difference (LSD) test at 5% level of significance

The percentage of damage observed on cotton plant decreased with delayed sowing. The most effective group of treatments in reducing plant damage and recorded least overall percentage of plant damage were observed on plots sown with seeds treated with Cruiser and plots sprayed with Carbaryl across all sowing dates and seed rates. As a result, less feeding injury caused by cotton flea beetle was observed on insecticide treated cotton plant. Further, insecticide treated plots reduced problem of stand loss that can be resulted due to cotton flea beetle incidence during early stages of cotton. In this respect, seed treatments are commonly used and were effective against flea beetles as they protect vulnerable cotyledon leaves and early true leaves[29]. The degree of damage caused by cotton flea beetle declined with the cotton plant pass early vegetative growth stages or with the increase of the age of the cotton plants. As a result, relatively minimum percent damage was recorded at second true leaf stage as compared to earlier growth stages of cotton plant. According to Mahbubur Rahman *et al.*[33], flea beetle feeding is most damaging at seedling phase, where cotyledons and the first true leaves are major feeding sites.

The improved cotton yield observed from this study might be because of the reduction in the infestation of cotton plants by cotton flea beetle with linked plant damage as well as lessening cotton leaves injury or shot-hole and, in turn, allow for normal photosynthetic activity of the plant. Current study findings showed that treatment groups combined with insecticides, especially with Cruiser seed dressing insecticide resulted in higher number of bolls and more seed cotton yield compared to totally no insecticide received groups. In similar way, Hossain *et al.*[34] reported that seed treatments with Gaucho 70 WS produced significantly higher yield of cotton than the untreated control . Heavy cotton flea beetle infestations caused significant yield loss and were recorded in untreated control plots compared to the treated. These observations made on yield loss were reported by Emosairue and Ukaegbu[35] in farmer's field. Furthermore, Schumutterer[19] observed yield improvement through controlling flea beetle on cotton. Cotton flea beetle incidence and injury during cotyledon and seedling stages caused seed cotton yield reduction as observed in this study. Crop is more susceptible to cotton flea beetle injury due to the slow growth of its terminal bud, cotyledons and hypocotyls during the first ten days after emergence than the later stages. The terminal bud contains tissue that will eventually develop into true leaves and fruiting structures. This beetle prefers to feed on these slow-developing parts and the damage it causes shows up as the plant grows. Leaves of a plant, which has been heavily attacked, are shot-holed and defoliated. Once the cotton plant develops the first three to four true leaves, it grows much faster and develops more tolerance to cotton flea beetle. Early planted cotton is more prone to cotton flea beetle damage. Finally, both seed treatment and foliar applied insecticides were effective against early season cotton flea beetle via lessening such damages. In similar context, Lamb[13] described that the greatest crop damage by crucifer flea beetle occurs during the first two weeks after the seedling appear and in this time, the beetles feed on the cotyledons, leaf tissue and growing tip, often killing the young seedlings.

CONCLUSION

This study indicates cotton flea beetle peak emergence usually coincided with the emergence of the early sown cotton both years and this resulted in greater infestation level in the early sown cotton than later sown cotton. Cotton seed treatment with Cruiser and foliar spraying of cotton seedlings with Carbaryl demonstrated satisfactory results against cotton flea beetle incidence and associated damages than untreated one. Delayed sowing also showed promising results in reducing incidence of this pest. Combining an appropriate minimum insecticide application strategy, time of planting and seed rate is most likely going to achieve greater control of cotton flea beetle than relying on either strategy independently. Seed treatment with systemic insecticide like Cruiser (Thiamethoxam) should be incorporated as an integral part of cotton flea beetle management tactics. Monitoring and insecticide application schedules for cotton flea beetle should focus on crop phenology, especially on cotyledon up to first true leaf stages.

SIGNIFICANCE STATEMENT

The cotton flea beetle, *Podagrica puncticollis* Weise, is a major economic pest of cotton in Northwestern Ethiopia, causing substantial leaf damage and plant losses during crop establishment. This study demonstrates that an integrated approach combining insecticide treatment, adjusted sowing dates and optimized seed rates significantly reduces beetle infestation and plant damage, while enhancing cotton yield. Early sowing with Cruiser-treated seeds at higher seed rates proved particularly effective. The findings provide critical insights for developing long-term monitoring, decision-support tools and ecologically sound integrated pest management (IPM) strategies, thereby supporting sustainable cotton production in the region.

