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Efficacy of different botanicals against gram pod borer, *Helicoverpa armigera* Hubner and pod fly, *Melanagromyza obtusa* Malloch in pigeonpea

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ABSTRACT

The efficacy of various botanicals against the gram pod borer, Helicoverpa armigera Hubner, and the pod fly, Melanagromyza obtusa Malloch, in pigeonpea was tested in a field experiment carried out during Kharif, 2018–19, 2019–20, and 2020–21 at the Agricultural Research Station, Anand Agricultural University, Derol, Gujarat, India. Determining the effectiveness of botanical extracts mainly some challanges affected such as botanical cost, application feasibility and farmer acceptance made complicated for pest management strategies in pigeonpea cultivation. The larval population of H. armigera was found to be considerably reduced in the plot treated with neem seed kernel extract at 5 percent and it was at par with azadirachtin at 0.15 EC @ 0.0006 percent and neem oil at 0.5 percent. A similar trend was also noted in terms of the percentage of harvested pod damage due to H. armigera; 5 percent of neem seed kernel extract had a significantly lower pod damage and was comparable to azadirachtin 0.15 EC 0.0006 percent. The lowest per cent grain damage due to pod fly, M. obtusa was noticed in a plot treated with azadirachtin 0.15 EC 0.0006 percent and it was at par with neem seed kernel extract 5 percent. Significantly higher seed yield was obtained in the treatment of neem seed kernel extract 5 per cent and it was at par with azadirachtin 0.15 EC 0.0006 percent. The highest ICBR was also recorded in the treatment of neem seed kernel extract at 5 percent.

Keywords: *Botanicals, Pigeonpea, gram pod borer, Helicoverpa armigera, Pod fly Melanagromyza obtusa,*

INTRODUCTION

Pigeonpea, *Cajanus cajan* (L.) is a short-lived, erect perennial shrub legume that goes by several names, including red gram, Tur, Arhar, *etc.* (Sharma et al. 2010). Pigeonpea is a significant source of nutrients such as protein (22.3%), carbohydrates (57.6%), fiber (1.5%), and minerals (3.5%) (Gupta *et al.* 2006). Pigeonpea is grown on 45.32 lakh hectares in India, with an annual production of 38.92 lakh tonnes and a productivity per hectare of 859 kg (Anonymous, 2020). Gujarat has a 2.13 lakh hectare pigeonpea cultivation area, however, it produces 2.11 lakh tonnes with a productivity of 991 kg/hectare (Anonymous 2020). Pigeonpeas have been discovered to be infested by more than 300 insect species from 61 families and 8 orders, beginning at the seedling stage and continuing through harvest and storage conditions (Kevel et al. 2010). However, according to Wadasker *et al*. (2013), the pod borer complex is solely responsible for approximately 60 percent of the damage. The pod borer complex, comprising the pod fly, *M.* Malloch, spotted pod borer, *M. vitrata* Geyer and gram pod borer, *H. armigera* Hubner, can diminish production by around as 60 per cent (Sreekanth *et al.,* 2021). Among these pests gram pod borer, *H. armigera* is the most awful and polyphagous pest of pigeonpea globally (Patel et al. 2019). Its preference for flowering and fruiting parts results in heavy loss of up to 60% or more under subsistence agriculture in the tropics. The annual monetary losses were estimated at US $ 400 in pigeonpea per hectare (Anonymous 2007).

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Another major pigeonpea pest in Southeast Asia is the pod fly, *M. obtusa*, which damages the crop from pod filling to harvest. The larva and pupal stages of the pod fly are both present inside the pods because this pest is an internal feeder. These pests alone cause a yield loss of 60 to 80 percent and the losses have been estimated at US $ 256 million annually (Patange and Chiranjeevi 2017). Farmers rely heavily on chemical insecticides to manage insect pests. Regular and indiscriminate use of chemical insecticides and the misuse of synthetic pesticides on the crop led to the development of insecticide resistance in target pests, pest resurgence, secondary pest outbreaks, loss of biodiversity, environmental pollution, residual toxicity and occurrence of human health hazards. Therefore, there is a need to develop eco-friendly tools for pest management. Out of different tools use of botanicals in one of them. Plant extracts act in many ways, *viz.* feeding deterrents, insect growth regulators, confusions, and repellents (Schmutterer 1990). Hence, the present experiment was conducted to evaluate some botanicals for the management of gram pod borer, *H. armigera* Hubner, and pod fly, *M. obtusa* Malloch in pigeonpea.

