

Original Research Article

Formatted: Font: 11 pt

Effect Field Efficacy of Different Insecticides against Fall Armyworm, *Spodoptera frugiperda* (J.M. Smith) in Maize at Belaka Municipality, Udayapur, Nepal

ABSTRACT

~~Action~~ This research was conducted to evaluate the five selected commercial formulation of insecticides against newly introduced Fall armyworm *spodoptera frugiperda* in the farmer's field at Belaka Municipality of Udayapur district-, Nepal. The experiment was laid out in Randomized completely blocked design (RCBD) from 23rd Feb, 2021. The prepared field was divided into ~~six~~ ~~treatments and~~ four replications ~~with six treatment~~ (Imidacloprid 70 % WDG@0.3ml/ltr water, Spinetoram 11.7 % SC@0.3ml/ltr water, Chlorantraniliprol 18.5 % W/W@0.4ml/ltr water, Emamectin Benzoate 5% WDG@0.4ml/ltr, Azadirachtin 0.03% EC @5ml/ltr and control).Total three spray of the insecticides were done at the interval of 7 days after the initial damage symptoms starts to appear. The field experiment showed that all the insecticides were significantly effective in reducing the number of live larvae per plant after 3rd spray where as fast and foremost reduction in live larvae was seen in the plot sprayed with spinetoram and chlorantraniliprole .There was 89% reduction of live larvae after 1st spray in the plot sprayed with spinetoram and chlorantraniliprole followed by emamectin benzoate, 66%. Similarly, no damage symptoms were seen in the plot sprayed with spinetoram and chlorantraniliprole after 3rd spray. The highest grain yield per plot was also gained from chlorantraniliprole (8.8 ton/ha) and spinetoram (8.5 ton/ha).

Formatted: Font: 11 pt, Highlight

Formatted: Font: 11 pt

Formatted: Font: 11 pt, Highlight

Formatted: Font: 11 pt

Formatted: Font: 11 pt, Highlight

Keywords: *Spodoptera frugiperda* , RCBD, Spinetoram, Chlorantraniliprol, Emamectin Benzoate

Highlight

- Insecticides spinetoram and chlorantraniliprole followed by emamectin benzoate were effective against fall armyworm in maize.

Comment [A1]: Recast/Format your abstracts.

Formatted: Font: 11 pt

Formatted: Font: 11 pt, Highlight

Formatted: Font: 11 pt

INTRODUCTION

Maize (*Zea mays*), belongs to the family poaceae is the leading crop in the world in term of production (FAOSTAT) [1]. In context of Nepal, it is the second most important crop after rice. It is cultivated in the area of 956447 ha with average production of 2713635 metric ton with an average productivity of 2.84 mt/ha (MoAD, 2020) [2]. Maize is one the major crop grown in Udayapur district in an area covering about of 17, 836 ha with average production of 39,846 metric tonn. Since a few years, the maize production has not increased as expected though there is advancement in agricultural

technologies and the development of new innovations. The crop has been largely affected by the severe outbreak of dangerous insect and pest among which Fall armyworm is the prime (Bista *et al.*, 2020) [3]. Although maize is the way of life for most of the farmers in udayapur district its productivity has been decreased due to the infestation of fall army worm. The invasive fall armyworm (FAW) is threatening maize production and the livelihoods of smallholder farmers.

Comment [A2]: Use numbers for references in the text

Formatted: Font: 11 pt

Formatted: Font: 11 pt

Fall armyworm has been reported for the first time in Nepal from gaidakot of Nawalparasi district in May 2019. Since then, insect has been spread into various maize growing agro ecological zones of Nepal. (Bajracharya *et al.*, 2019). It is the most destructive pest in maize cultivation to decline production and productivity. Caterpillars of this Spodoptera species are considerably more voracious than many other noctuid maize pests. Each of its six larval instars feeds extensively on young maize leaves often destroying the vegetation growth point of the plant. As per the unpublished report of National Plant Protection Organization (NPPO) about 20% losses has been reported in the maize field in Chitwan, Nepal. (GC & YD, 2020). The invasion of pest in Nepal is somehow a new phenomenon and its systematic studies including losses before and after invasion are yet to be quantified.

