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EFFECT OF STAGGARED PLANTING ON THE SEASONAL ABUNDANCE OF DIAMONDBACK MOTH (*PLUTELLA XYLOSTELLA* LINN) ON CABBAGE UNDER NORTH EASTERN HILL ZONE, IMPHAL

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ABSTRACT
The experiment was attempted during the *rabi* season of 2009-10and 2010-11 to study the effect of staggered planting on seasonal incidence vis-à-vis peak period of incidence of diamondback moth, *Plutella xylostella* (Linn.). Results revealed that in both the years, the larvae of diamondback moth first appeared at the end of January (0.20 and 0.15/plant), increased gradually and reached its peak by the end of March with a population (12.05 and 11.20/plant) during the two seasons respectively. The larval population declined (2.20 and 0.60/ plant) by the second week of April in both the years. The correlation studies indicated a significant positive correlation between larval population of diamondback moth and max. and min. temperature with an exception to the second year max. temperature, which showed a non-significant interaction. During 2009-10, the relative humidity (R.H), total rainfall and bright sunshine hours (BSSH) had negative correlation, whereas in the second year (2010-2011), R.H and rainfall had positive relation with the larval population of diamondback moth. There was a marked variation of diamondback moth incidence in different dates of planting. The result showed that early planted crop (15th Nov.) harbored least number of the target pest (0.06/plant) with highest yield (20.80t/ha) whereas late planting (14th Jan.) resulted in highest population (3.37 /plant) with the lowest yield of 6.15t/ha and devoid of any marketable heads.

INTRODUCTION

Cabbage is one of the most popular vegetables in the world. India is the second largest producer of cabbage in the world after China producing 68.70Lakh tonnes in an area of 3.1 Lakh Hactares (Anon., 2009). In India, the major producing states are Uttar Pradesh, Orissa, Bihar, Assam, West Bengal, Maharashtra and Karnataka. Cabbage is a rich source of Ca, P, Na, K, S Vitamin A, Vitamin C and dietary fibre. It contains a good amount of Vitamin C (100mg/100g fresh). It is generally used as cooked vegetables either alone or is mixed with potato, peas or other vegetable as fried or in curry form. It is also eaten raw as salad, stewed or boiled items in continental form (Hazra *et al*., 2011). Though an important vegetable crop, cabbage is known to be infested by several insect pests *viz*., tobacco caterpillar, *Spodoptera litura* Fabricius ; diamondback moth, *Plutella xylostella* Linnaeus; cabbage leaf webber, *Crocodolomia binotalis* Zeller; aphids, *Brevicornye brassicae* Linnaeus and *Lipaphis erysimi* Kalt; painted bug, *Bagrada cruciferum* Kirk.; and flea beetle, *Phyllotreta cruciferae* Goeze (Rao and Lal, 2005). Out of these, diamondback moth, *Plutella xylostella* (L.) is the most destructive pest (Mahla *et al*., 2005; Kumar *et al*., 2007). In India, diamondback moth has national importance on cabbage as it causes 50-80% annual loss in the marketable yield (Devjani and Singh, 1999 and Ayalew, 2006). Krishnamoorthy (2004) also reported that there is 52% loss in yield due to the attack of diamondback moth. The severity of the incidence of diamondback moth is greatly influenced by the prevailing climatic conditions which vary from region to region. Several researchers (Shukla and Kumar, 2004; Wagle *et al*., 2005 and Venkateswarlu *et al*., 2011) have studied the effect of different dates of transplanting and the seasonal abundance of diamondback moth with the corresponding yield of cabbage in different parts of India. It is learnt from the works of the past researchers that the dates of transplanting have a great impact on the incidence of the pest which may be attributed to the difference in weather conditions. Early planted crops harbour less pest population with the corresponding increase in yield than the late planted crops (Bana *et al*., 2012). Though the agro-climatic condition of Manipur is highly favourable for the successful cultivation of cabbage, this has not yet translated into higher yield mainly due to the attack of insect pests particularly diamondback moth. Though the pest has increasingly become a menace causing great economic losses, little work has been carried out and the information available at present is very meager and of little relevance. Hence, the present experiment was conducted to study the effect of staggered planting on the seasonal abundance and the effect of weather parameters on the incidence of diamondback moth with the objective of arriving at the crucial conclusion on the most suitable date of planting so as to decrease pest infestation for higher yield and productivity with least damage to the environment.