MATERIALS AND METHODS

A field study was carried out at Agricultural Research Station, Anand Agricultural University, Derol (Gujarat) India, to assess the effectiveness of various botanicals against gram pod borer, *Helicoverpa armigera* Hubner and pod fly, *Melanagromyza obtusa* Malloch in pigeonpea during *Kharif*, 2018-19, 2019-20 and 2020-21. The pigeonpea variety AGT 2 was used in the experiment, which was set up using a randomised block design with ten treatments and three replications. Pigeonpea crop was sown in mid-July at a spacing of 120 x 30 cm. The gross plot size was 6.0 x 5.1 m, whereas the net plot size was 3.6 x 5.0 m. The crop was raised using all agronomic methods. Neem seed kernel extracts 5 per cent, neem leaf extract 10 percent, neem oil 0.5 per cent, custard apple leaf extract 10 percent, custard apple seed extract 5 per cent, garlic extract 5 per cent, tobacco decoction 2 percent, eucalyptus leaf extract 10 per cent, azadirachtin 0.15 EC 0.0006 per cent were evaluated along with control. The first spray was applied at the initiation of the pest and the subsequent two sprays were applied at 10-day intervals. The spray was applied with a manually operated knapsack sprayer fitted with a hollow cone nozzle. For record the observations, 5 plants were selected randomly from each net plot area and number of larvae of *H. armigera* was counted. The larval population was recorded before the first spray, 5 and 10 days after each spray. Before harvesting the crop at maturity, 100 pods were randomly plucked from each net plot area and the pod was segregated into healthy and damaged. Based on this per cent, pod damage due to *H. armigera* was worked out. Plucked pods were opened and their grains were segregated into healthy and damaged for workout percent grain damage due to *M. obtusa*. At harvest, grain yield was recorded from each net plot and it was converted into kg/ha. The data from the field experiments were subjected to appropriate transformation and analyzed statistically for comparing treatments following the Analysis of Variance technique (ANOVA) for Randomized Block Design (RBD) and the results were interpreted at a 5% level of significance.

