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Field Efficacy of botanical extracts against Pod borers on Pigeon pea, *Cajanus cajan* (L.) Mill sp.

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ABSTRACT

Pigeon pea, a significant pulse crop, is vulnerable to a diverse array of insect pests at different stages of its growth, leading to direct yield losses. Frequent and injudicious use of chemical insecticides for pest management has led to the development of resistance and resurgence of less significant pests. Consequently, there is avital need to explore more environmentally friendly and narrow spectrum pesticides that do not pose long-term health risks to mammals. Additionally, alternative techniques must be developed to minimalize the use of broad-spectrum pesticides while ensuring optimal crop productivity. The present studies were performed on the eco-friendly management of pod borers by integrating 5% botanical extracts of plants *viz.*, Neem, Madar, Datura, Moringa, Murayya, Congress grass and Lantana and a Chemical insecticide, Chlorantraniliprole 18.5 SC @30 gm a.i. / ha during *Kharif* seasons 2021-22 and 2022-23 in pigeonpea at NBCRC, Pantnagar, Uttarakhand. The aqueous botanical leaf extracts were found active in reducing the mean percent infestation over untreated control against the target pests like *H. armigera* and *M. vitrata* recording lowest in Neem (60.85 % and 54.65%, respectively) and highest in Congress grass (35.10% and 31.20%, respectively). The use of leaf extracts against pod borers resulted in a decrease in their larval populations, which was evident from the significantly lower levels of pod damage observed in treated plots. The lowest damage was recorded in neem-treated plots (3.50%) while the highest was in Lantana-treated plots (8.78%), in comparison to the untreated control (10.61%). As a result, the reduction in pod damage caused by pod borer larvae had a proportional effect on the grain yield of pigeonpea. Treated plots had a significantly higher yield, ranging from 825 kg/ ha to 933 kg/ ha, in comparison to the untreated control (732 kg/ ha). Neem-treated plots had the highest incremental cost-benefit ratio (ICBR) of 1:7.64, while Lantana-treated plots had the lowest ICBR of 1:3.01.

Key words: *Pigeonpea, aqueous extracts, Pod borers, Chlorantraniliprole*

Introduction

Pigeonpea [*Cajanus cajan*(L.) Millspaugh] is a significant and the second most important pulse in India after chickpea (Nene *et al.*, 1990). It is also known as red gram, arhar or tur which is a perennial legume from the family *Fabaceae.* It is an agricultural crop of rainfed-drylands, also begrown on mountain gradients to reduces oil loss. India has the largest acreage and production of pigeonpea. Approximately 90% of the world's land area and 93% of its output are found in India (Anon, 2000). The total land under pulses worldwide is around 93.18 million hectares, and at a yield level of 964 kg/ha, production is estimated to be 89.82 million tons. With a yield of 40.35 lakh tons and a productivity of 885 kg/ha, arhar covers 49.10 lakh hectares in India. (Anon, 2021). In India, red gram takes second position in totalpulse

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production after Bengalgram. It is grown throughout the country except the hilly regions where the temperature during winters falls very low. Uttar Pradesh Maharashtra, Andhra Pradesh, Gujarat and Karnataka are the states where pigeonpea is grown primarily and more than 87% of the cultivated area and 83% of the total production is accounted by them collectively (Anon, 2000).

