INDIAN MUSTARD AND BUCKWHEAT AS TRAP PLANTS OF DIAMONDBACK MOTH (*Plutella xylostella* L.) IN CABBAGE CULTIVATION

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ABSTRACT

Diamondback moth (Plutella xylostella) is an important pest of crucifer crops. It greatly reduced both yield and crop quality on cabbage (Brassica oleracea var. capitata). The field study was conducted to evaluate the efficacy of two trap plants: Indian mustard (Brassica juncea), and Buckwheat (Fagopyrum esculentum) from November 2018 to March 2019 in Chitwan, Nepal. Diamondback moths' population were similar in trap plants but was significantly lower as compared to the control plot. Diamondback moth larvae population was lower during early vegetative growth stages whereas trapping efficacy of trap crops were gradually reduced with the development of maturity in trap plants. The lowest damage of wrapper leaves were obtained in Indian mustard deployed trap plant followed by buckwheat trap plant and control respectively; however, the yield was similar in all treatments. In addition, natural enemies were observed higher in traps crops deployed plots compared to the control plots. Therefore, trap plants can be used as an alternative sustainable pest management tool to manage diamondback moth as well as increase the abundance of natural enemies.

Keywords: Buckwheat, cabbage, diamondback moth, indian mustard, trap plant

INTRODUCTION

Cabbage (*Brassica oleracea* var *capitata* L.) is the most popular vegetable crop in Nepal. The edible portion of cabbage is "vegetative bud". It is eaten as a vegetable in curries, soups, pickles, and salads. In Nepal, the total area under cabbage cultivation was 30311 ha with a yield of 17.11 mt/ha in the fiscal year 2018/19, whereas, in Chitwan district, the area under cabbage production is 340 ha with the productivity of 15.53 mt/ha in the fiscal year 2018/19 (MoALD, 2019).

Several factors are responsible for the decreased productivity of cabbage in Nepal including inadequate supply of quality inputs (Sharma, 2019) and insect pest damage (Kafle *et al.*, 2012). Insect pests namely diamondback moth (*Plutella xylostella* Linn.), cabbage butterfly (*Pieris brassicae* Linn.), cabbage aphid (*Brevicoryne brassicae* Linn.) and mustard aphid (*Lipaphis erysimae* Kalt.), cabbage borer (*Hellula undalis* Fab.), cabbage looper (*Trichopulsia ni* Hub.) are major pests on cabbage and cauliflower (Yadav and Malik, 2014). Diamondback moth is one of the well-known and

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destructive insect pests of crucifers around the world. About 80-90% loss is caused by this pest in cabbage crop (Robert and Wright, 1996). Recent studies have shown that the trend of pesticide use is increasing in Nepal (Sharma *et al*., 2013), and 90% of total pesticides are used in vegetable farming (Atreya and Sitaula, 2010). So far diamondback moth has been reported to develop resistance against 877 different insecticides of more than ten modes of action classes (Mota-Sanchez and Wise, 2020).

In Nepal, integrated pest management (IPM) is being used as an alternative method to replace the intensive use of insecticide against this pest (Upadhaya, 2003). This has improvised the concept of growers to minimize the use of harmful chemical pesticides to control diamondback moths and reduced their intensity in the field crops. Eventually, the use of botanical products, bio-pesticides, habitat manipulation techniques, etc. has been developed. The use of trap plants is the alternative pest management strategy for the various categories of insect pests that are farmers friendly and cheap (Tiwari *et al*., 2019). Trap plants either trap the pest in the border by restricting the movement of pests from the perimeter of the field or attract the pest into a more preferred plant (Hokkanen, 1991). The various implementation types of trap crops based on temporal or spatial deployment are perimeter, sequential, push-pull, etc. (Hokkanen, 1991; Shelton & Badenes-Perez, 2006). Conventional trap cropping for lepidopteran pests relies on the capacity of trap crops to attract for oviposition and keep the pest away from the cash crop (Badenes-Perez *et al*., 2005). Hence, this study was undertaken to develop alternative pest management for *P. xylostella* in cabbage fields and reduce pesticide amount in vegetable farms.