RESULTS AND DISCUSSION

The data on the efficacy of various botanicals against *H. armigera* of pigeonpea are given in Table 1. Data for the year 2018–19 showed that the pooled over periods for the first spray showed that the plot treated with neem seed kernel extract (5 %) was found the significantly least larval population of *H. armigera* (0.82 larva/plant), and it has statistically remained at par with tobacco decoction 2 percent (0.87 larva/plant) and custard apple leaf extract 10 percent (1.00 larva/plant). For the second spray, the data was pooled over spray recorded a significantly least population of *H. armigera* larva (0.72 larva/plant) in the plots applied with neem seed kernel extract 5 percent and it was statistically at par with the rest of all treatments except control. Pooled data computed for the third spray indicated that a significantly lower larval population of *H. armigera* (0.59 larva/plant) recorded in the plot treated with azadirachtin 0.15 EC 0.0006 per cent and it remained at par with the other treatments except neem leaf extract 5 per cent and control. The data on combine over periods and sprays computed for *Kharif,* 2018-19 (Table 1) suggested that, all the tested botanical treatments were found to be significantly superior to the control. The significantly lowest larval population of *H. armigera* (0.79 larva/plant) was observed with the application of neem seed kernel extract 5 per cent and it remained at par with custard apple leaf extract 10 per cent, azadirachtin 0.15 EC, tobacco decoction 2 per cent, neem oil 0.5 per cent and custard apple seed extract 5 per cent. In the year 2019-20, pooled over periods data worked out for the first spray indicated that a significantly minimum larval population of *H. armigera* (0.29 larva/plant) recorded in treatment neem seed kernel extract 5 per cent and it was at par with azadirachtin 0.15 EC 0.0006 per cent (0.42 larva/plant). Based on pooled data of second spray, results revealed that a significantly lower larval population of *H. armigera* (0.27 larva/plant) was found in a plot treated with neem seed kernel extract 5 per cent and it was at par with azadirachtin 0.15 EC 0.0006 per cent and neem oil 0.5 per cent. The pooled data of the third spray revealed that the neem seed kernel extract 5 per cent had a significantly lower larval larval population of *H. armigera* (0.16 larva/plant) but it was remained at par with azadirachtin 0.15 EC 0.0006 per cent and neem oil 0.5 per cent. Overall pooled data of three sprays for *Kharif*, 2019-20 showed that the lowest larval population of *H. armigera* (0.24 larva/plant) was recorded in the treatment of neem seed kernel extract 5 per cent and it remained at par with azadirachtin 0.15 EC 0.0006 per cent (0.35 larva/plant). During the year 2020-21, pooled over periods for the first spray revealed that the significantly lowest larval population of *H. armigera* (0.36 larva/plant) was noted in plots that received treatment with neem seed kernel extract 5 per cent and it was at par with azadirachtin 0.15 EC 0.0006 per cent (0.53 larva/plant). The second spray pooled data showed that the minimum larval population of *H. armigera* (0.41 larva/plant) observed in the plot treated with neem seed kernel extract 5 per cent and it was at par with azadirachtin 0.15 EC 0.0006 per cent (0.52 larva/plant), neem oil 0.5 per cent (0.62 larva/plant) and custard apple leaf extract 10 per cent (0.79 larva/plant). Based on pooled data of the third spray, results revealed that a significantly lower larval population of *H. armigera* (0.23 larva/plant) was found in a plot treated with neem seed kernel extract 5 percent and it was at par with azadirachtin 0.15 EC 0.0006 per cent and neem oil 0.5 per cent. Computed data on sprays for *Kharif,* 2020–21, pooled over periods showed that the significantly lowest number of larval population of *H. armigera* (0.33 larva/plant) noticed in plot treated with neem seed kernel extract 5 per cent and it was at par with azadirachtin 0.15 EC 0.0006 per cent. The pooled analysis of three years of data indicated that the neem seed kernel extract 5 per cent had a significantly lower larval population of *H. armigera* (0.44 larva/plant) in comparison to the rest of the treatments but it remained at par with azadirachtin 0.15 EC @ 0.0006 per cent (0.53 larva/plant) and neem oil 0.5 per cent (0.69 larva/plant). The present finding is also supported by Shrinivasan and Sridhar (2008) reported that neem oil 3 per cent and neem seed kernel extract 5 per cent were found effective in reducing the larval population of *Maruca vitrata* in pigeonpea. According to Singh and Nath (2011), NSKE 5 per cent was the most efficient treatment for *Helicoverpa armigera* and *Clavigralla gibbosa* Spinola. Nath *et al.* (2017) also discovered that two applications of NSKE 5 per cent, one during the flowering and pod-formation phase and the other 20 days later, were superior to one in terms of diminishing the *Exelastis atomosa* larval population. Das *et al.* (2022) revealed that among the bio-pesticides, *Bacillus thuringiensis* and azadirachtin were found to be effective against the pod borer complex in pigeonpea. According to Hadiya *et al.* (2023), plots that received with azadirachtin 0.15 EC (0.0006 %) and neem oil (0.5%) had significantly lower larval populations of *L. boeticus*.

Pod damage due to gram pod borer, *H. armigera:* The data on per cent pod damage by *H. armigera* recorded at the time of harvest of pigeonpea crop are presented in Table 2. During the year 2018-19, the significantly lowest pod damage (5.00%) was observed in plots treated with neem seed kernel extract 5 per cent and it was at par with azadirachtin 0.15 EC @ 0.0006 per cent (7.33%) and neem oil 0.5 per cent (9.00%). Significantly highest pod damage (17.33%) was noticed in control. In the year 2019-20, significantly lowest per cent pod damage (6.00%) was recorded in the treatment neem seed kernel extract at 5 per cent and it was at par with azadirachtin 0.15 EC @ 0.0006 per cent (8.00%). In the year 2020-21, the relatively least per cent pod damage (7.33%) was registered in the plot treated with azadirachtin 0.15 EC @ 0.0006 per cent (9.67%).