Pigeonpea is not only susceptible to insect pests during different stages of growth in the fields but also during storage. An array of pests attacks the crop, mainly during the reproductive stage, leading to direct yield losses. The presence of diseases, insect pests, and viral infections transmitted by insects are the significant obstacles in achieving higher yields (Dubey and Sharma, 2002). Among all the constraints, insectpests like Gram pod borer, *Helicoverpa armigera* (Hubner), Pod bug, *Clavigrall agibbosa* (Spinola), Spotted pod borer, *Maruca vitrata* (Geyer), Pod fly, *Melanoagromyza obtuse* (Malloch) and storage pests such as the bruchid *Callosobruchus maculatus* (Linnaeus) are recognized to cause infestations in pigeonpea crops at different stages of growth. (Lal and Singh, 1998); (Srilaxmi and Paul, 2010; Sharma, 2016). Under favorable conditions, 60 - 90 percent reduction in the grain yield is reported by pigeonpea pod borers. *H. armigera* and *M. vitrata* are the primary pests responsible for such losses (Jalondhara *et al.,* 2017). The production is drastically reducedby *H. armigera* larvae because they feed voraciously on leaves in the first instars before switching to growing pods and seeds (Sardar *et al.,* 2018) whereas *M. vitrata* becomes a threat particularly in the stages of flowering to pod development, it has been discovered to be a pest of approximately 39 host plants in Asia (Yadav and Singh 2014).

Currently,various synthetic chemicals are used to prevent pigeonpea from being infested by insect pests in the field. However, their application in field for controlling insect pests has led to the development of resistance, toxic residues in food grains, which pose a risk to human health, and have negative impacts on the ecosystem, apart from being costly. Therefore, there is a crucial need for adopting alternative methods not based on chemical pesticides to protect pigeonpea from insect infestations. Management practices that are eco-friendly are being given more attention nowadays due to their safety and efficacy. Recently, several locally available products are being used effectively for managing different insect pests in the fields. Hence, using locally available products is regarded as the most feasible and environmentally sound approach to counter the increasing threat posed by traditional pesticides. As a result, this study aimed to study the effectiveness of aqueous extracts procured from plant leaves against the Gram pod borer and Spotted pod borer on pigeonpea.

Materials and Methods

A field trial was conducted at Crop Research Centre, G. B. Pant university of Agriculture and Technology, Pantnagar to estimate efficiency of aqueous botanical extracts in contradiction of gram pod borer and spotted pod borer during rainy (*kharif*) season 2021-22 and 2022-23. The treatments are T1- Neem (*Azadiracta indica*), T2-Madar (*Calotropis gigantea*), T3-Datura (*Datura stramonium*), T4- Murayya (*Muray yakoeinigi*), T5-Moringa (*Moringa oleifera*), T6-Congress grass (*Parthenium hysterophorus*), T7- Lantana (*Lantana camera*) T8- Chlorantraniliprole 18.5SC @30 gm a.i. / ha and T9- untreated Control where water is sprayed. Sowing of Pigeonpea variety (PAU 291) was done on 24th June during *Kharif* 2021 and 28th June during *Kharif* 2022, laid out in a Randomized Block Design with three replications. The plot size was 4.0m x 4.0 m at spacing of 15 cm x 60 cm.

Preparation of 5% leaf extracts: Fresh leaves of the respective plants were gathered from the university surroundings, GBPUA&T, Pantnagar during morning hours, brought to laboratory and washed thoroughly 3-4 times with tap water. 50 g of the chopped material were steeped overnight in one litre of water to generate one litre of a 5% extract. After the soaking material was strained through muslin cloth, a mortar and pestle was used to shatter the leftover material. To create a 5% leaf extract for spraying, the residue was extracted once more, filtered through muslin fabric, and the amount was increased to one liter. A small amount of detergent was added to the filtrate to serve as a sticker and wetting agent. The resulting 5% formulation was used to spray on pigeonpea crops to control *H. armigera* and *M. vitrata.*

Pretreatment assessments were noted 24 hours before the application of spray, whereas three, seven, and ten days after the spraying process, post-treatment evaluations were made on five plants for each treatment in each replication. Two rounds of spraying were conducted, and data on various insects such as larvae of Gram pod borer and Spotted pod borer were documented.