MATERIALS AND METHODS

Design and layout

The experiment was conducted during *rabi* season of 2009-2010 and 2010-2011 at the Research Farm of Agriculture,

Central Agricultural University, Imphal. Seeds of cabbage cv. "Pride of India" were sown in raised nursery beds in lines with 7cm distance and 1cm deep, which were covered with a mixture of soil and well decomposed farmyard manure. The bed was covered with paddy straw which was removed after germination of seeds. The seedlings were ready for transplanting after 30 days. The seedlings were transplanted on five different dates at 15 days interval i.e., 15 th and 30th Nov., 15th and 30th Dec., and 14th Jan in both the years considering the differential planting dates as treatments. The plot size was 20sq.m (5x4m) and spacing was maintained at 40x50cm. The experiment was laid out in randomized block design (RBD) with four replications. No insecticides were applied during the entire crop growth and the crop was subjected to natural pest infestation. Irrigation was given as and when necessary. The field was kept free of weeds by giving two hand weedings at 30 and 60 days after planting.

Observation

The crop was kept under vigil for the appearance of diamondback moth larva. To estimate the larval population of diamondback moth, direct visual counting method was used (Lal, 1998). The observations were recorded at weekly interval throughout the crop growth on five (5) randomly selected plants from each plot. The weather data viz., maximum and minimum temperature, relative humidity, rainfall and bright sunshine hours recorded in the Tulihal Airport, Imphal were collected for correlating with the population fluctuation phenomena of diamondback moth. The cabbage head harvested from each plot was recorded and computed to tonnes/ha.

Statistical analysis

The data on the pest incidence were statistically analysed for the seasonal incidence and then computed with correlation co-efficient studies to see the effect of different abiotic factors on the population of diamondback moth. The data obtained from different dates of staggered sowing were subjected to ANOVA (analysis of variance) after necessary transformation of data wherever required.

RESULTS AND DISCUSSION

Seasonal abundance of diamondback moth at different growth stages of the crop

The data on seasonal abundance of diamondback moth recorded on cabbage (Table 1) revealed that during 2009-10, the infestation of diamondback moth (larva) was first recorded on 31st January with an initial population of 0.20/plant. The population increased gradually in successive weekly counts and reached a peak of 12.05/plant on 27th March and thereafter, the population dwindled to 6.00/plant in 3rd April and to 2.20/plant in 10th April. During 2010-2011 also, the population fluctuation trend was similar to that of 2009-10. It reached its peak on 27th March with a population of 11.20/ plant and declined thereafter to 0.60/plant on 10th April. The findings of the present author are in conformity with the findings of Goudegnon *et al*. (1999) who observed that diamondback moth population attained its peak during February and March. The maximum population of diamondback moth in the month of March was also reported by Devjani and Singh (1999); Kumar *et al*. (2007) and Venkateswarlu *et al*. (2011) which are in agreement with the present findings. On the contrary, Shukla and Kumar (2004b) reported that in Rajasthan, the diamondback moth appeared in the beginning of September and the population reached it's peak by the end of November followed by a declined phase from the last week of December to the last week of January, but this difference may probably be due to the difference in transplanting time and the prevailing climatic conditions of the region.

Results obtained from Table 2 revealed that the larvae of diamondback moth first appeared when the crops were 30 days old with a population of 0.24 and 0.19/plant during 2009-10 and 2010-11 respectively. The two years mean data clearly indicated that diamondback moth maintained its population (2.06/plant) at 60 days old crop with its peak population (4.63/plant) at 75 days old crop and then the population declined (4.52/plant) at 90 days old crop. The appearance of diamondback moth larvae at 30 days old crop was also observed by Meena and Singh (2012) and the peak population of diamondback moth recorded at 75 days old crop is in partial conformity with the findings of Garcia (1991) who observed that the highest number of larvae (14/plant) was recorded at 45 and 60 days after transplanting. However, the findings of Parvathi *et al*. (2002) are in conformity with the present findings as they also reported that the damage due to diamondback moth was severe in the later stages of the crop (70 days after planting). Devi and Raj (1991) also observed that the peak population of diamondback moth coincides with the active vegetative and late growth stages of crops.