Pooled analysis of three years of data showed that the lowest per cent pod damage (5.96%) recorded with spraying of neem seed kernel extract 5 per cent and it was at par with azadirachtin 0.15 EC @ 0.0006 percent (8.06%). The present finding is in accordance with the earlier work by Nath and Singh (2006) reported similar efficacy of NSKE 5 per cent against pod damage by *Helicoverpa armigera* in pigeonpea. Ahmed *et al.* (2020) also recorded that azadirachtin 1 per cent @ 1.0 ml/litre at 7 days intervals on the yard long bean showed the best performance in respect of the reduction of flower and pod damage due to *Maruca vitrata* of 59.94 and 66.10 per cent, respectively. Dehury *et al.* (2020) noticed that apart from chemical insecticides azadirchtin and *Bt. Kurastaki* very effective for major pigeonpea pests reducing the damage to pods and grains.

Grain damage due to pod fly, M. obtuse: The data on the grain damage at the harvest stage by *M. obtusa* are given in Table 2. In the year 2018-19, significantly lowest per cent grain damage (12.97%) was recorded in a plot treated with azadirachtin 0.15 EC @ 0.0006 per cent and it was at par with neem seed kernel extract 5 per cent and neem oil 0.5 per cent. During the year 2019-20, data revealed that the significantly lowest per cent grain damage (11.05%) was recorded in treatment azadirachtin 0.15 EC @ 0.0006 per cent and it was at par with neem seed kernel extract 5 per cent (15.11%) and neem oil 0.5 per cent (18.06%). In the year 2020-21, the significantly lowest per cent grain damage (13.52%) was recorded in a plot treated with azadirachtin 0.15 EC @ 0.0006 per cent and it was at par with neem seed kernel extract 5 per cent (16.23%) and neem oil 0.5 per cent (20.35%). The combined data from three spray indicated that the significantly lowest per cent grain damage (12.24%) was recorded in the plot treated with azadirachtin 0.15 EC @ 0.0006 per cent and it was at par with neem seed kernel extract 5 per cent (16.32%).

Grain yield: The data on the effect of different treatments on the grain yield of pigeonpea are presented in Table 2. During the year 2018-19, a significantly maximum grain yield was noticed in the treatment of azadirachtin 0.15 EC @ 0.0006 percent (1424 kg/ha), but it was at par with neem seed kernel extract 5 per cent (1399 kg/ha) and neem oil 0.5 percent (1339 kg/ha). In the year 2019-20, a significant maximum grain yield (1209 kg/ha) was observed in the treatment neem seed kernel extract 5 per cent and it was at par with azadirachtin 0.15 EC @ 0.0006 per cent (1153 kg/ha). Similarly, during 2020-21, a substantially maximum grain yield (1224 kg/ha) was recorded in the plot treated with neem seed kernel extract 5 per cent and it was at par with azadirachtin 0.15 EC @ 0.0006 percent (1192 kg/ha).

The based on pooled data analysis results revealed that the highest grain yield (1277 kg/ha) was recorded in the treatment of neem seed kernel extract 5 per cent and it was at par with azadirachtin 0.15 EC 0.0006 per cent (1256 kg/ha). The present findings might be substantiated by Berani *et al.* (2018) findings, which revealed that azadirachtin 0.15 EC 0.0006 per cent, NSKE 5 per cent neem oil 0.3 per cent and neem leaf extract 10 percent registered the higher grain yield of black gram.