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REFERENCES

1. Gudeta, B. and A.G. Egziabher, 2019. Cotton production potential areas, production trends, research status, gaps and future directions of cotton improvement in Ethiopia. Greener J. Agric. Sci., 9: 163-170.
2. Addis, T., A. Kachi and J. Wang, 2021. A review of current state and future directions of cotton production in Ethiopia. Cogent Food Agric., Vol. 7. 10.1080/23311932.2021.1880533.
3. Zeleke, M., M. Adem, M. Aynalem and H. Mossie, 2019. Cotton production and marketing trend in Ethiopia: A review. Cogent Food Agric., Vol. 5. 10.1080/23311932.2019.1691812.
4. Prakash, S., M. Kumar, Radha, S. Kumar and S. Jaconis *et al*., 2023. The resilient cotton plant: Uncovering the effects of stresses on secondary metabolomics and its underlying molecular mechanisms. Funct. Integr. Genomics, Vol. 23. 10.1007/s10142-023-01118-9.
5. Mobolade, A.J., I.J. Ejemen, J.A. Rufus and E.A. Festus, 2014. Control of flea beetles *Podagrica* spp. (Coleoptera: Chrysomelidae) infestation on okra (*Abelmoschus esculentus* (L.) Moench) using *Piper guineense* seed extracts. Arch. Phytopathol. Plant Prot., 47: 2332-2339.
6. Tokel, D., B.N. Genc and I.I. Ozyigit, 2022. Economic impacts of Bt (*Bacillus thuringiensis*) cotton. J. Nat. Fibers, 19: 4622-4639.
7. Eshetu, A.A., A.M. Bayeh, B.D. Tebkew and A.W. Mulatu, 2021. Susceptibility of several cotton varieties to the cotton flea beetle, *Podagrica puncticollis* Weise (Coleoptera: Chrysomelidae), in a hot dry tropical environment of Ethiopia. Entomol. Hell., 30: 1-19.
8. Abebe, E.A., 2015. Cotton flea beetle, *Podagrica puncticollis* weise (Coleoptera: Halticidae) in Metema District, Northern Ethiopia: Yield loss assessment and management. Open Access Lib. J., Vol. 2. 10.4236/oalib.1101128.
9. Ekoja, E.E. and O.O.R. Pitan, 2022. Refining trapping protocols for field management of *Podagrica* spp. Crop Prot., Vol. 162. 10.1016/j.cropro.2022.106096.
10. la Croix, E.A.S., 1961. Observations on the ecology of the cotton flea-beetles in the Sudan Gezira and the effect of sowing date on the level of population in cotton. Bull. Entomol. Res. 52: 773-783.