At harvest, the percentage of pods and seeds damaged by various pod borer complexes and pod bugs was calculated by counting the number of damaged and undamaged pods. Additionally, the damage caused by individual pod borer complex species was evaluated by taking into account the damaged pods' feeding and hole-emergence patterns, such as the large, regular, round holes on *H. armigera* pods, the irregular, scraping, and holes on *M. vitrata* pods, and the tiny, peripheral holes on *M. obtusa*. Next, kg/ha was used to calculate the total yield for each plot.

$$\text{Per cent pod damage} = \frac{\text{Number of damaged pods}}{\text{Total number of pods}} \times 100$$

The data on the percentage of damaged pods was transformed using the arcsine method before being analyzed, while the population count data was transformed into "x + 1.0 values to ensure accurate analysis. ANOVA was then used to examine the yield data and the transformed data, and Duncan's Multiple Range Test (DMRT) was used to compare the treatment means for further assessment.

Results and Discussion

Botanical extracts procured from different leaves were tested against the larvae of *H. armigera* and *M. Vitrata*in Pigeonpea during the *Kharif*, 2021-22 and 2022-23 and the pooled data pertaining to the larval feeding, pod damage, grain yield and Incremental Cost benefit Ratio are presented in Table 1 and 2. There were no significant differences in Gram pod borer infestation among the different treatments before application during *kharif*, 2021 and 2022 representing homogenous population throughout the trial (Table 1). During *kharif*, 2021, leaf extracts showed a influential effect on gram pod borer by reducing its occurrence to a range of 4.50 to 7.33 after both sprays, whereas, Chlorantraniliprole 18.5 SC@ 30 g a.i/ha (2.17 larvae/5 plants) and in control (10.96 larvae/5 plants) plots were recorded with the lowest and highest overall mean larval population, respectively. During *kharif*, 2022, the *H. armigera* larvae ranged from 4.79 to 8.08 larvae/5 plants after both sprays, whereas the Chlorantraniliprole 18.5 SC@ 30 g a.i/ha (3.00 larvae/5 plants) and untreated control (12.79 larvae/5 plants) plots were noted with the minimum and maximum overall mean larval population, respectively. The data on overall pooled

Table 1. Effect of aqueous leaf extracts against *H. armigera* and *M. vitrata* on pigeonpea during Kharif seasons 2021-22 and 2022-23.