Economics: The treatment with neem seed kernel extract 5 per cent had the highest ICBR (1:7.05) and it followed by azadirachtin 0.15 EC 0.0006 per cent (1:4.83), neem oil 0.5% (1:4.11), custard apple leaf extract 10 per cent (1:3.47), neem leaf extract 10 per cent (1:2.06), custard apple seed extract 5 per cent (1:1.83), tobacco decoction 2 per cent (1:3.22), garlic extract 5 per cent (1:1.02) were found effective in managing the *H. armigera* and *M. obtusa* (Table 3). According to Dehury *et al.* (2020), of all the biopesticides, azadirchtin found the highest cost-benefit ratio and the greatest benefits when compared to farmer's practices.

CONCLUSION

From the above result of the three years of field experiments, it can be concluded that azadirachtin 0.15 EC 0.0006 per cent and neem seed kernel extract 5 percent were found to effectively managed of gram pod borer, *H. armigera* and pod fly, *M. obtusa* in pigeonpea. The effect of these treatments is reflected in the seed yield of pigeonpea.

In future, this study will helpful to the farmers for effective management of gram pod borer (*H. armigera*) and pod fly (*M. obtusa*) in pigeonpea.

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CONFLICTING INTERESTS

The author(s) declared no potential conflicts of interest concerning this article's research, authorship, and/or publication.

Table 1: Estimates of variability parameters for different characters in Pink Brinjal (Solanum melongena L.)