People are unaware about the IMP packages and proper management practices as it is newly entered pests in Nepal. Due to the improper knowledge about the management practices, farmers in infected areas are spraying various highly toxic insecticides like cocktail formulations of chlorpyrifos 50% and cypermethrin 5% which are readily available in the local market with various trade name (Bajracharya *et al.*, 2019). Farmers are using high dose of various insecticides with frequent application without the knowledge of their efficacy. Various researches have been done nationally and internationally against fall armyworm. Various insecticides and pesticides and different management practices are recommended against fall armyworm in different countries but they are either not registered in Nepal or not easily available in local market. Considering all these factors, this research is focused on evaluating some of the selected insecticides including those insecticides with novel mode of action against fall army worm which are easily available in local market to generate baseline data to find the best insecticides for its management.

MATERIALS AND METHODS

Field experiment was laid out on Randomized completely blocked design (RCBD). An experimental plot of 221 meter square (length 13m and breadth 17m) was selected at farmer field. The prepared field was divided into four replications with six treatment (5 insecticides + 1 control/water spray) in each. The gap between two replication was 0.5m and the gap between each treatment in a replication was 0.4m. Each treatment plot size was (4*2.5) meter square. Fertilizer dose was 2.75 kg urea, 2.22 kg DAP and 1.11 kg MOP as per general recommendation (100:60:40 kg NPK /ha). Half dose of Urea and full dose of DAP and MOP was applied as basal dose during field preparation. Remaining half

dose of nitrogen was applied twice, one after 25 days of sowing and next after 45 days, as side dressing. A hybrid variety of maize, Tx Hybrid were line shown on 23rd of Feb 2021 maintaining spacing of 60 cm row to row and 25 cm plant to plant. Plants were thinned and one plant per hill was maintained after three weeks of sowing. First weeding was done 30 days after showing and second weeding and earthing up were done 45-50 days after showing. The duration of the research was four months (Feb 23- Jun 16,2021)

Table 1: List of the treatments used in field experiment.

| Treatments | Chemical name | Formulation | Doses | Trade name |
|------------|---------------------|-------------|-------------|------------|
| T1 | Imidacloprid | 70 % WDG | 0.3ml/later | Allmire |
| T2 | Spinetoram | 11.7 % SC | 0.3ml/ltr | Largo |
| T3 | Chlorantraniliprole | 18.5 % W/W | 0.4ml/ltr | Cover |
| T4 | Emamectin Benzoate | 5% WDG | 0.4ml/ltr | Cobra |
| T5 | Control | | water | Water |
| T6 | Azadirachtin | 0.03% EC | 5ml/ltr | Multineem |

After the initial symptoms starts to appear, the first data -was recorded. After that the treatments were applied as a foliar spray in research field-. The data was recorded from 10 randomly tagged plants per plot on the basis of scoring scale (0-5). The data were recorded thrice at an interval of 7

days. The plant was observed on the presence and absent of live larvae, the presence and absent of foliar damage on the upper four leaves and whorl, height of the plant and later yield data were collected.

The recorded data were subjected to analysis of variance (ANNOVA) using Genstat software (15th edition). Comparison among significant variables was done by LSD test at the 5% level of significance and separation of mean was done by using Duncan's Multiple Range Test (DMRT).

Scoring scale for Foliar damage by FAW:

Table 122, Scoring scale (0-5) for assessment of foliar damage due to fall armyworm (Davis and Williams 1992).

| Score | Damage symptoms / description |
|-------|---|
| 0 | No visible feeding symptoms on upper leaves and whorl |
| 1 | Papery window damage symptoms on upper leaves and whorl |
| 2 | Few small holes on upper leaves and whorl |
| 3 | Ragged holes on upper leaves and partially whorl damage |
| 4 | whorl and upper leaves extensively damaged |
| 5 | Whorl completely destroyed and plant dying due to extreme defoliation |