S. No	Treatments	*H. armigera* larvae before application during 2021	*H. armigera* larvae before application during 2022	***H. armigera* larvae after application during 2021	***H. armigera* larvae after application during 2022	**Pooled mean	**Mean Percent reduction over control	*M. vitrata* larvae before application during 2021	*M. vitrata* larvae before application during 2022	***M. vitrata* larvae after application during 2021	***M. vitrata* larvae after application during 2022	**Pooled mean	**Mean Percent reduction over control
T_1	Neem@5%	6.33^{ab}(2.71)	8.67^{ab}(3.11)	4.50^{f}(2.31)	4.79^{g}(2.38)	4.65^{f}(2.34)	60.85	12.67^{bc}(3.69)	15.33^{bc}(4..04)	5.67^{f}(2.57)	10.06^{g}(3.32)	7.86^{g}(2.94)	54.65
T_2	Madar@5%	6.00^{bc}(2.65)	8.33^{b}(3.05)	5.25^{e}(2.47)	5.54^{f}(2.54)	5.40^{e}(2.51)	56.44	12.33^{cd}(3.65)	15.67^{ab}(4.08)	6.50^{e}(2.73)	10.67^{f}(3.41)	8.58^{f}(3.07)	50.50
T_3	Datura@5%	5.33^{d}(2.51)	8.33^{b}(3.05)	6.50^{c}(2.72)	6.92^{cd}(2.80)	6.71^{c}(2.76)	43.52	12.00^{d}(3.60)	15.33^{bc}(4.04)	8.33^{c}(3.05)	12.28^{d}(3.64)	10.31^{d}(3.34)	40.50
T_4	Murayya@5%	5.67^{cd}(2.58)	8.33^{b}(3.05)	5.63^{de}(2.56)	6.17^{e}(2.66)	5.90^{de}(2.61)	50.33	12.67^{bc}(3.69)	15.33^{bc}(4.04)	7.17^{d}(2.85)	11.50^{e}(3.53)	9.33^{e}(3.19)	46.16
T_5	Moringa@5%	6.00^{bc}(2.65)	8.33^{b}(3.05)	6.08^{cd}(2.65)	6.63^{de}(2.75)	6.35^{cd}(2.70)	46.54	12.00^{d}(3.60)	15.00^{cd}(4.00)	7.83^{c}(2.96)	12.06^{d}(3.61)	9.94^{d}(3.29)	42.64
T_6	Congress grass @5%	5.67^{cd}(2.58)	8.67^{ab}(3.11)	7.33^{b}(2.86)	8.08^{b}(3.01)	7.71^{b}(2.93)	35.10	12.67^{bc}(3.69)	14.33^{e}(3.92)	9.17^{b}(3.18)	13.61^{c}(3.82)	11.39^{c}(3.50)	31.20
T_7	Lantana@5%	6.00^{bc}(2.64)	8.67^{ab}(3.11)	7.29^{b}(2.83)	7.46^{c}(2.90)	7.37^{b}(2.87)	37.97	11.33^{e}(3.51)	14.67^{de}(3.96)	9.50^{b}(3.23)	14.28^{b}(3.91)	11.89^{b}(3.57)	31.40
T_8	Chlorantraniliprole18.5SC@30ga.i/ha	5.67^{cd}(2.58)	8.67^{ab}(3.11)	2.17^{g}(1.73)	3.00^{h}(1.94)	2.58^{g}(1.83)	78.30	13.00^{ab}(3.74)	14.67^{de}(3.96)	3.50^{g}(2.10)	6.06^{h}(2.64)	4.78^{h}(2.37)	72.42
T_9	Control	6.67^{a}(2.77)	9.00^{a}(3.16)	10.96^{a}(3.42)	12.79^{a}(3.70)	11.88^{a}(3.56)	-	13.33^{a}(3.79)	16.00^{a}(4.12)	16.33^{a}(4.15)	18.33^{a}(4.39)	17.33^{a}(4.27)	-
	SE(m)	0.076	0.063	0.112	0.098	0.105		0.112	0.046	0.092	0.069	0.080	
	CD	0.228	0.189	0.335	0.294	0.315		0.336	0.139	0.276	0.206	0.241	

*Figures in parentheses are square root transformed values ** Mean of three observations after both sprays (3DAS, 7DAS and 10DAS) mean population of larvae of the two years showed that Chlorantraniliprole 18.5 SC@ 30 g a.i/ha (2.58 larvae/5 plants) was recorded with the lowest larvae followed by the leaf extracts formulations of *i.e.,* Neem (4.65 larvae/5 plants), Madar (5.40 larvae/5 plants), Murayya (5.90 larvae/5 plants) and Moringa (6.35 larvae/5 plants). However, the treatments *viz.* Datura (6.71 larvae/5 plants), lantana (7.37 larvae/5 plants) and Congress grass (7.71 larvae/5 plants) were also found prominently superior over the control (11.88 larvae/5 plants). Based on the mean percent reduction over control in *H. armigera*, the order of efficiency observed was Chlorantraniliprole 18.5 SC@ 30 g a.i/ha (78.30%) >Neem (60.85)> Madar (56.44%)>Murayya (50.33%)> Moringa (46.54%)> Datura (43.52%)> Lantana (37.97%)>Congress grass (35.10%). The current results are also supported by Dehury *et al.* (2020) who reported that neem formulations show prominent results on reducing *H. armigera* infestation on pigeonpea when related to untreated control. Ajay Kumara and Tiwari. (2018) also recorded that treatments, Madar 5% (w/v), Lantana 5% (w/v), Datura 5% (w/v)were effective in minimizing the damage due to borers complex *i.e.,* Gram pod borerand Spotted pod borer in Pigeonpea. Prabhu *et al.* (2012) and Prabhu *et al.* (2018) stated that leaf extracts of Calotropis at 2, 4, 6, 8 and 10 per cent concentrations showed ovicidal activity against *H. armigera*.