Sr. No	Treatment	No. of larva(e)/plant												
		2018-19				2019-20				2020-21				Pooled over spray over years
		1st spray pooled	2nd spray pooled	3rd spray pooled	Pooled over periods and sprays	1st spray pooled	2nd spray pooled	3rd spray pooled	Pooled over periods and sprays	1st spray pooled	2nd spray pooled	3rd spray pooled	Pooled over periods and sprays	
1	Neem Seed Kernal Extract 5%	1.15^{a}	1.11^{a}	1.15^{ab}	1.14^{a}	0.89^{a}	0.88^{a}	0.81^{a}	0.86^{a}	0.93^{a}	0.96^{a}	0.86^{a}	0.91^{a}	0.97^{a}
		(0.82)	(0.72)	(0.83)	(0.79)	(0.29)	(0.27)	(0.16)	(0.24)	(0.36)	(0.41)	(0.23)	(0.33)	(0.44)
2	Neem Leaf Extract 10%	1.39^{de}	1.17^{a}	1.19^{b}	1.25^{c}	1.20^{c}	1.23^{b}	1.27^{d}	1.23^{cd}	1.30^{cde}	1.24^{bc}	$1.21c^{de}$	1.25^{de}	1.25^{c}
		(1.44)	(0.86)	(0.92)	(1.07)	(0.94)	(1.01)	(1.11)	(1.01)	(1.19)	(1.05)	(0.97)	(1.07)	(1.05)
3	Neem Oil 0.5%	1.33^{cde}	1.13^{a}	1.06^{ab}	1.17^{ab}	1.12^{bc}	1.00^{a}	0.94^{ab}	1.02^{b}	1.13^{bc}	1.06^{ab}	1.04^{abc}	1.08^{bc}	1.09^{ab}
		(1.27)	(0.79)	(0.61)	(0.88)	(0.75)	(0.50)	(0.38)	(0.54)	(0.78)	(0.62)	(0.59)	(0.66)	(0.69)
4	Custard Apple Leaf Extract 10%	1.23^{abc}	1.11^{a}	1.10^{ab}	1.15^{a}	1.18^{c}	1.18^{b}	1.14^{bc}	1.17^{c}	1.21^{cd}	1.13^{abc}	1.10^{bcd}	1.15^{cd}	1.15^{cb}
		(1.00)	(0.73)	(0.72)	(0.81)	(0.89)	(0.89)	(0.80)	(0.87)	(0.96)	(0.79)	(0.70)	(0.81)	(0.83)
5	Custard Apple Seed Extract 5%	1.30^{bcd}	1.21^{a}	1.05^{a}	1.18^{ab}	1.30^{cd}	1.26^{b}	1.22^{c}	1.26^{cd}	1.33^{de}	1.28^{c}	1.25^{de}	1.29^{e}	1.24^{c}
		(1.19)	(0.95)	(0.60)	(0.90)	(1.19)	(1.09)	(0.99)	(1.09)	(1.28)	(1.14)	(1.07)	(1.16)	(1.05)
6	Garlic extract 5%	1.32^{cde}	1.25^{a}	1.06^{ab}	1.21^{bc}	1.29^{cd}	1.28^{b}	1.27^{c}	1.28^{cd}	1.34^{de}	1.29^{c}	1.30^{de}	1.31^{e}	1.27^{c}
		(1.25)	(1.06)	(0.63)	(0.97)	(1.16)	(1.14)	(1.11)	(1.14)	(1.29)	(1.17)	(1.18)	(1.21)	(1.10)
7	Tobacco decoction 2%	1.17^{ab}	1.22^{a}	1.12^{ab}	1.17^{ab}	1.25^{cd}	1.19^{b}	1.16^{bc}	1.20^{cd}	1.28^{cd}	1.26^{bc}	1.18^{cd}	1.24^{de}	1.20^{bc}
		(0.87)	(0.99)	(0.76)	(0.87)	(1.06)	(0.92)	(0.85)	(0.94)	(1.14)	(1.08)	(0.90)	(1.04)	(0.95)
8	Eucalyptus leaf extract 10%	1.32^{cde}	1.25^{a}	1.08^{ab}	1.22^{bc}	1.29^{cd}	1.31^{b}	1.30^{cd}	1.30^{d}	1.36^{de}	1.29^{c}	1.27^{de}	1.31^{e}	1.28^{c}
		(1.24)	(1.06)	(0.67)	(0.98)	(1.16)	(1.22)	(1.19)	(1.19)	(1.35)	(1.17)	(1.12)	(1.21)	(1.13)
9	Azadirachtin 0.15 EC (0.0006%)	1.29^{bcd}	1.12^{a}	1.05^{a}	1.15^{ab}	0.96^{ab}	0.92^{a}	0.87^{a}	0.92^{ab}	1.01^{ab}	1.01^{a}	0.93^{ab}	0.98^{ab}	1.02^{a}
		(1.16)	(0.76)	(0.59)	(0.83)	(0.42)	(0.35)	(0.26)	(0.35)	(0.53)	(0.52)	(0.36)	(0.47)	(0.53)
10	Control	1.45^{e}	1.47^{b}	1.41^{c}	1.44^{d}	1.43^{d}	1.58^{c}	1.51^{d}	1.51^{e}	1.48^{e}	1.62^{d}	1.42^{e}	1.51^{f}	1.49^{d}
		(1.61)	(1.66)	(1.49)	(1.59)	(1.54)	(2.00)	(1.78)	(1.78)	(1.69)	(2.12)	(1.52)	(1.79)	(1.72)
S. Em. ±	T	0.04	0.04	0.04	0.02	0.06	0.06	0.07	0.04	0.06	0.07	0.06	0.04	0.04
	P	0.02	0.02	0.02	0.01	0.03	0.02	0.03	0.02	0.03	0.03	0.03	0.02	0.02
	S	--	--	--	0.01	--	--	--	0.02	--	--	--	0.02	0.02
	Y	--	--	--	--	--	--	--	--	--	--	--	--	0.01
	T× P	0.06	0.06	0.06	0.03	0.09	0.08	0.10	0.05	0.08	0.09	0.09	0.05	0.03
	T × S	--	--	--	0.04	--	--	--	0.06	--	--	--	0.06	0.03
	T × Y	--	--	--	--	--	--	--	--	--	--	--	--	0.03
	S × P	--	--	--	0.02	--	--	--	0.03	--	--	--	0.03	0.04
	S × Y	--	--	--	--	--	--	--	--	--	--	--	--	0.02
	P × Y	--	--	--	--	--	--	--	--	--	--	--	--	0.01
	T × P × S	--	--	--	0.06	--	--	--	0.09	--	--	--	0.09	0.05
	T × P × Y	--	--	--	--	--	--	--	--	--	--	--	--	0.05
	T × S × Y	--	--	--	--	--	--	--	--	--	--	--	--	0.06
	P × S × Y	--	--	--	--	--	--	--	--	--	--	--	--	0.03
	T × P × S × Y	--	--	--	--	--	--	--	--	--	--	--	--	0.08
C.D. at 5%		Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.
C.V. %		7.76	8.73	9.10	8.39	12.47	11.29	14.70	12.73	10.87	13.05	13.33	12.51	11.36

Note: Figures outside parenthesis are $\sqrt{x+0.5}$ transformed values and those inside parenthesis are retransformed values. Treatment means with the letter(s) in common are not significant by DNMRT at a 5% level of significance. Significant parameters and their interactions: P, Y, S × Y and P × S × Y.