Formatted: Font: 11 pt, Not Bold, Not Italic

Formatted: Font: 11 pt

Formatted: Font: 11 pt

Formatted: Font: 11 pt

Formatted: Font: 11 pt

Formatted: Font: 11 pt

Formatted: Font: 11 pt

Formatted: Font: 11 pt

Formatted: Font: 11 pt

Formatted: Font: 11 pt

RESULTS AND DISCUSSIONS

Effect of insecticides in the reduction of live larvae Reduction in live larvae

The number of live larvae per plant and reduction of live larvae before and after spraying different insecticides are given in the table 1. All the insecticides were found significantly effective in reducing fall armyworm infestation after 3rd spray. Spinetoram and chlorantraniliprole were found consistently superior in reducing the live larvae of FAW as compared to others insecticides. There was 89% reduction of the live larvae after 1st spray in the plot sprayed with spinetoram and chlorantraniliprole, followed by emamectin benzoate (66%). Which was then reduced to 100% after 2nd and 3rd spray. Similar result was reported by (Bharadwaj *et al.*, 2020) where Spinetoram 11.7 SC and chlorantraniliprole 18.5 WW was found most effective treatment in reducing the population of *S. frugiperda* followed by Emamectin benzoate 5 WG. After 7 days of 1st spray, significantly least number of larvae was recorded with spinetoram (0.08 larvae per plant), chlorantraniliprole (0.1 larvae per plant), emamectin benzoate (0.23 larvae per plant), This finding is supported by (Deshmukh *et al.*, 2020a) where after 7 days of first spray, the lowest number of larvae per plant was recorded with

spinetoram (0.13 larvae per plant), plant, chlorantraniliprole (0.13 larvae per plant), emamectin benzoate (0.17 larva per plant), Live larvae were not found in maize plant after second spray in the plot sprayed with Spinetoram, Chlorantraniliprol and emamectin benzoate. Similar result was reported in a study conducted by (Bajracharya *et al.*, 2019) where the Spinetoram, chlorantraniliprole and emamectin benzoate was found promising for live larvae reduction.

Table 3. Reduction of FAW larval count in different observations after pesticides spray

| S.N. | Treatments | Reduction in larval count in second observation | Reduction in larval count in third observation | Reduction in larval count in fourth observation |
|------|--------------------|---|--|---|
| 1 | Imidacloprid | 65 ^{bc} | 86 ^b | 100 ^b |
| 2 | Spinetoram | 89 ^{bc} | 100 ^b | 100 ^b |
| 3 | Chlorantraniliprol | 89 ^c | 100 ^b | 100 ^b |
| 4 | Emamectin Benzoate | 66 ^c | 100 ^b | 100 ^b |
| 5 | Control | -58 ^a | -75 ^a | -85 ^a |
| 6 | Neem | 45 ^b | 78 ^b | 100 ^b |
| | CV % | 54.3 | 52.5 | 60.6, too high? |
| | LSD | 40.42 | 51.4 | 63.10 |
| | Prob | ** | ** | ** |
| | s.e.d. | 19 | 24.11 | 29.60 |

Note: NS- Non-Significant; *- Significant at 5% level of significance and **-Significant at 1% level of significance, CV-Coefficient of variance, LSD-Least Significant Difference, s.e.d-standard error of differences of mean

Effect of different insecticides on the ~~foliar~~foliar and upper parts of leaves

On the basis of damage symptoms on whorl and upper four leaves chlorantraniliprole and spinetoram were found superior compared to all others treatments. Chlorantraniliprole and spinetoram were effective in reducing foliar damage of maize as compared to untreated control in green house experiment (Sisay *et al.*, 2019). Emamectin benzoate was found second most effective insecticides on the basis of damage symptoms. Emamectin is effective insecticides against lepidopteran insect pest (Argentine *et al.*, 2002) and it was found very effective against *S. frugiperda* in laboratory condition when treated with pesticide treated cotton leaves and flowers. Similarly (Hardke *et al.*, 2011) reported that chlorantraniliprole is highly effective in bioassay against *S. frugiperda* in laboratory as well as effective in controlling the pest in field sorghum.

Table 4. Evaluation of various insecticides against FAW damage on whorl and upper leaves in maize

