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Bio-Efficacy of Different Geographical Isolates of *Helicoverpa armigera* Nucleopolyhedrosis Virus (HaNPV) Against Gram Pod Borer, *Helicoverpa armigera* (Hubner) in Pigeonpea

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ABSTRACT

The bio-efficacy of eight geographical isolates of *Helicoverpa armigera* NPV @ 500 LE/ha, along with Emamectin benzoate (0.3 g/L) and untreated control were evaluated against gram pod borer, *Helicoverpa armigera* (Hubner) in pigeonpea at Zonal Agricultural Research Station, UAS, GKVK, Bangalore. Hosur HaNPV isolate (0.50/plant) was significantly superior in reducing the larval population than Gulbarga isolate (0.73/ plant), followed by Hyderabad (0.75/plant), Dhule (0.92/plant), Udaipur isolates (0.97/plant) and untreated control (1.23/plant), but it was statistically on par with emamectin benzoate (0.48/plant), followed by Akola (0.63/plant), Ranjanukunte (0.67/plant) and Chandapura isolates (0.68/plant). Hosur isolate (59.35%) gave maximum percentage reduction in larval population over control, which was next to that of emamectin benzoate (60.98%). Significantly lower pod damage was recorded in plots treated with Rajanukunte isolate (3.80%) and it was statistically on par with Emamectin benzoate (3.67%), followed by Akola (4.03%), Hosur (4.40%), Chandapura (4.60%) and Hyderabad isolates (4.63%). In comparison with untreated control, the reduction in pod damage in case of emamectin benzoate, Rajanukunte, Akola, Hosur, Chandapura and Hyderabad isolates of HaNPV was 37.05, 34.31, 30.87, 24.53, 21.10 and 20.58 per cent, respectively. Highest grain yield was recorded in plots treated with Hosur isolate (1566.67 kg/ha), in contrast to untreated control (1453.33 kg/ha). Hosur HaNPV isolate (1:3.29) was found to be the most economically viable treatment, as compared to emamectin benzoate (1:1.77), followed by Rajanukunte (1:1.22), Chandapura (1:1.09) and Gulbarga isolates of HaNPV(1:0.21).

Keywords: Pigeonpea, *Helicoverpa armigera*, HaNPV isolates, emamectin benzoate

PIGEONPEA [*Cajanuscajan* (L.) Millsp.] is an important pulse crop, contributing immensely as source of protein to the vast population of our country. Various biotic and abiotic constraints are known to be associated with low production of pigeonpea. Amongst biotic, gram pod borer (*Helicoverpa armigera* (Hubner), gram pod fly (*Melanagromyza obtusa* Malloch) and spotted pod borer (*Maruca vitrata* Geyer) are the major insect pests affecting the productivity of pigeonpea. Of these, *H. armigera*is reported as a major polyphagous pest of pigeonpea, which is also serious on chickpea, mungbean, urdbean, lentil and soybean. The larvae feed on the grains after inserting its head inside the pod while leaving the rest of the body outside (David and Ramamurthy, 2012). It has been estimated that *H. armigera* causes a loss of around $350 million annually in pigeonpea and around $2 billion in various crops in the semiarid tropics (Sharma *et al.*, 2005). Although chemical insecticides are preferred for timely and efficient pod borer management, their over exploitation and indiscriminate application has led to various hazards like development of insecticide resistance, resurgence, environment pollution as well as the health problems. These problems had led to the search for safer alternatives which will also be efficient in controlling the insect pests. Bio-pesticides based on baculovirus group, *i.e.*, the nucleopolyhedrosis (NPV) offers immense scope for eco-friendly suppression of *H.armigera* (Pugalengthi *et al.*, 2013). The major advantage is that they are host specific and can be formulated in any carrier as the virus particles are occluded in proteinecious crystals called as occlusion bodies (Dhaliwal and Arora, 2001). However, differences in virulence based on their geographical diversity will facilitate the exploitation of the better geographical isolate with greater virulence and obtain better suppression of *H. armigera* in pigeonpea. It has

been earlier reported that different geographical isolates showed varied performance in controlling the insect pests (Gupta *et al.*, 2007; Jeyarani *et al.*, 2010). In the light of earlier reports on similar investigations the present work is aimed at evaluating different geographical isolates of HaNPV, in order to determine the most efficient isolate under field conditions, that could be commercially exploited in a more efficient manner.