MATERIALS AND METHODS

EXPERIMENTAL SITE

The research was conducted at Bharatpur Metropolitan City- 18, Chitwan from November 2018 to March 2019. The site is located at the latitude of 27^0 63'North; longitude 84^0 28' and altitude of 168 meters above sea level. The experiment was designed by laying three main plots with long side running East-West. The plot was further divided into six small cabbage plots and trap plants were sown in the perimeter of each main plot. Indian mustard, *Brassica juncea* (L.) (Czern.) (var. Pusa Bold) and Buckwheat, *Fagopyrum esculentum* Moench (var. Mithe Fapar-1) were used as trap plants in the experiment. Trap plants deployed field was 8 m distance from control plots (Fig 1). The area of each cabbage plot was 6.75 m^2 with 4 rows and 5 cabbage plants in each row. Row to row and plant to plant spacing was maintained at 60 cm and 45 cm, respectively.

Both trap plants were sown in the perimeter of the cabbage field just before 15 days of cabbage transplanting. Two rows of trap plants were sown in a continuous line or row with 15 cm intra-spacing and 10 cm outside of the cabbage plot. The net area occupied by each trap plant was 6.66 m^2 outside of cabbage plots (Fig 1). They were sown 15 days before to synchronize the plant vegetative period with cabbage growth and pest incidence.

Table 1. Treatments in the experimental field

Treatments	Treatment details
Treatment 1	Trap plant: Indian mustard (*Brassica juncea*) in the perimeter of the cabbage plot
Treatment 2	Trap crop: Buckwheat (*Fagopyrum esculentum)* in the perimeter of the cabbage plot
Treatment 3	Control (cabbage only)

AGRONOMIC PRACTICES AND PLANTING MATERIALS

Cabbage cv "Green Coronet" was used for this study. The experimental field was plowed thoroughly as required by disc harrow. FYM was used @ 20 t/ha in the field. Thirty-five days old seedlings of 2- 4 true leaf stages were transplanted in the field on 28th December 2018. Basal dose of fertilizer was applied @ 120:80:60 kg NPK/ha in which half dose of N and a full dose of P and K were applied and the remaining dose (i.e., 50kg/ha) N was applied after 45 days of transplanting (DAT) as a side dressing in the field. Different intercultural practices such as weeding, earthing-up, and irrigation were done from time to time on a need basis.

LAYOUT OF THE EXPERIMENT

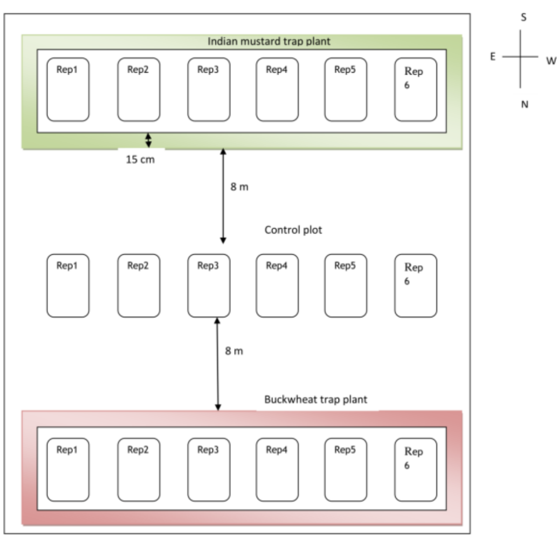

Figure 1. Layout of the experimental field

DATA COLLECTION AND ANALYSIS

Six cabbage plants from each treatment plot were randomly selected for data collection. The diamondback moth larvae populations were directly counted by observing the whole outer leaves of cabbage. Data were recorded starting from 50 DAT after the adult moth begin to appear in Wotta-T trap placed for monitoring in nearby cabbage field. It was then recorded evenly after 4 days of the first count up to ten times. Field collected insect counting data were square root transformed before ANOVA (Gomez & Gomez, 1984). The data was statistically analyzed by using analysis of variance using the R-Studio (Version 3.6.1) software package.

RESULTS

EFFICACY OF TRAP PLANTS

In most of the recordings, the numbers of diamondback moths was significantly lower in trap deployed cabbage plots as compared to control plots but were not significantly different between trap plants. However, the non-significant population of diamondback moth was similar among the trap plants, and control at 66 DAT, 74 DAT, 78 DAT, and 82 DAT (Table 2).