| S.N. | Treatments | Pest Damage score before spray | Pest Damage score after 1 st spray | Pest Damage score after 2 nd spray | Pest Damage score after 3 rd spray | Damage reduction before spray and after 3 rd spray |
|------|-----------------------------------|--------------------------------|---|---|---|---|
| 1 | Imidacloprid | 2.75 ^{ab} | 1.25 ^a | 0.75 ^{ab} | 0.50 ^a | 83.3 |
| 2 | Spinetoram | 3.75 ^b | 1.25 ^a | 0.75 ^{ab} | 0.00 ^a | 100 |
| 3 | Chlorantraniliprol | 3.00 ^{ab} | 1.25 ^a | 0.50 ^a | 0.00 ^a | 100 |
| 4 | Emamectin Benzoate | 3.00 ^{ab} | 1.75 ^{ab} | 1.00 ^{ab} | 0.25 | 88 |
| 5 | Control | 2.75 ^{ab} | 3.00 ^b | 3.25 ^c | 3.50 ^b | -33.3 |
| 6 | Neem Azadiractin (adopt one word) | 2.50 ^a | 1.75 ^{ab} | 1.50 ^{bc} | 1.75 ^b | 29.2 |
| | CV % | 22.7 | 44.3 | 45.3 | 47.1 ^c | 32.4, too high ? |
| | LSD | 1.014 | 1.143 | 0.881 | 0.71 | 30 |
| | Prob | NS | * | ** | ** | ** |

Formatted: Font: 11 pt

Formatted: Font: 11 pt

Formatted: Font: 11 pt

Formatted: Font: 11 pt

Formatted: Font: 11 pt

Formatted: Font: 11 pt

Formatted: Font: 11 pt, Highlight

Formatted: Font: 11 pt

Formatted: Font: 11 pt

Formatted: Font: 11 pt

Formatted: Font: 11 pt

Formatted: Font: 11 pt, Highlight

Formatted: Font: 11 pt, Highlight

Formatted: Font: 11 pt

Formatted: Font: 11 pt

| | | | | | |
|--------|--------|---------|---------|---------|---------|
| | (0.21) | (0.036) | (0.001) | (<.001) | (<.001) |
| s.e.d. | 0.476 | 0.536 | 0.413 | 0.33 | 14 |

Formatted: Font: 11 pt

Note: NS- Non-Significant; *- Significant at 5% level of significance and **-Significant at 1% level of significance, CV-Coefficient of variance, LSD-Least Significant Difference, s.e.d- standard error of differences of mean.

Formatted: Font: 11 pt

Formatted: Font: 11 pt

Effect of different insecticides on the yield of maize

Of the tested insecticides, the highest grain yield was recorded in the treatment of chlorantraniliprole 18.5 SC (8.82 ton/ha) followed by spinetoram 11.7 SC (8.59 ton /ha) and emamectin benzoate 5 SG (7.47 ton/ha). Similar result was reported by (Deshmukh *et al.*, 2020) in the field efficacy of insecticides for management of invasive fall armyworm where Chlorantraniliprole recorded the higher grain yield, followed by spinetoram and emamectin benzoate. In the present experiment lowest reduction in damage (29.2%) and lowest yield (6.35 ton/ha) were observed from azadirachtin after control (water sprayed) plot. Pesticides have no significant effect on plant height. Similar result was reported by (Sisay *et al.*, 2019). Thzere were no significant difference in the height of the plant after chemical spray.

Table 5. Yield analysis of maize.

| S.N. | Treatments | 500 grain weight(gm) | Yield t/ha | Cobs per plot | Initial plant stand | Final plant stand | Plant height |
|------|--------------------|----------------------|-------------------|--------------------|---------------------|-------------------|---------------------|
| 1 | Imidacloprid | 147.6 | 7.2 ^{ab} | 49.0 ^b | 52 | 40 | 266 ^{ab} |
| 2 | Spinetoram | 148.5 | 8.5 ^c | 53.5 ^b | 53 | 44 | 267.5 ^{ab} |
| 3 | Chlorantraniliprol | 151.2 | 8.8 ^c | 53.5 ^b | 50 | 40 | 275 ^c |
| 4 | Emamectin Benzoate | 148.0 | 7.4 ^b | 49.75 ^b | 51 | 40 | 264.4 ^{ab} |

Formatted: Font: 11 pt

Formatted: Font: 11 pt

Formatted: Font: 11 pt

Formatted: Font: 11 pt

Formatted: Font: 11 pt

| | | | | | | | |
|---|------------------|---------|-------------------|-------------------|---------|---------|-------------------|
| 5 | Control | 143.6 | 6.2 ^a | 42.0 ^a | 52 | 39 | 255 ^a |
| 6 | Neem Azadiractin | 144.4 | 6.3 ^{ab} | 43.5 ^a | 47 | 35 | 259 ^{ab} |
| | CV % | 5.54 | 9.9 | 5.8 | 11.1 | 10 | 2.3 |
| | LSD | 11.8 | 1.115 | 4.221 | 8.5 | 6 | 8.97 |
| | Prob | NS | ** | ** | NS | NS | ** |
| | | (0.759) | (<.001) | (<.001) | (0.717) | (0.086) | (0.005) |
| | s.e.d. | 5.3 | 0.523 | 1.98 | 4 | 3 | 4.21 |

Note: NS- Non-Significant; *- Significant at 5% level of significance and **-Significant at 1% level of significance, CV-Coefficient of variance, LSD-Least Significant Difference, s.e.d- standard error of differences of mean.