Material and Methods

Production of *Helicoverpa armigera* nucleopolyhedrosis virus

The *H. armigera* larvae were reared on artificial diet (Wakil *et al.*, 2011) in multilocular rearing trays, until they attained pupation. Pupae were transferred onto thick filter paper placed in a container to facilitate adult emergence. Adults were provided with muslin cloth for egg laying. Cotton swab dipped in honey solution (1:1) was provided as adult food. Muslin cloth with eggs were collected and kept for hatching. After egg hatching the cloth was transferred on to a container having diet. The 4th instar larvae were used for the virus production. Each diet cube of 0.5 g was inoculated with 10 µl of virus suspension of 6.0 x 10^5 POBs/ml. The larvae were allowed to feed for 24 hrs on NPV contaminated diet and then transferred onto healthy diet. It took 7-8 days for the death of larvae. Infected larvae collected were homogenized in equal volume of distilled water using a blender. The resulting slurry was filtered with double layer muslin cloth. More water was added to the filtrate and centrifuged at 500 rpm for one minute. The supernatant was collected and centrifuged further at 2500 rpm for 5 minutes. The pellet was collected and supernatant was discarded. The resulting pellet was suspended in distilled water. The concentration of solution was determined by using a Neuber haemocytometer. All working equipments and places were regularly cleaned with 0.1 per cent sodium hypochloride solution. Precautions were taken to avoid the cross contamination of the isolates (Narendrappa *et al.*, 2014).

Determination of total cost of spray application of the isolates

The total cost of spray application was worked out by determining the cost of production of HaNPV for each one of the geographical isolates. Further, the cost of adjuvants, surfactant and labour charges for spray application for each isolates was added as per the prevailing market price, to the cost of production (Jeyarani *et al.*, 2010) and thus the total cost of spray application was computed (Table I).

Table I

Cost of producing the required dose of each HaNPV isolate and spray application against gram pod borer, Helicoverpa armigera *(Hubner) in pigeonpea under field conditions*

Isolates of HaNPV	Yield per 50 inoculated larvae	Number of larvae required for producing recommended field dose *i.e.*, 3.0 x 10^{12} POBs / ha (500LE / ha) (Rs)	Cost of producing required dose 3.0 x 10^{12} POBs / ha (500LE / ha) (Rs)	Total cost of spray application (Rs / spray / ha)*
GUL	1.34 x 10^{11}	1120	728.00	1918.00
HOR	3.93 x 10^{11}	382	248.30	1438.30
RKE	2.36 x 10^{11}	636	413.40	1603.40
UDR	2.30 x 10^{11}	653	424.45	1614.45
HYD	1.52 x 10^{11}	987	641.55	1831.55
AKL	8.75 x 10^{10}	1715	1114.75	2304.75
DHL	1.20 x 10^{11}	1250	812.50	2002.50
CHAN	1.49 x 10^{11}	1007	654.55	1844.55

*comprises surfactant (Active 90) @ Rs. 440/spray/ha, crude sugar @ Rs. 150/spray/ha, cost of application @ Rs. 600/spray/ha

Experimental details

The present study was carried out at All India Co-ordinated Research Project (Pigeonpea), Zonal Agricultural Research Station, UAS, GKVK, Bangalore during *kharif* 2017-18, which is situated in $77^0 38'$E longitude and an altitude of 930'meters above MSL. The experiment was laid down in randomized complete block design. The plot size was 5 x 5 m^2 with three replications. The variety BRG-3 was sown on 13th August, 2017 with a spacing of 60 x 30 cm and all the recommended agronomical practices, except plant protection were followed as per the package of practice of UAS, Bangalore (Anon., 2012). The treatments comprised of eight different Ha-NPV geographical isolates @ 500 LE / ha and Emamectin benzoate 5 SG @ 0.3 g/L as standard insecticidal check as well as an untreated control. The eight of HaNPV isolates were Gulbarga (GUL), Hosur (HOR), Rajanukunte (RKE), Udaipur (UDR), Hyderabad (HYD), Akola (AKL), Dhule (DHL) and Chandapura (CHAN). The Active (90) 0.1 per cent was added as a surfactant. Crude cane sugar @ 2.00 kg/ha was added for all the virus treatments as phagostimulant. Untreated control plots was sprayed with surfactant active (90) 0.1 per cent and crude cane sugar at 2.00 kg/ha, without HaNPV. The treatments were imposed by using a knapsack sprayer. Precautions were taken to avoid any cross contamination between the treatments. The crop was regularly monitored for the presence of larvae and pod damage. For recording of the data, ten plants were tagged randomly in each plot. The treatments were imposed when the pest incidence was noticed. The observations were documented one day before treatment imposition as pretreatment count and subsequently at seven and 10 days after spray (DAS), as post-treatment counts. The data was recorded on number of live larvae per plant. The damage caused by the larvae could be recognized by bigger and round holes made on the pods and larval feeding on the developing grains. At the time of observation, 50 pods were randomly collected from each one of the labelled plants. From these collected pods, the number of pods damaged by *H. armigera* was counted. Percentage pod damage was calculated by adopting the following formula (Nitharwal *et al.*, 2017),