Table 2. Mean number of diamondback moth recorded on cabbage plants adjacent to each trap plant in different time interval

Observation / Treatment	50 DAT	54 DAT	58 DAT	62 DAT	66 DAT	70 DAT	74 DAT	78 DAT	82 DAT	86 DAT
Indian mustard	1.38^{b}	1.70^{b}	1.17^{b}	1.86^{b}	3.09	2.21^{b}	3.66	3.10	3.91	4.16^{b}
Buckwheat	1.64^{b}	1.54^{b}	1.58^{b}	2.40^{b}	2.82	2.33^{b}	3.17	3.84	4.14	4.52^{b}
Control	2.39^{a}	2.68^{a}	3.06^{a}	3.34^{a}	3.23	3.34^{a}	3.75	3.72	4.48	5.02^{a}
Means	1.808	1.977	1.939	2.539	3.049	2.633	3.531	3.658	4.182	4.569
Sem(±)	0.052	0.022	0.029	0.051	-	0.017	-	-	-	-
CV (%)	31.16	18.64	21.54	21.82	-	12.45	-	-	-	-
p-value	0.028	<0.001	<0.001	0.002	0.547	<0.001	0.297	0.089	0.073	0.007

DAT: Days after transplanting; CV: coefficient of variation; Values with the same letters in a column are not significantly different at 5% by DMRT (Duncan's multiple range test)

CABBAGE DAMAGE AND YIELD PATTERN IN TRAP PLANTS

The biological yield and net yield of cabbage were non-significant both in trap plants used field and control. However, the number of damaged wrapper leaves per plant was observed highly significant. The highest number of damaged wrapper leaves in cabbage plants was observed with control (6.37) followed by buckwheat (5.16) and Indian mustard (3.73) (Table 3).

Table 3. Cabbage yield (biological and net) and mean number of damaged wrapper leaves in cabbage field adjacent to each trap plant and control plots

Treatments	Biological yield (mt/ha)	Net yield (mt/ha)	Number of damaged wrapper leaves/plant
Indian mustard	78.44	54.94	3.73[c]
Buckwheat	74.53	52.28	5.16[b]
Control	69.58	44.17	6.37[a]
Means	74.19	50.46	5.09
Sem(±)	-	-	0.06
CV (%)	-	-	11.96
p-value	0.555	0.314	<0.001

CV: coefficient of variation; Values with the same letters in a column are not significantly different at 5% by DMRT (Duncan's multiple range test)

POTENTIAL NATURAL ENEMIES

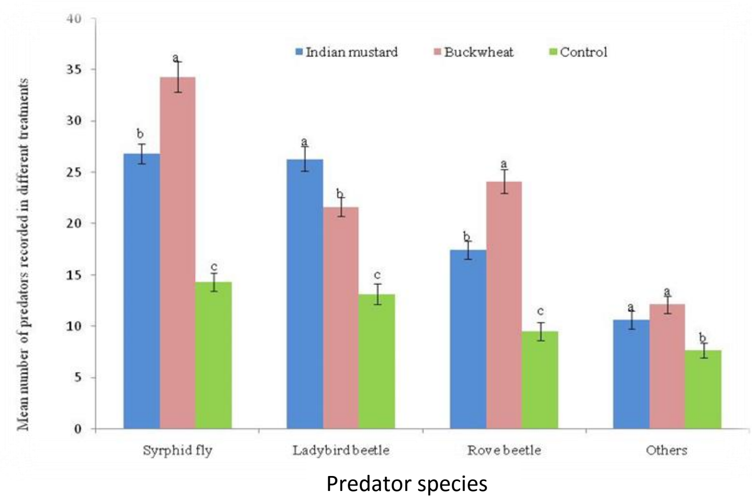

Figure 2. Mean number of predators; syrphid fly (adult and larvae), ladybird beetle (adult and larvae), rove beetle and other observed in trap deployed cabbage plot and control plot. Letters are used to denote the significant different treatments from each other; error bars are standard error of the mean LSD (5%), (df=10).

Number of beneficial predators such as syrphid flies (*Syrphus spp.*) (Syrphidae: Diptera), ladybird beetle (*Coccinella septempunctata* L.) and rove beetle were significantly higher in trap plants deployed cabbage plot compared to control plot (Fig 2). Significantly higher *Syrphus spp.* and rove beetle populations were observed in buckwheat deployed cabbage plots followed by Indian mustard deployed trap and the lowest in control cabbage plots (Fig 2). But, the ladybird beetle (*C. septempunctata)* population was significantly higher in the Indian mustard trap followed by buckwheat deployed and control cabbage plots. Other potential beneficial predators such as ants (Formicidae: Hymenoptera), braconid wasps (Braconidae: Hymenoptera), spiders (Arachnids), carabids (Carabidae: Coleoptera), wasps (Ichneumonidae: Hymenoptera), etc. were significant in trap and control cabbage plots but statistically at par between two trap deployed cabbage plots.