Maruca infestation before application during *kharif*, 2021 and 2022 showed no significant differences among treatments indicating homogenous larval population throughout the experiment. During *Kharif* 2021, the botanical extracts showed a significant result on *M. vitrata* by minimizing its occurrence to a range of 5.67 to 9.17 after both sprays, whereas the Chlorantraniliprole 18.5 SC@ 30 g a.i/ha (3.50 larvae/5 plants) and untreated control (16.33 larvae/5 plants) plots were recorded with the lowest and highest overall mean larval population, respectively. During *kharif*, 2022, the *M. vitrata* larvae ranged from 10.06 to 14.28 larvae/5 plants after both sprays, whereas the Chlorantraniliprole 18.5 SC@ 30 g a.i/ha (6.06 larvae/5 plants) and untreated control (18.33 larvae/5 plants) plots were documented with the lowest and maximum larval population mean overall, respectively. According to statistics on the combined average population of larvae over the two years, Chlorantraniliprole 18.5 SC@ 30 g a.i/ha (4.78 larvae/5 plants) was found to have the fewest larvae, followed by formulations including leaf extracts such as Neem (7.86 larvae/5 plants), Madar (8.58 larvae/5 plants), Murayya (9.33 larvae/5 plants) and Moringa (9.94 larvae/5 plants). However, the treatments *viz.* Datura (10.31 larvae/5 plants), Congress grass (11.39 larvae/5 plants) and lantana (11.89 larvae/5 plants) were also found pointedly higher over control (17.33 larvae/5 plants). Based on the mean percent reduction over control in *M. vitrata,* the order of efficacy observed was in the order: Chlorantraniliprole 18.5 SC@ 30 g

Table 2. Effect of aqueous leaf extracts on Pod damage, seed damage, grain yield and ICBR in pigeonpea during Kharif seasons 2021-22 and 2022-23.

S. No	Treatments	*Pooled Percent Pod damage(%) during 2021 and 2022			*Pooled Cumulative pod damage (%)	*Pooled Seed damage (%)	Overall Yield (Kg/ ha)	ICBR
		M. vitrata	*H. armigera*	*M. obtusa*				
T_1	Neem@5%	3.83^{ef}(11.25)	4.17^{fg}(11.74)	1.67^{d}(9.01)	3.50^{fg}(10.67)	25.17^{f}(30.10)	933	7.64
T_2	Madar@5%	4.67^{de}(12.35)	5.50^{ef}(13.52)	2.50^{d}(10.12)	4.44^{ef}(11.99)	27.17^{e}(31.42)	901	6.26
T_3	Datura@5%	7.17^{bc}(15.51)	7.67^{cd}(16.02)	3.17^{cd}(13.08)	6.67^{cd}(14.87)	30.83^{c}(33.74)	852	4.16
T_4	Murayya@5%	5.83^{cd}(13.94)	6.17^{de}(14.24)	5.17^{b}(11.72)	5.39^{de}(13.30)	28.33^{de}(32.16)	887	5.66
T_5	Moringa@5%	6.50^{bc}(14.74)	7.17^{cde}(15.51)	4.17^{bc}(12.91)	6.22^{cd}(14.38)	29.33^{d}(32.80)	869	4.87
T_6	Congress grass@5%	7.67^{b}(16.05)	8.50^{bc}(16.89)	5.00^{b}(13.93)	7.33^{bc}(15.62)	32.00^{c}(34.46)	841	3.67
T_7	Lantana@5%	9.50^{a}(17.94)	10.00^{b}(18.41)	6.83^{a}(15.12)	8.78^{b}(17.15)	35.67^{b}(36.69)	825	3.01
T_8	Chlorantraniliprole18.5 SC@30ga.i/ha	2.67^{f}(9.32)	3.33^{g}(10.50)	2.00^{d}(7.95)	2.67^{g}(9.26)	14.17^{g}(22.10)	1038	10.72
T_9	Control	10.17^{a}(18.57)	13.67^{a}(21.70)	8.00^{a}(16.40)	10.61^{a}(18.89)	38.50^{a}(38.37)	732	
	SE(m)	0.684	0.871	0.626	0.727	0.604		
	CD	2.052	2.611	1.877	2.180	1.811		