$$\text{Pods damaged (\%)} = \frac{\text{Number of damaged pods}}{\text{Total number of pods}} \times 100$$

The analysis of variance (ANOVA) was worked out after appropriate transformation of the data and the means were separated by Duncan's Multiple Range Test (DMRT) by using the SPSS software, by following the methodology as suggested by Jeyarani *et al*. (2010). The percentage reduction larval population and pod damage over untreated control due to the different treatments was calculated as per the formula given by Abbott (1925).

$$\text{Reduction over control (\%)} = \frac{C - T}{C} \times 100$$

where,

C: per cent pod damage of control or larval population on control

T: per cent pod damage of treated plot or larval population on treatments

Results and Discussion

Effect of different geographical isolates of HaNPV on the *H. armigera* larval number is presented in Table II. Prior to the treatment imposition, the larval population per plant ranged from 1.17 to 1.57 and there were no significant differences between the treatments. After 7 day of spraying (DAS), Hosur isolate of HaNPV (0.53/plant) was found to be superior in reducing larval population as compared to Hyderabad isolate (0.80/plant), followed by Dhule isolate (0.97/plant), Udaipur isolate (1.03/plant) and untreated control (1.23/plant), However, it was statistically on par with Emamectin benzoate (0.57/ plant), followed by Akola (0.67/plant), Rajanukunte (0.70/plant), Chandapura (0.77/plant) and Gulbarga isolates (0.77/plant). The next effective one was Hyderabad isolate (0.80/plant), but it was statistically on par with Dhule isolate (0.97/plant), Udaipur isolate (1.03/plant) and untreated control (1.23/plant).

At 10 day of spray (DAS), all treatments were found to be superior in reducing larval population over untreated control (Table II). Among all the treatments, Emamectin benzoate (0.40/plant) was significantly superior in reducing the larval population as compared

TABLE II

Effect of different geographical isolates of the HaNPV on larval population of gram pod borer, Helicoverpa armigera *(Hubner) in pigeonpea under field conditions*

Treatments	Number of larvae per plant				Reduction in larval number over control (%)
	Pre - treatment count	7 DAS	10 DAS	Pooled mean **	
GUL	1.17 (1.08)	0.77 (0.88) bcd	0.70 (0.84) bcd	0.74 (0.86) bcd	40.65
HOR	1.20 (1.09)	0.53 (0.73) d	0.47 (0.68) ef	0.50 (0.70) e	59.35
RKE	1.27 (1.12)	0.70 (0.83) cd	0.63 (0.79) cde	0.67 (0.81) de	45.53
UDR	1.57 (1.25)	1.03 (1.02) ab	0.90 (0.95) b	0.97 (0.98) ab	21.14
HYD	1.33 (1.16)	0.80 (0.89) bc	0.70 (0.84) bcd	0.75 (0.87) bcd	39.02
AKL	1.17 (1.08)	0.67 (0.82) cd	0.60 (0.77) def	0.63 (0.80) de	48.78
DHL	1.40 (1.18)	0.97 (0.98) ab	0.87 (0.93) bc	0.92 (0.95) bc	25.20
CHAN	1.17 (1.08)	0.77 (0.87) bcd	0.60 (0.78) de	0.68 (0.83) cde	44.72
Emamectinbenzoate	1.33 (1.15)	0.57 (0.75) cd	0.40 (0.63) f	0.48 (0.69) e	60.98
Untreated control	1.20 (1.09)	1.23 (1.11) a	1.23 (1.11) a	1.23 (1.11) a	-
F test	NS	*	*	*	
S.Em (±)	(0.0483)	(0.0516)	(0.0483)	(0.0483)	-
CD (p=0.05)	-	(0.15)	(0.14)	(0.14)	-
CV (%)	(7.50)	(9.93)	(9.96)	(9.65)	-