DISCUSSIONS

For reducing pesticide pressure in conventional pest management strategies, trap plants are an appealing option. When trap plants maintain harmful pest populations below the damage threshold level, they become an efficient way to minimize insecticide application (George *et al.*, 2019). Habitat manipulation by planting different border trap plants and non-crop origin can also conserve natural enemies and becomes a more efficient biological pest control strategy. Habitat manipulation can also result in a more effective biological pest control strategy by conserving natural enemies (Landis *et al.*, 2000). In this study, Indian mustard treatment helped reduce the incidence of *P. xylostella* during the initial growth phase. Then, the efficacy of traps remained in decreasing order. Inconsistency result of Indian mustard was observed for trapping diamondback moth. A similar result was stated by Smyth *et al.* (2003), who concluded that oviposition preference differed significantly among pre-flowering Indian mustard as a trap plant with growth stages of cabbage. In other observations, Srinivasan and Moorthy (1992) also performed sowing Indian mustard 15 days before and a second time 25 days after planting the main crop (cabbage) to maintain the plant population and floral density long-lasting to observe the effect of the trap. Badenes-Perez *et al.* (2005) evaluated that Indian mustard was highly attractive for diamondback moth Karimzadeh and Besharatnejad (2019) suggested that Indian mustard using trap plant could be recommended for the diamondback moth control, including the highest attraction of diamondback moth adults towards Indian mustard trap plant.

As a trap for diamondback moth, buckwheat was more effective during the early vegetative growth period i.e. up to 65 days of transplanting of cabbage. In a similar study, early floral densities of buckwheat in border effectively check egg, larval or pupal densities of diamondback moth in cabbage fields (Lee & Heimpel, 2005). The sudden rise of infestation of diamondback moth was observed in those plots where trapping boundary with buckwheat was applied. This sudden rise in infestation may be due to a decrease in floral density of buckwheat trap while flowers start to convert into a fruit-setting phase which leads to a decrease in the nectar of flowering buckwheat. Bohinc and Trdan (2013) also mentioned that the developmental stage of the trap determined the intensity of feeding by pests and other predators. Trap plants could be maintained with flowering or non-flowering plants that provide any form of ecosystem services such as shelter, nectar, alternative host, and pollen (Tiwari *et al.*, 2018). For the better growth and development of insect predators and parasitoids, floral nectar that is rich in source of sugar, protein, lipids and other compounds are vital to them (Nicolson and Thornburg, 2007). Similar findings were demonstrated when *Diadegma semiclausum* (Nilsson *et al.*, 2016), and *D. insulare* (Lee & Heimpel, 2005) had access to the nectar of flowering buckwheat plants, larval parasitism of diamondback moth was increased. Biological control of insect pests could be improved by providing habitat diversification (Landis *et al.*, 2000) and natural enemies with food resources such as floral nectar within the production field. Joshi *et al.* (2000) reported that cabbage with buckwheat or potato-buckwheat-mustard is one famous crop combination to achieve the various noxious pest controls within the agro-ecosystem.

CONCLUSIONS

The study demonstrates that *B. juncea* and *F. esculentum* are the potential trap plants for the diamondback moth. The higher efficacy of both trap crops was observed during the early growth stage when maximum foliage and flowering period occurred. Meanwhile, a higher population of beneficial predators such as syrphid fly, ladybird beetles, rove beetle was observed in trap crops deployed cabbage fields. This finding works as an alternative pest management option for farmers in developing countries.

REFERENCES

Atreya, K. and Sitaula, B. K., 2010 Mancozeb: growing risk for agricultural communities. 6:9-10. https://www.nepjol.info/index.php/HJS/article/view/1794

Badenes-Perez, F. R. Shelton, A. M. and Nault, B. A., 2005. Using yellow rocket as a trap crop for diamondback moth (Lepidoptera: Plutellidae). Journal of Economic Entomology 98: 884-890.

Bohinc, T. and Trdan, S., 2013. Sowing mixtures of Brassica trap crops is recommended to reduce *Phyllotreta* beetles injury to cabbage. Acta Agriculturae Scandinavica Section Soil and Plant Science 63: 297-303.

George, D. Port, G. and Collier, R., 2019. Living on the Edge: Using and Improving Trap Crops for Flea Beetle Management in Small-Scale Cropping Systems. Insects. 10: 286. https://www.mdpi.com/528972

Gomez, K. A. and Gomez, A. A., 1984. Statistical procedures for agricultural research. John Wiley and Sons.

