Field efficacy of botanicals against sucking pests in pigeonpea[*Cajanus cajan* (L.) Millsp.] under organic cultivation

ABSTRACT

Investigations were carried out at Agronomy Instructional Farm, Chimanbhai Patel College of Agriculture, S. D. Agricultural University, Sardarkrushinagar during *kharif*, 2022-23 and 2023-24for evaluation of various botanicalson the incidence of sucking pests *viz.*, aphid, thrips,leaf hopperand pod bug in pigeonpea.Among thebotanicals treatment,NSKE @ 5 per cent + cow urine @ 10 per centrecorded significantly minimum1.91 aphid per 10 cm shoot,3.54 thrips per flower, 2.27 leaf hopper per 3 leaves and 1.93 pod bug per plant. The highest yield was obtained in the treatment of NSKE @ 5 per cent + cow urine @ 10 per cent (1300 kg/ha) and it was at par with NSKE @ 5 per cent (1282 kg/ha) and *dashparniark* @ 10 per cent (1258 kg/ha). The maximum increase in yield over control (76.07%) was obtained in NSKE @ 5 per cent + cow urine @ 10 per cent. The minimum avoidable losses (1.41%) and highest PCBR (1:16.12) was observed in the plot treated with NSKE @ 5 per cent.

Keywords: Aphid, Thrips, Leaf hopper, Pod bug, NSKE, Cow urine, Pigeonpea and *Cajanus cajan*

INTRODUCTION

Pulses hold a significant role in Indian agriculture, being both the largest producer and consumer of these crops globally. They offer a high-quality protein, nearly three times that of cereals. Pigeonpea [*Cajanus cajan*(L.) Millsp.] is the second most important pulse crop in the country after chickpea. It is locally known as arhar, tur or red gram. It seems that Africa is the probable place of origin and was introduced in India by ancient traders but a few writers including Vavilov (1926) and Nene (2006), consider India as its native home. Pigeonpea is rich source of protein (22.3%) which supplies a major share of the protein requirement of the vegetarian population of the country, making it a valuable component for improving food security and nutrition for many poor families. It has better quality of fiber 7g/100g of seeds (Kandhare, 2014).

Pigeonpea occupies an area of 6.36 million hectares in the world with annual production of 5.48 milliontonnes (FAO 2021). In India, it is grown on 5.05 million hectares with an annual production and productivity of 4.34 million tonnes and 859 kg/ha, respectively. Maharashtra, Uttar Pradesh, Madhya Pradesh, Karnataka, Gujarat, Andhra Pradesh, Telangana, Jharkhand, Chhattisgarh and Odisha are the major pigeonpea growing states. In Gujarat it is grown on 2.50 lakh hectares with an annual production of 2.90 lakh tonnes (Anon., 2022).

The key pest of pigeonpea can be grouped into three categories: flower and pod feeding Lepidoptera, pod sucking Hemiptera and seed feeding Diptera and Hymenoptera (Khajuria *etal*., 2015). So, there is a need to investigate the tools for the sucking pests of pigeonpea to develop an effective management strategy as well as focused on the use of safer pesticides and their integration with other eco practices and need of their sustainable management which may prove economically and ecological viable.

MATERIALS AND METHODS

To determine the relative efficacy of different plant products *viz*., Neem seed kernel extract (NSKE), NSKE + Cow urine, *Agniastra*, *Neemastra*, *Brahmastra*, *Panchparni ark* and *Dashparni ark*against sucking insect pests of organic pigeonpea, a field trial was conducted at Agronomy Instructional Farm, C. P. College of Agriculture, S. D. Agricultural University, Sardarkrushinagar during *kharif*, 2022-23 and 2023-24. The experiment was conducted in randomized block design (RBD)with three replications having plot area 3.60 m × 3.00 m. The variety GT 103was grown with spacing 60 cm × 20 cm under recommended agronomical practices.All the botanicals were applied as foliar spray using a knapsack sprayer equipped with a hollow cone nozzle. Spraying occurred during the morning hours, with attention paid to prevent the drift of the spray fluid. The sprayer was thoroughly cleaned before the application of each botanical. The first spray of botanicals was applied at the initiation of the flowering stage, followed by a second and third spray applied at ten-day intervals after the first spray.