11. Frohlich, G. and F. Koehler, 1969. Pests and Diseases of Tropical Crops and Their Control. Pergamon Press, Oxford, United Kingdom, Pages: 371.
12. Subedi, I.P. and K. Vaidya, 2003. Control of flea beetle, *Phyllotreta nemorum* L. (Coleoptera: Chrysomelidae) using locally available natural resources. Himalayan J. Sci., 1: 111-114.
13. Lamb, R.J., 1984. Effects of flea beetles, *Phyllotreta* spp. (Chrysomelidae: Coleoptera) on the survival, growth, seed yield and quality of canola, rape and yellow mustard. Can. Entomol., 116: 269-280.
14. Munkvold, G.P., C. Watrin, M. Scheller, R. Zeun and G. Olaya, 2014. Benefits of Chemical Seed Treatments on Crop Yield and Quality. In: Global Perspectives on the Health of Seeds and Plant Propagation Material, Gullino, M.L. and G. Munkvold, Springer, Dordrecht, Netherlands, ISBN: 978-94-017-9389-6, pp: 89-103.
15. Jeschke, P., R. Nauen, M. Schindler and A. Elbert, 2011. Overview of the status and global strategy for neonicotinoids. J. Agric. Food Chem., 59: 2897-2908.
16. Benson, G.A.S., 2017. Efficacy of selected insecticides and botanicals in the control of field insect pest of okra (*Abelmoschus esculentus*) in Akure. Int. J. For. Hortic., 3: 1-5.
17. Weiss, M.J., P. McLeod, B.G. Schatz and B.K. Hanson, 1991. Potential for insecticidal Management of flea beetle (Coleoptera: Chrysomelidae) on canola. J. Econ. Entomol., 84: 1597-1603.
18. Dosdall, L.M., M.G. Dolinski, N.T. Cowle and P.M. Conway, 1999. The effect of tillage regime, row spacing, and seeding rate on feeding damage by flea beetles, *Phyllotreta* spp. (Coleoptera: Chrysomelidae), in canola in central Alberta, Canada. Crop Prot., 18: 217-224.
19. Joyce, R.J.V., 1969. Pests of crops in Northeastern and Central Africa, with particular reference to the Sudan. H. Schmutterer. Stuttgart: Gustav Fischer Verlag. (1969), pp. 296, DM.58. Exp. Agric., 5: 345-346.
20. Chattopadhyay, P., G. Banerjee and S. Mukherjee, 2017. Recent trends of modern bacterial insecticides for pest control practice in integrated crop management system. 3 Biotech, Vol. 7. 10.1007/s13205-017-0717-6.
21. Raghavendra, K.V., B. Rekha, K.B. Ramesh, K.T. Felix and S. Chander, 2023. Integrated pest management strategy for striped flea beetle, *Phyllotreta striolata* infesting radish (*Raphanus sativus*). Indian J. Agric. Sci., 93: 1308-1313.
22. Lemenih, M., S. Feleke and W. Tadesse, 2007. Constraints to smallholders production of frankincense in Metema District, North-Western Ethiopia. J. Arid Environ., 71: 393-403.
23. Alemu, B., E. Garedew, Z. Eshetu and H. Kassa, 2015. Land use and land cover changes and associated driving forces in North Western Lowlands of Ethiopia. Int. Res. J. Agric. Sci. Soil Sci., 5: 28-44.
24. Steel, R.G.D. and J.H. Torrie, 1980. Principles and Procedures of Statistics: A Biometrical Approach. 2nd Edn., McGraw Hill, New York, United States, ISBN-13: 9780070609266, Pages: 633.
25. Bracken, G.K. and G.E. Bucher, 1986. Yield losses in canola caused by adult and larval flea beetles, *Phyllotreta cruciferae* (Coleoptera: Chrysomelidae). Can. Entomol., 118: 319-324.
26. Wilde, G., K. Roozeboom, A. Ahmad, M. Claassen and B. Gordon *et al*., 2007. Seed treatment effects on early-season pests of corn and on corn growth and yield in the absence of insect pests. J. Agric. Urban Entomol., 24: 177-193.
27. Zeiss, M.R. and L.P. Pedigo, 1996. Timing of food plant availability: Effect on survival and oviposition of the bean leaf beetle (Coleoptera: Chrysomelidae). Environ. Entomol., 25: 295-302.
28. Bazie, S., Y. Ebabuye, S.W. Kim and Y.S. Lee, 2019. Integrated management of haricot bean foliage beetle in Northeastern Ethiopia. Psyche: J. Entomol., Vol. 2019. 10.1155/2019/3728651.
29. Dosdall, L.M. and F.C. Stevenson, 2005. Managing flea beetles (*Phyllotreta* spp.) (Coleoptera: Chrysomelidae) in canola with seeding date, plant density, and seed treatment. Agron. J., 97: 1570-1578.
30. Knodel, J.J., D.L. Olson, B.K. Hanson and R.A. Henson, 2008. Impact of planting dates and insecticide strategies for managing crucifer flea beetles (Coleoptera: Chrysomelidae) in spring-planted canola. J. Econ. Entomol., 101: 810-821.
31. Witkowski, J.F. and G.W. Echtenkamp, 1996. Influence of planting date and insecticide on the bean leaf beetle (Coleoptera: Chrysomelidae) abundance and damage in Nebraska soybean. J. Econ. Entomol., 89: 189-196.
32. Ulmer, B.J. and L.M. Dosdall, 2006. Emergence of overwintered and new generation adults of the crucifer flea beetle, *Phyllotreta cruciferae* (Goeze) (Coleoptera: Chrysomelidae). Crop Prot., 25: 23-30.
33. Mahbubur Rahman, M., M. Ahsanul Haque, A. Habib, S. Akter and M.S. Rana, 2026. Species composition of flea beetles (*Phyllotreta* spp.) and the influence of sowing time on infestation dynamics in mustard. Discover Plants, Vol. 3. 10.1007/s44372-026-00641-w.
34. Hossain, S.M.A., M.A. Baque and M.R. Amin, 2013. Comparative effectiveness of seed treating and foliar insecticides against sucking pests of cotton and impact on their natural enemies. Bangladesh J. Agric. Res., 38: 61-70.
35. Emosairue, S.O. and G.C. Ukaegbu, 1994. Effect of Lamdacyhalothrin on the population of *Podagrica uniforma* (jacoby) and p. Sjostedti (jacoby) and the yield of okra (*Abelmoschus esculentus* (l.) Moench in the Calabar humid area. J. Appl. Chem. Agric. Res., 1: 25-29.