Figures in parenthesis are the square root transformed values for number of larvae per plant

**Pooled mean of two observations

In each column means followed by same alphabets are statistically on par by DMRT (p=0.05)

NB: HaNPV isolates evaluated, GUL-Gulbarga, HOR-Hosur, RKE-Rajanukunte, UDR-Udaipur, HYD-Hyderabad, AKL-Akola, DHL-Dhule, CHAN-Chandapura

to Chandapura isolate (0.60/plant) followed by Rajanukunte (0.63/plant), Hyderbad(0.70/plant), Gulbarga(0.70/plant), Dhule (0.87/plant), Udaipur isolates (0.90/plant) and untreated control (1.23/plant), but it was statistically on par with Hosur (0.47/plant), followed by Akola isolates (0.60/plant). The Akola isolate (0.60/plant) was statistically on par with Chandapura (0.60/plant), Rajanukunte (0.63/plant), Hyderbad (0.70/plant) and Gulbarga isolates (0.70/plant) but all these were significantly superior than Dhule isolate (0.87/plant), followed by Udaipur isolate (0.90/plant) and untreated control (1.23/plant). Dhule (0.87/plant) and Udaipur (0.90/plant) isolates were least effective and statistically on par with each other but superior than untreated control (1.23/plant) in reducing larval population.

The pooled data of 7 DAS and 10 DAS (Table II) showed that all treatments were effective in reducing the larval population over untreated control. Emamectin benzoate (0.48/plant) was superior than all the HaNPV isolates, but was statistically on par with Hosur isolate (0.50/plant), followed by Akola isolate (0.63/plant), Rajanukunte isolate (0.67/plant) and Chandapura isolate (0.68/plant). Next in the order was Gulbarga isolate(0.73/plant) which was effective in reducing the larval population and was statistically on par with Hyderabad isolate (0.75/plant) followed by Dhule (0.92/plant) and Udaipur isolates (0.97/plant). However, the Udaipur isolate was on par with untreated control (1.23/plant).

Data based on the pooled mean (Table II) showed that Emamectin benzoate (60.98%) recorded maximum percentage reduction in larval population over untreated control, followed by Hosur (59.35%), Akola (48.78%), Rajanukunte (45.53%), Chandapura (44.72%), Gulbarga (40.65%), Hyderabad (39.02%), Dhule (25.20%) and Udaipur isolates HaNPV (21.14%) in decreasing order of their efficacy.

Before the treatment imposition, percentage pod damage ranged from 3.47 to 4.73 per cent (Table III),

TABLE III

Effect of different geographical isolates of the HaNPV on pod damage (%) caused by of gram pod borer, Helicoverpa armigera (Hubner) in pigeonpea under field conditions

Treatments	Pod damage (%)				Reduction in pod damage over control (%)
	Pre - treatment	7 DAS	10 DAS	Pooled mean **	
GUL	4.07 (11.61)	4.73 (12.56) ^{abcd}	4.87 (12.74) ^{abc}	4.80 (12.65) ^{abc}	17.67
HOR	3.93 (11.42)	4.40 (12.10) ^{cde}	4.40 (12.10) ^{cde}	4.40 (12.10) ^{cd}	24.53
RKE	3.67 (10.98)	3.87 (11.28) ^{de}	3.80 (11.18) ^{de}	3.83 (11.23) ^{cd}	34.31
UDR	4.73 (12.54)	5.60 (13.67) ^{ab}	5.60 (13.66) ^{ab}	5.60 (13.67) ^{ab}	03.95
HYD	4.13 (11.73)	4.60 (12.37) ^{bcde}	4.67 (12.47) ^{bcde}	4.63 (12.42) ^{bcd}	20.58
AKL	3.73 (11.14)	4.00 (11.53) ^{de}	4.07 (11.63) ^{cde}	4.03 (11.58) ^{cd}	30.87
DHL	4.53 (12.23)	5.47 (13.51) ^{abc}	5.73 (13.84) ^{ab}	5.60 (13.67) ^{ab}	03.95
CHAN	4.07 (11.62)	4.47 (12.20) ^{cde}	4.73 (12.56) ^{abcd}	4.60 (12.38) ^{bcd}	21.10
Emamectinbenzoate	3.47 (10.70)	3.67 (11.01) ^{e}	3.67 (11.01) ^{e}	3.67 (11.01) ^{d}	37.05
Untreated control	4.20 (11.76)	5.77 (13.85) ^{a}	5.93 (14.09) ^{a}	5.83 (13.97) ^{a}	-
F test	NS	*	*	*	
S.Em (±)	(0.63)	(0.48)	(0.51)	0.49	-
CD (p=0.05)	-	(1.41)	(1.53)	(1.46)	-
CV (%)	(9.46)	(6.64)	(7.12)	(6.81)	-