Hokkanen, H. M., 1991. Trap cropping in pest management. Annual Review of Entomology 36: 119-138. https://sci-hub.do/10.1146/annurev.en.36.010191.001003

Joshi, R. C. Matchoc, O. R. O. Bahatan, R. G. and Pena, F. D., 2000. Farmers' knowledge, attitudes and practices of rice crop and pest management at Ifugao Rice Terraces, Philippines. International Journal of Pest Management 46: 43-48.

Kafle, L. Katuwal, M. Mandal, C. K. GC, Y. D. and Tiwari, S., 2012. The Efficacy of bio-rational compounds against the diamondback moth, *Plutella xylostella* (L.) (Lepidoptera: Plutellidae) in Nepal. Formosa Entomology 32: 289-296.

Karimzadeh, J. and Besharatnejad, M. H., 2019. Ecological control of Plutella xylostella (Lepidoptera, Plutellidae) using trap cropping and Bt applications. Archives of Phytopathology and Plant Protection, 52:19-20.

Landis, D. A. Wratten, S. D. and Gurr, G. M., 2000. Habitat management to conserve natural enemies of arthropod pests in agriculture. Annual Review of Entomology. 45: 175-201.

Lee, J. C. and Heimpel, G. E., 2005. Impact of flowering buckwheat on Lepidopteran cabbage pests and their parasitoids at two spatial scales. Biol. Control. 34: 290-301.

MoALD, 2019. Annual Progress Report, Government of Nepal, ministry of agricultural and livestock development, agri-business promotion and statistics division, Singha Durbar, Kathmandu.

Mota-Sanchez, D. and Wise, J.C., 2020. The arthropod pesticide resistance database. Michigan State University. Retrived from: http://pesticideresistance.org

Nicolson, S. W. and Thornburg, R. W., 2007. Nectar chemistry. In Nectaries and Nectar pp. 215-264.

Nilsson, U. Porcel, M. Świergiel, W. and Wivstad, M., 2016. Habitat manipulation–as a pest management tool in vegetable and fruit cropping systems, with the focus on insects and mites. SLU, EPOK – Centre for Org Food and Farming, Uppsala, Sweden.

Robert, H.J. and Wright, D.J., 1996. Multitrophic interactions and management of the diamondback moth: A review. Bulletin of Entomological Research 86, 205-216.

Sharma, D. Thapa, R., Manandhar, H. Shrestha, S. and Pradhan, S., 2013. Use of pesticides in Nepal and impacts on human health and environment. Journal of Agriculture and Environment 13: 67-74. https://doi.org/10.3126/aej.v13i0.7590

Sharma, M., 2019. A review article on value chain analysis of vegetable sub-sector in Nepal. Acta Science of Agriculture 3: 15-20.

Shelton A. M. and Badenes-Perez F. R., 2006. Concepts and applications of trap cropping and pest management. Annual Review of Entomology 51: 285-308.

Smyth, R. R. Hoffmann, M. P. and Shelton, A. M., 2003. Effects of host plant phenology on oviposition preference of *Crocidolomia pavonana* (Lepidoptera: Pyralidae). Environmental Entomology 32: 756-764.

Srinivasan, K. and Moorthy, P. K., 1992. Development and adoption of integrated pest management for major pests of cabbage using Indian mustard as a trap crop. 511-521 pp. In 2nd International Workshop on the Diamondback Moth and other Cruciferous Pests. Asian Vegetable Research and Development Center, Taipei, Taiwan

Tiwari, S. Dickinson, N. Saville, D. J. and Wratten, S. D., 2018. Host plant selection by the wheat bug, Nysius huttoni (Hemiptera: Lygaeidae) on a range of potential trap plant species. Journal of Economic Entomology 111: 586-594.

Tiwari, S. Pudasaini, R. Kafle, L. Bhattarai, S. Ali, M. P., Babar, T. K. and Reddy, G. V. P., 2019. Trap cropping in South Asia: concepts, limitations, and future strategy. Annual Review of Entomological Society of America 112: 340-347.

Upadhya, B. P., 2003. Prospect of integrated pest management in sustainable agricultural development in Nepal. 205-216 pp. In Integrated Pest Management in Nepal (Neupane, F.P. edited). Proceedings of a National Seminar, Kathmandu, Nepal. 25-26 September 2002. Himalayan Resources Institute, New Baneshwor, Ktm, Nepal

Yadav, N. K. and Malik, Y. P., 2014. Efficacy of some new insecticides against diamond back moth (*Plutella xylostella* L.) of cauliflower and cabbage. Bioscience Trends 7: 1180-1183.