Table 2 Effect of different botanicals on pod damage, grain damage and yield of pigeonpea

Sr. No.	Treatment	*Pod damage (%) at harvest due to *H. armigera*				*Grain damage (%) at harvest due to *M. obtusa*				Yield (kg/ha)			
		2018-19	2019-20	2020-21	Pooled	2018-19	2019-20	2020-21	Pooled	2018-19	2019-20	2020-21	Pooled
1	Neem Seed Kernal Extract 5%	12.88^{a}	14.05^{a}	15.49^{a}	14.13^{a}	25.03^{ab}	22.80^{ab}	23.68^{ab}	23.83^{ab}	1399^{a}	1209^{a}	1224^{a}	1277^{a}
		(5.00)	(6.00)	(7.33)	(5.96)	(18.01)	(15.11)	(16.23)	(16.32)				
2	Neem Leaf Extract 10%	21.96^{cd}	20.98^{bc}	23.51^{bc}	22.14^{cde}	30.50^{bcd}	28.69^{bc}	30.74^{cde}	29.96^{cdef}	885^{cd}	902^{cd}	887^{bc}	891^{c}
		(14.33)	(13.00)	(16.33)	(14.20)	(25.79)	(23.07)	(26.22)	(24.94)				
3	Neem Oil 0.5%	17.21^{abc}	19.50^{bc}	21.08^{bc}	19.25^{b}	26.86^{abc}	25.09^{abc}	26.80^{abc}	26.24^{bc}	1339^{ab}	960^{c}	982^{b}	1094^{b}
		(9.00)	(11.33)	(13.33)	(10.87)	(20.46)	(18.06)	(20.35)	(19.55)				
4	Custard Apple Leaf Extract 10%	19.32^{bcd}	20.51^{bc}	22.23^{bc}	20.68^{bc}	28.01^{bcd}	26.59^{bc}	27.46^{bcd}	27.34^{bcd}	996^{cd}	990^{bc}	977^{b}	988^{bc}
		(11.00)	(12.33)	(14.33)	(12.47)	(22.12)	(20.04)	(21.27)	(21.10)				
5	Custard Apple Seed Extract 5%	18.89^{bcd}	21.88^{c}	24.80^{c}	21.85^{bcd}	26.02^{ab}	29.28^{bc}	31.59^{cde}	28.96^{cde}	1062^{bc}	919^{cd}	889^{bc}	956^{bc}
		(10.67)	(14.00)	(17.67)	(13.85)	(19.26)	(24.14)	(27.57)	(23.44)				
6	Garlic extract 5%	22.89^{cd}	22.39^{c}	25.18^{c}	23.48^{cde}	30.89^{bcd}	30.64^{c}	32.06^{cde}	31.19^{def}	853^{cd}	906^{cd}	877^{bc}	879^{c}
		(15.33)	(14.67)	(18.33)	(15.88)	(26.44)	(26.01)	(28.21)	(26.81)				
7	Tobacco decoction 2%	20.92^{bcd}	20.79^{bc}	22.68^{bc}	21.46^{bcd}	28.50^{bcd}	26.61^{bc}	30.60^{cde}	28.56^{cde}	936^{cd}	978^{c}	970^{b}	961^{bc}
		(13.00)	(12.67)	(15.00)	(13.38)	(22.80)	(20.10)	(26.07)	(22.85)				
8	Eucalyptus leaf extract 10%	23.10^{cd}	22.56^{c}	25.81^{c}	23.81^{de}	32.94^{cd}	31.24^{c}	33.12^{de}	32.42^{ef}	785^{cd}	896^{cd}	867^{bc}	849^{cd}
		(15.67)	(15.00)	(19.00)	(16.30)	(29.71)	(27.02)	(29.98)	(28.74)				
9	Azadirachtin 0.15 EC (0.0006%)	15.49^{ab}	16.24^{ab}	17.78^{ab}	16.50^{a}	20.91^{a}	19.08^{a}	21.47^{a}	20.48^{a}	1424^{a}	1153^{ab}	1192^{a}	1256^{a}
		(7.33)	(8.00)	(9.67)	(8.06)	(12.97)	(11.05)	(13.52)	(12.24)				
10	Control	24.46^{d}	23.49^{c}	27.01^{c}	24.98^{e}	34.20^{d}	31.65^{c}	35.83^{e}	33.88^{f}	730^{d}	766^{d}	751^{c}	749^{d}
		(17.33)	(16.00)	(20.67)	(17.83)	(31.92)	(27.81)	(34.33)	(31.07)				
	S. Em. ± T	1.79	1.46	1.75	0.87	1.92	2.02	1.72	1.00	97.12	50.75	48.53	43.16
	Y	--	--	--	0.53	--	--	--	0.60	--	--	--	21.88
	T x Y	--	--	--	1.67	--	--	--	1.89	--	--	--	69.19
	C.D. at 5%	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.
	C.V.%	15.76	12.50	13.44	13.92	11.71	12.90	10.16	11.58	16.16	9.08	8.74	12.10