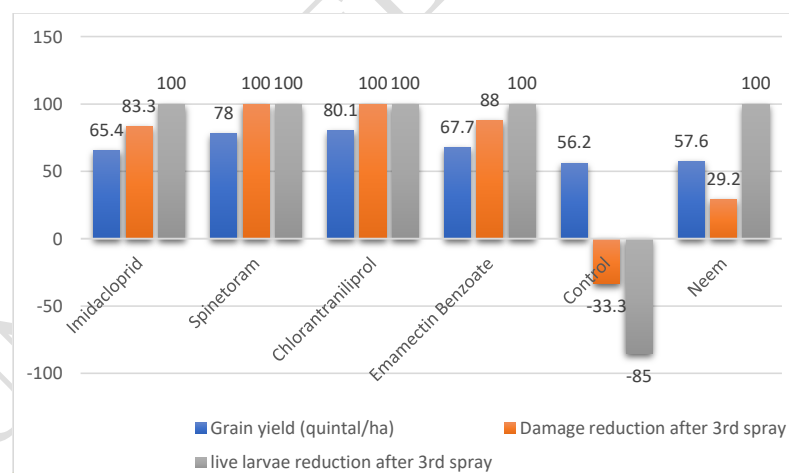


Figure 144: Effect of treatments on reduction of live larvae, foliar damage and yield.

This figure shows that there was 100% reduction in the number of live larvae and damage symptoms after third spray in the plot sprayed with chlorantraniliprole and spinetoram. The highest grain yield was from the plot sprayed with chlorantraniliprole followed by spinetoram. Similarly lowest grain yield and lowest reduction in live larvae and damage symptoms was from the neem sprayed plot.

CONCLUSION

Maize is the most cultivated crop in the world where as in context of Nepal it is the second most cultivated crop after rice. Maize production is affected by various insects and pest out of which FAW is the one. An experiment was conducted to evaluate the efficacy of different insecticides against FAW in maize at Belaka, Municipality, Udayapur, Nepal. From the research findings it was concluded that out of the five different insecticides used, all the used insecticides played an important role in the reduction of live larvae after 3rd spray. However, the insecticides chlorantraniliprole and spinetoram shows faster and effective result in the reduction of FAW in maize at Belaka, municipality Udayapur. These two insecticides showed effective result in the reduction of live larvae as well as foliar damages as compared to other insecticides and also the yield of grain was more in the plot sprayed with these two insecticides. Similarly, Emamectin Benzoate was found second most effective insecticides after these two insecticides. There was not much more difference in the grain yield, reduction in foliar damage and live larvae in the emamectin benzoate sprayed plot so, it can also be used properly and alternately to manage fall armyworm in maize after those two insecticides. Hence two of the insecticides spinetoram and chlorantraniliprole followed by emamectin can be used effectively to reduce the infestation of FAW in maize.

REFERENCE

FAOSTAT. (n.d.). Retrieved July 2, 2021, from <http://www.fao.org/faostat/en/#data/QC>

MoAD. (2020a). *Statistical Information on Nepalese Agriculture 2018/19*. Ministry of Agriculture, Land Management and Cooperatives.

Bista S, Thapa MK, Khana S. Fall armyworm: Menace to Nepalese farming and the integrated management approaches. *International Journal of Environment, Agriculture and Biotechnology*. 2020;5(4): page number? <https://ijeab.com/detail/fall-armyworm-menace-to-nepalese-farming-and-the-integrated-management-approaches/>

Bajracharya ASR, Bhat B, Sharma P, Shashank PR, Meshram NM, Hashmi TR. First record of fall army worm *Spodoptera frugiperda* (J. E. Smith) from Nepal. *Indian Journal of Entomology*. 2019;81(4): 635 to ? <https://doi.org/10.5958/0974-8172.2019.00137.8>

Formatted: Font: 11 pt, Highlight

Formatted: Font: 11 pt

Formatted: Font: 11 pt, Highlight

Formatted: Font: 11 pt

Formatted: Font: 11 pt, Highlight

Comment [A3]: Present only major findings in this part.