Interaction between various weather parameters and

Table 1: Population fluctuation of DBM on cabbage during 2009-10 and 2010-11

Month	Date of observation	Mean no. of larval population of DBM/ plant*	
		2009-10	2010-11
November	22.11	0.00 (0.71)	0.00 (0.71)
	29.11	0.00 (0.71)	0.00 (0.71)
December	06.12	0.00 (0.71)	0.00 (0.71)
	13.12	0.00 (0.71)	0.00 (0.71)
	20.12	0.00 (0.71)	0.00 (0.71)
	27.12	0.00(0.71)	0.00 (0.71)
January	03.01	0.00(0.71)	0.00 (0.71)
	10.01	0.00 (0.71)	0.00 (0.71)
	17.01	0.00 (0.71)	0.00 (0.71)
	24.01	0.00 (0.71)	0.00 (0.71)
	31.01	0.20 (0.84)	0.15 (0.81)
February	07.02	0.40 (0.95)	0.30 (0.89)
	14.02	1.65 (1.47)	1.15 (1.28)
	21.02	2.50 (1.73)	1.95 (1.57)
	28.02	3.80 (2.07)	2.65 (1.77)
March	06.03	5.50 (2.45)	5.10 (2.37)
	13.03	9.25 (3.12)	8.65(3.02)
	20.03	11.15 (3.41)	10.65 (3.34)
	27.03	12.05 (3.54)	11.20 (3.42)
April	03.04	6.00 (2.55)	4.50 (2.24)
	10.04	2.20 (1.64)	0.60 (1.05)
SEm ±	-	0.062	0.059
CD (p = 0.05)	-	0.15	0.15

Figures in parentheses are √Actual population + 0.5, * - Mean of four replications

population of diamondback moth on cabbage

A simple correlation co-efficient was worked out between the number of larvae and the weather factors *viz*., temperature (max. and min.), relative humidity, rainfall and bright sunshine hours. The results presented in Table 3 revealed that the maximum temperature had a positive effect in both years(r = 0.73 and r = 0.40, respectively), but it was significant only in the first year while the minimum temperature had positive and significant effect (r = 0.69 and r = 0.56, respectively) in both the years. Though, the relative humidity had negative and positive relation with the larval population of diamondback moth in both years (r = -0.26 and r = 0.11 respectively), it had no significant effect with the pest population. The correlation studies also revealed that rainfall had negative but non-significant (r = -0.12) effect in 2009-10 while positive and significant (r = 0.46) relation was observed in 2010-2011. However, bright sunshine hours (BSSH) had negative non-significant relation (r = -0.06 and r = -0.33 respectively, in both years). The present findings of the significant positive correlation of diamondback moth population with the maximum and minimum temperature was also reported by Venkateswarlu *et al*. (2011) but the findings of the same author that significant negative relation with the relative humidity and significant positive with BSSH is in contrast with the present findings as it has been observed that the relative humidity has no significant effect and BSSH has negative and non-significant relation with the population fluctuation of diamondback moth. The finding of Aysheshim *et al*. (1996) that the population of diamondback moth had positive non-significant relation with the maximum temperature is also in partial agreement with the present finding. Meena and Singh (2012) also reported that the minimum temperature showed positive and significant relation with the larval population of diamondback moth which corroborates the present findings. The present finding of the non-significant relation of diamondback with the relative humidity and BSSH is in conformity with the observations made by Bana *et al*. (2012).

Effect of staggered planting on the incidence of diamondback moth of cabbage

There was a marked variation of diamondback moth incidence in different transplanting dates in both the years (Table 4). The first transplanted crop (15th Nov) recorded lowest population of diamondback moth (0.07 and 0.04/plant in 2009-10 and 2010-11, respectively), which was followed by the subsequent planting dates i.e., 30th Nov., 15th Dec., and 30th Dec. and the highest population (3.67 and 3.07/plant in both years, respectively) was observed in the late transplanted crop (14th Jan.). The two years pooled data indicated that there exists a significant difference between staggered planting dates and diamondback moth incidence. The lowest population (0.06/ plant) of diamondback moth was recorded in the early (15th Nov.) transplanted crop followed by 30th Nov., 15th Dec., and 30th Dec. However, the highest population of diamondback moth was recorded in the late (14th Jan.) transplanted crop with 3.37/plant. It is evident from the experiment that the incidence of diamondback moth was low in the early planted crop and the incidence subsequently increased with the delay in planting dates. A lower incidence in the early planted crop

Table 2: DBM population on cabbage at different ages of the crop during *rabi* season of 2009-10 and 2010-11

Age (in days from the date of transplanting)	Mean population/plant*		
	2009-10	2010-11	Mean
15	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)
30	0.24 (0.86)	0.19 (0.83)	0.22 (0.85)
45	0.80 (1.14)	0.64 (1.07)	0.72 (1.10)
60	2.16 (1.63)	1.96 (1.57)	2.06 (1.60)
75	4.23 (2.17)	5.03 (2.35)	4.63 (2.26)
90	5.12 (2.37)	3.92 (2.10)	4.52 (2.24)

Figures in parentheses are √Actual population + 0.5, * - Mean of four replications

Table 3: Correlation co-efficient of larval population of diamondback moth with abiotic factors during *rabi* season of 2009-10 and 2010-11