*Figures in parentheses are Angular transformed values a.i/ha (72.42%) >Neem (54.65)> Madar (50.50%)> Murayya (46.16%)> Moringa (42.64%)> Datura (40.50%)> Lantana (31.40%)>Congress grass (32.20%). The present findings are supported by Rekha (2005) and Mallikarjuna *et al.* (2009), who reported that two applications of NSKE (5%) were effective in managing field bean pod borers. Additionally, Sindhu and Shekarappa (2019) also observed that neem extracts were the most effective treatment in reducing percent defoliation and pod damage caused by *M. vitrata*, with a reduction of 24.36 and 13.77, respectively, while also resulting in the highest yield and net returns (1:10.97).

The results reveal that the aqueous extracts being evaluated were also effective in reducing pigeonpea pod damage due to insect pests *i.e.,*Spotted pod borer, Gram pod borer and Pod fly whereas seed damage by pod bug during both *kharif* seasons 2021 and 2022 (Table 2). According to the pooled data of both the years (2021 and 2022), among the plots sprayed with aqueous extracts, the treatment Neem recorded the lowest cumulative pod and lowest seed damage (3.50% and 25.17 %, respectively) followed by Madar having cumulative pod and seed damage (4.44% and 27.17%), Murayya with cumulative pod and seed damage (5.39% and 28.33%, respectively), Moringa with cumulative pod and seed damage (6.22% and 29.33%) and the highest cumulative pod and seed damage (8.78% and 35.67%) was observed in Lantana whereas, Chlorantraniliprole 18.5 SC@ 30 g a.i/ha recorded the lowest cumulative pod and seed damage (2.67 % and 14.17%, respectively)and the highest cumulative pod and seed damage (10.61 % and 38.50%) was noticed in untreated control. The effectiveness of Madar, Lantana, and Datura leaf extracts in reducing pod damage caused by pod borers was also reported by Bijeswar *et al.* (2018). These findings align with Ahmad, 2020 who observed that Azadirachtin resulted in only 7.33% pod borer damage and 14.25% grain damage, indicating the superior performance compared to the untreated control in managing *H. armigera* infestation in Pigeon pea.

The pooled grain yield and ICBR data for the two years showed that Chlorantraniliprole 18.5 SC@ 30 g a.i/ha was registered with maximum grain yield of 1038 kg/ ha and ICBR of 1:10.72 whereas the untreated control with minimum grain yield of 732 kg/ ha. However, among the leaf extracts, neem recorded maximum grain yield (933kg/ha) and ICBR 1: 7.64 which was found at par with Madarhaving 931 kg/ ha of grain yield and 1:6.26 ICBR. The treatment Murayya recorded 887 kg/ha of grain yield with ICBR of 1: 5.66 whereas the treatment Moringa leaf extract recorded 869 kg/ ha of grain yield with ICBR of 1: 4.87 found significantly superior grain yield over other. The treatments Datura, Congress grassand lantana recorded with grain yield of 852kg/ ha, 841kg/ ha and 824 kg/ ha, respectively with ICBR of 1: 4.16, 1: 3.67 and 1: 3.01, respectively showed significantly lower mean grain yield and ICBR among plant leaf extracts (Table 2). The above findings align with Bhavana and Nagar, 2019 who reported that Calotropis leaves has highest yield and Cost benefit ratio (1: 2.38).

The current field investigations demonstrated unequivocally that plant leaf extracts @5%, such as those from neem, madar, murayya, and moringa, were effective against the larval populations of *H. armigera* and *M. vitrata*, resulting in lower pod damage, greater grain yields, and ICBR. Therefore, since aqueous plant leaf extracts at a concentration of 5% are readily available to farmers and are both affordable and environmentally safe, they can be seamlessly integrated into an integrated pest management program to combat the pod borer complex in pigeonpea crops.

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Conflict of Interest- None

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