Formatted: Font: 11 pt

Formatted: Font: 11 pt, Highlight

Formatted: Font: 11 pt

Formatted: Font: 11 pt, Highlight

Formatted: Font: 11 pt

Formatted: Font: 11 pt, Highlight

Formatted: Font: 11 pt

Formatted: Font: 11 pt, Highlight

Formatted: Font: 11 pt, Not Italic, Highlight

Formatted: Font: 11 pt

Formatted: Font: 11 pt, Highlight

Formatted: Font: 11 pt

Formatted: Font: 11 pt, Not Italic, Highlight

Formatted: Font: 11 pt, Highlight

Formatted: Font: 11 pt

Formatted: Default Paragraph Font, Font: 11 pt, Font color: Auto

Formatted: Font: 11 pt

Formatted: Font: 11 pt, No underline, Highlight

Formatted: Font: 11 pt, No underline

Formatted: Font: 11 pt, No underline, Highlight

Formatted: Font: 11 pt, Not Italic, No underline, Highlight

Formatted: Font: 11 pt, No underline

Formatted: Font: 11 pt, No underline, Highlight

Formatted: Font: 11 pt, No underline

Formatted: Font: 11 pt, Not Italic, No underline, Highlight

Formatted: Font: 11 pt, No underline, Highlight

Formatted: Font: 11 pt, No underline

Formatted ...

Formatted: Font: 11 pt, No underline

Formatted ...

Formatted: Font: 11 pt, No underline

Formatted ...

Formatted: Font: 11 pt

GC, & YD. (2020). *Fall Armyworm Incursion in Nepal-What Can be Done with the Lessons from Other Countries.*

Formatted: Font: 11 pt, No underline

Formatted: Font: 11 pt

Bharadwaj, G., Mutkule, D., Thakre, B., & Jadhav, A. (2020). Bio-efficacy of different insecticides against fall armyworm, *Spodoptera frugiperda* (J.E. Smith) on Maize. *Journal of Pharmacognosy and Phytochemistry.*

Formatted: Font: 11 pt, No underline

Formatted: Font: 11 pt

Deshmukh, S., Pavithra, H. B., Kalleshwaraswamy, C. M., Shivanna, B. K., Maruthi, M. S., & Mota-Sanchez, D. (2020). Field efficacy of insecticides for management of invasive fall armyworm, *spodoptera frugiperda* (J. E. Smith) (Lepidoptera: Noctuidae) on maize in India. *Florida Entomologist*, 103(2), 221. <https://doi.org/10.1653/024.103.0211>

Formatted: Font: 11 pt, No underline

Formatted: Font: 11 pt

Sisay, B., Tefera, T., Waggari, M., Ayalew, G., & Mendesil, E. (2019). The efficacy of selected synthetic insecticides and botanicals against fall armyworm, *spodoptera frugiperda*, in maize. *Insects*, 10(2), 45. <https://doi.org/10.3390/insects10020045>

Formatted: Font: 11 pt, No underline

Formatted: Default Paragraph Font, Font: 11 pt, Font color: Auto

Argentine, J. A., Jansson, R. K., Halliday, W. R., Rugg, D., & Jany, C. S. (2002). Potency, spectrum and residual activity of four new insecticides under glasshouse conditions. *Florida Entomologist*, 85(4), 552–562. [https://doi.org/10.1653/0015-4040\(2002\)085\[0552:PSARAO\]2.0.CO;2](https://doi.org/10.1653/0015-4040(2002)085[0552:PSARAO]2.0.CO;2)

Formatted: Font: 11 pt, No underline

Formatted: Default Paragraph Font, Font: 11 pt, Font color: Auto

Hardke, J. T., Temple, J. H., Leonard, B. R., & Jackson, R. E. (2011). Laboratory toxicity and field efficacy of selected insecticides against fall armyworm (Lepidoptera: Noctuidae). *The Florida Entomologist*, 94(2), 272–278.

Formatted: Font: 11 pt, No underline

Formatted: Font: 11 pt

Formatted: Font: 11 pt

UNDER PEEK