Figures in parenthesis are the angular transformed values for per cent pod damage; **Pooled mean of two observations
DAS: Days after spray
In each column means followed by same alphabets are statistically on par by DMRT (p=0.05)
NB: HaNPV isolates evaluated, GUL-Gulbarga, HOR-Hosur, RKE-Rajanukunte, UDR-Udaipur, HYD-Hyderabad, AKL-Akola, DHL-Dhule, CHAN-Chandapura

but there was no significant difference with respect to percentage pod damage among the treatments. Seven days after imposing the treatments (7 DAS), Emamectin benzoate was found significantly superior in reducing pod damage (3.67%) when compared to Gulbarga (4.73%) Dhule (5.47%), Udaipur isolates HaNPV (5.60%) and untreated control (5.77%).

However, Emamectin benzoate was statistically on par with Ranjanukunte isolate (3.87%), followed by Akola (4.00%), Hosur (4.40%), Chandapura (4.47%) and Hyderabad isolates of HaNPV (4.60%). Though Gulbarga isolate (4.73%) was effective in reducing the pod damage, it was statistically on par with Dhule (5.47%), Udaipur isolates of HaNPV (5.60%) and untreated control (5.77%) (Table III).

Ten days after treatment imposition (10 DAS), Emamectin benzoate was found to be significantly superior in reducing pod damage (3.67%) as compared to Chandapura (4.73%), Gulbarga (4.87%), Udaipur (5.60%), Dhule isolates of HaNPV (5.73%) and untreated control (5.93%), but it was on par with Ranjanukunte (3.80%), followed by Akola (4.07%), Hosur (4.40%) and Hyderabad (4.63%) isolates of HaNPV. However, Chandapura isolate (4.73%) was found to reduce pod damage to some extent, and was statistically on par with Gulbarga isolate (4.87%), Udaipur isolate (5.60%), Dhule isolate (5.73%) and untreated control (5.93%) (Table III).

Similar trend was observed when pooled means were compared with respect to pod damage percentage. Emamectin benzoate (3.67%) was significantly superior than Gulbarga isolate (4.80%), followed by Udaipur isolate (5.60%), Dhule isolate (5.60%) and untreated control (5.83%), but Emamectin benzoate was statistically on par with Rajanukunte isolate (3.83%), Akola isolate (4.03%), Hosur isolate (4.40%), Chandapura (4.60%) and Hyderabad isolates of HaNPV(4.63%). However, Gulbarga isolate (4.80%) was found to be significantly less effective and it was on par with Udaipur isolate (5.60%), Dhule isolate (5.60%) and untreated control (5.83%) (Table III).

As far as the percentage reduction in pod damage was concerned (Table III), Emamectin benzoate (37.05%) was found to be significantly superior than Rajanukunte isolate (34.31%) followed by Akola isolate (30.87%), Hosur isolate (24.53%), Chandapura (21.10%), Hyderabad (20.58%), Udaipur (3.95%) and Dhule isolates of HaNPV (3.95%).

Cost : Benefit ratio

Data on grain yield was recorded for each treatment at crop maturity. The grain yield for each treatment was converted into kg per hectare. Additional yield for each treatment was calculated by deducting treatment yield from the yield obtained from untreated control. Value of additional yield was worked out by multiplying the yield (kg/ha) with the market price. Net profit from each treatment was calculated by deducting cost of protection (Rs/ha) from value of additional yield (Rs/ha). Cost : Benefit ratio (Table IV) was worked out to find out the most economically viable treatment (Jeyarani *et al*., 2010; Sreekanth *et al.*, 2014).