Note: *Figures outside parenthesis are arcsine transformed values and those inside parenthesis are retransformed values, Treatment means with the letter(s) in common are not significant by DNMRT at a 5% level of significance.

Table 3 Economics of botanical treatments evaluated against gram pod borer, H. armigera, and pod fly, M. obtusa in pigeonpea

Sr. No.	Botanical insecticides	Quantity of Botanical insecticides required for 3 spray (kg or l/ha)	Price of Botanical insecticides (`/litre or kg)	Cost of Botanical insecticides required for 3 sprays (`) (A)	Labor cost for preparation of botanicals extract for 3 sprays (`) (B)	Total cost of botanical insecticide for 3 sprays (`) (A + B)	Labour cost for 3 spray (`) (C)	Total cost for 3 sprays (`) (A+B+ C)	Yield (kg/ha)	Net gain yield over control (Kg/ha)	Net Realization (`)	ICBR
1	Neem Seed Kernal Extract 5%	90	10	900	534	1434	3060	4494	1277	528	31680	1: 7.05
2	Neem Leaf Extract 10%	180	0.0	0.0	1068	1068	3060	4128	891	142	8520	1: 2.06
3	Neem Oil 0.5%	9	220	1980	0.0	1980	3060	5040	1094	345	20700	1: 4.11
4	Custard Apple Leaf Extract 10%	180	0.0	0.0	1068	1068	3060	4128	988	239	14340	1: 3.47
5	Custard Apple Seed Extract 5%	90	30	2700	1068	3768	3060	6828	957	208	12480	1: 1.83
6	Garlic extract 5%	90	45	4050	534	4584	3060	7644	879	130	7800	1: 1.02
7	Tobacco decoction 2%	36	10	360	534	894	3060	3954	961	212	12720	1: 3.22
8	Eucalyptus leaf extract 10%	180	0.0	0	1068	1068	3060	4128	849	100	6000	1: 1.45
9	Azadirachtin 0.15 EC (0.0006%)	7.2	450	3240	0.0	3240	3060	6300	1256	507	30420	1: 4.83
10	Control	-	-	-	-	-	-	-	749	-	-	-

Note: Labour charges @ ` 332/- per day x 2 labours = 664 `/ha and `178/- per day x 2 labours = 356 `/ ha. Total labour cost: 1020 `/ha for application of botanical insecticides. Cost of labor for preparation of leaves extract @ 178 x 2 = 356 `/ha and for collection and preparation of seed extract and tobacco decoction @ 178 `/ha. Price of pigeonpea seed: 60 `/Kg.

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