Year	Weather factors				
	Temperature (°C)		Relative humidity (%)	Rainfall(mm)	Bright sunshine hours (BSSH)
	Maximum	Minimum			
2009-10	0.73**	0.69**	-0.26 NS	-0.12NS	-0.06NS
2010-11	0.40NS	0.56**	0.11NS	0.46*	-0.33NS

* - Significant at p = 0.05, ** - Significant at p = 0.01, NS - Non-significant

Table 4: Effect of different dates of planting on the incidence of diamondback moth and on yield of cabbage during *rabi* season of 2009-10 and 2010-11

Planting dates	Mean population/ plant*		Pooled mean population/plant		Yield (t/ha)	Pooled mean yield (t/ha)
	2009-10	2010-11	2009-10	2010-11		
15th Nov.	0.07(0.76)	0.04(0.73)	0.06(0.74)	20.29	21.31	20.80
30th Nov.	0.61(1.06)	0.56(1.03)	0.58(1.04)	18.78	18.83	18.81
15th Dec.	2.78(1.81)	2.04(1.56)	2.41(1.69)	11.63	12.13	11.88
30th Dec.	3.36(1.96)	2.63(1.77)	3.00(1.87)	8.20	7.69	7.95
14th Jan.	3.67(2.04)	3.07(1.89)	3.37(1.96)	6.28	6.03	6.15
SEd ±	0.06	0.12	0.07	0.28	0.51	0.29
CD (P = 0.05)	0.13	0.26	0.14	0.61	1.11	0.60

Figures in parentheses are √Actual population + 0.5, * - Data based on 21 observations taken from four replications

could be attributed to low initial population with built up of diamondback moth population at slow pace in the early part of the season. Further, the vulnerable stage of the crop coincided with favorable conditions for infestation in the late planted crops. Similar findings on the effect of date of planting on the incidence of diamondback moth was reported by Viraktamath *et al*. (1994) who observed that the level of leaf damage by *P. xylostella* was lowest (16.87) in the crop planted in the 1st week of October and highest (98.83) in the crop planted in the 1st week of January, followed by that planted in 1st week of December (48.18) and no heads were marketable in either case. The finding of Ali and Karim (1995) that the infestation of *P. xylostella* was low in early crops is in agreement with the present findings. Likewise, observations made by Bhoir and Patil (1999) that early transplanting (30th Nov.) recorded the lowest larval population of diamondback moth (2.39/plant) are also in conformity with the present findings. The present observation of the early transplanted crops recorded lower population while the late transplanted crops recorded higher population also confirms the findings of Bana *et al*. (2012) who observed that the minimum infestation of diamondback moth was recorded on early transplanted crops (26th Sept.) followed by 3rd and 10th Oct. and the maximum infestation was on late transplanted crop (24th Oct.)

Effect of staggered planting on the yield of cabbage

The yield of cabbage presented in Table 4 revealed that the maximum yield of 20.80 t/ha was harvested from early transplanted (15th Nov.) crops, followed by 18.81t/ha, 11.88t/ha and 7.95t/ha on 30th Nov., 15th Dec. and 30th Dec. transplanted crop respectively, whereas significantly lowest yield of 6.15t/ha was harvested from the late transplanted crop on 14th Jan. This indicates that early transplanted crop of cabbage gives significantly higher yield than the late planted crops, and the yield decreases with delay in planting dates. This finding corroborates with the report of Viraktamath *et al*. (1994), who observed that the early crop planted in the 1st week of Oct. gave the highest average yield per plot (12.2 kg), while in the late crops planted in 1st week of Jan. and 1st week of Dec., the percentage of damage was very high and no heads were marketable in either case. Bhoir and Patil (1999) also reported that early transplanted crop (30th Nov.) gave maximum yield (19.38t/ha) while late transplanted crop (30th June) recorded lowest yield (8.77t/ha). Similarly, the findings of Bana *et al*. (2012) that highest yield of cabbage was obtained from the crop transplanted on 10th Oct, while minimum yield was recorded from the late planted crop (24th Oct.) is also in conformity with the present finding.

It is evident from the present study that the larvae of diamondback moth first appeared from the last week of January and reached a peak population in the last week of March. Correlation studies also revealed that temperature had positive and significant effect on the population build up of diamondback moth. The early transplanted crop had significant minimum pest incidence with higher yield than the late transplanted crop. Hence, to escape the load of pest attack in the later part of the season and to harvest the maximum possible yield, planting of cabbage crop early in the month of November is highly advocated and this will delay or minimize the application of insecticides for managing the pest problem.

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