No significant differences were observed with respect to the grain yield data among the treatments (Table IV). Highest grain yield was recorded in plots treated with Hosur isolate of HaNPV (1566.67 kg/ha) followed by Emamectin benzoate (1552.00 kg/ha), Chandapura (1524.00 kg/ha), Rajanukunte (1518.67 kg/ha), Gulbarga (1496.00 kg/ha), Akola (1493.33 kg/ha), Dhule (1484.00 kg/ha), Hyderabad (1464.00 kg/ha) and Udaipur isolates of HaNPV(1461.33 kg/ha) as compared to untreated control (1453.33 kg/h). Based on Cost : Benefit ratio, Hosur isolate (1:3.29) was found to be the most economically viable treatment as compared to Emamectin benzoate (1:1.77), followed by Rajanukunte isolate (1:1.22), Chandapura isolate (1:1.09) and Gulbarga isolate (1:0.21) in the decreasing order. However, the C:B ratio was negative in case of Akola (1:-0.05), Dhule (1:-0.17), Hyderabad (1:-0.68) and Udaipur isolates of HaNPV (1:-0.73). This may be due to lower increase in yield as compared to the untreated control and relatively higher cost of imposition of these treatments in relation to the benefits derived.

In the present study, Hosur HaNPV isolate was found to be very effective as compared to the other isolates. It was on par with chemical insecticide, Emamectin benzoate, in reducing larval population

TABLE IV

Grain yield and C : B ratio of different HaNPV isolates evaluated against gram pod borer, Helicoverpa armigera *(Hubner) in pigeonpea*

Treatments	Grain yield (Kg/ha)	Increase in Grain yield over control (Kg/ha)	Cost of Increase Grain yield (Rs/ha)*	Total Cost of spray application (Rs/spray/ha)*	Net income (Rs/ha)	Cost : benfit ratio
GUL	1496.00	42.67	2325.52	1918.00	407.52	1:0.21
HOR	1566.67	113.34	6177.03	1438.30	4738.73	1:3.29
RKE	1518.67	65.34	3561.03	1603.40	1957.63	1:1.22
UDR	1461.33	8.00	436.00	1614.45	-1178.45	1:-0.73
HYD	1464.00	10.67	581.52	1831.55	-1250.03	1:-0.68
AKL	1493.33	40.00	2180.00	2304.75	-124.75	1:-0.05
DHL	1484.00	30.67	1671.52	2002.50	-330.98	1:-0.17
CHAN	1524.00	70.67	3851.52	1844.55	2006.97	1:1.09
Emamectin benzoate	1552.00	98.67	5377.52	1940.00	3437.52	1:1.77
Control	1453.33	-	-	-	-	-
F test	NS	-	-	-	-	-
S.Em (±)	-	-	-	-	-	-
CD (p=0.05)	-	-	-	-	-	-
CV (%)	11.32	-	-	-	-	-

*Market price of produce (grain yield) @ Rs. 54.50/kg

or pod damage. The HaNPV isolate from Hosur recorded slightly higher yield and highest Cost : Benefit ratio (1:3.29) as compared to emamectin benzoate (1:1.77). Earlier reports have also reported the differences in performance of different isolates of HaNPV. Gupta *et al.* (2007) found that Samba isolate of HaNPV caused significantly highest larval mortality (98.33%) of *H. armigera*, followed by Udhyewalla (86.11%) and Chenani (81.66%), after 9 days of spray, in pot experiment with tomato.

In an investigation, Jeyarani *et al.* (2010) found that among the HaNPV isolates, CBE I (Coimbatore) and NEG (Negamum) reduced the *H. armigera* larval population on cotton (63.63 %) and chickpea (61.50%) and reduced the boll/pod damage by 61.09 and 61.01 per cent, respectively. Plots treated with CBE I (980 kg/ha) and NEG (983 kg/ha) produced the highest yield, which was on a par with endosulfan (973.3 kg/ha) with Cost : Benefit ratios of 1:1.36, 1:1.48 and 1:0.87, respectively. Plots treated with Rajasthan isolate showed lowest yield, as compared to untreated control. According to Rudramuni *et al.* (2012), among the different HaNPV commercial formulations evaluated, PDBC® isolate of the virus performed better in reducing the boll damage in cotton and recorded highest yield than others.

Therefore, the present investigation reveals that the Hosur isolate of HaNPV, by virtue of recording significantly lower pest population and higher grain yield, has proved to be most efficacious. The Hosur isolate of HaNPV is the most economically viable treatment for the suppression of *H. armigera* in pigeonpea, with highest C:B ratio of 1:3.29. However, its performance needs to be tested further across different seasons and locations in order to confirm its superior efficacy and economic viability.

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