Method of recording the observations

During the course of the investigation, the population of aphids, thrips, leaf hoppers and pod bugs was recorded. Five plants were selected at random from each net plot per replication and tagged with labels, leaving the border rows. Observations on sucking pests were recorded from each treatment one day before spraying and after 3, 6 and 9 days of spraying. The second and third spray was applied ten days interval after the first spray. The data thus obtained were statistically analyzed.The total number of aphids on 10 cm long terminal shoots. Thrips were calculated by shaking open flowers with twigs over a piece of white paper and recording the total number of thrips that fell onto the paper.The population of leaf hoppers was recorded by counting the total number of leaf hoppers present on three leaves (upper, middle and lower leaf) of five randomly selected plants from each net plot.The number of pod bugs were recorded on five randomly selected plants from each net plot.At harvest, yield was recorded separately from each net plot. Based on the yield, the economics were calculated. Avoidable loss and increase in yield over control were calculated by applying the formula suggested by Khosla (1977).

$$\text{Avoidable loss (\%)} = \frac{\text{Highest yield in treated plot} - \text{Yield in treatment}}{\text{Highest yield in treated plot}} \times 100$$

$$\text{Increase in yield over control (\%)} = \frac{\text{Yield in treatment} - \text{Yield in control}}{\text{Yield in control}} \times 100$$

RESULTS AND DISCUSSION

Aphid

The pooled data from 2022-23 and 2023-24 on managing aphid populations using various botanicals, presented in Table 1, showed that aphid populations were initially uniform across plots. For 2022-23, NSKE @ 5% + cow urine @ 10% was the most effective treatment (1.80 aphid/10 cm shoot), followed by NSKE @ 5% alone (2.05 aphid/10 cm shoot). Other effective treatments included *dashparni ark* @ 10% (2.34 aphid/10 cm shoot), *neemastra* @ 10% (2.87 aphid/10 cm shoot)and *brahmastra* @ 10% (3.10 aphid/10 cm shoot). *Agniastra*@ 10% (3.35 aphid/10 cm shoot) and *panchparni ark* @ 10% (4.00 aphid/10 cm shoot) were less effective. The control had the highest aphid population (6.62 aphid/10 cm shoot). In 2023-24, NSKE @ 5% + cow urine @ 10% remained the most effective (2.03 aphid/10 cm shoot), followed by NSKE @ 5% (2.42 aphid/10 cm shoot) and *dashparni ark* @ 10% (2.72 aphid/10 cm shoot).*Neemastra* @ 10% (3.25 aphid/10 cm shoot), *brahmastra* @ 10% (3.74 aphid/10 cm shoot)and *agniastra*@ 10% (3.94 aphid/10 cm shoot) were also effective, while *panchparni ark* @ 10% recorded higher aphid populations (4.55 aphid/10 cm shoot). Overall, NSKE @ 5% + cow urine @ 10% was the superior treatment across both years, recording the lowest aphid population (1.91 aphid/10 cm shoot), followed by NSKE @ 5% (2.23 aphid/10 cm shoot) and *dashparni ark* @ 10% (2.52 aphid/10 cm shoot).Earlier, Jat *et al*. (2018) at Udaipur, Rajasthan found that flowering (60.11%) and grain-filling stages (61.21%) led to a significantly maximum mean reduction in the population of Blackgram aphids. The variation of effect of treatment it may be due to the different dose of botanicals and different ecological conditions in particular locations.

Thrips

The pooled data from 2022-23 and 2023-24 on the efficacy of various botanicals in managing thrips populations, presented in Table 2, showed that the initial thrips populations were uniformly distributed across plots.For 2022-23, NSKE @ 5% + cow urine @ 10% was the most effective treatment (3.24 thrips/flower), closely followed by NSKE @ 5% (3.54 thrips/flower).*Dashparni ark*@ 10% (3.78 thrips/flower), *neemastra* @ 10% (4.90 thrips/flower)and *brahmastra* @ 10% (5.22 thrips/flower) were also effective. *Agniastra*@ 10% (5.51 thrips/flower) and *panchparni ark* @ 10% (6.66 thrips/flower) were less effective. The control recorded the highest thrips population (10.62 thrips/flower).For 2023-24, NSKE @ 5% + cow urine @ 10% again proved most effective (3.85 thrips/flower), followed by NSKE @ 5% (4.21 thrips/flower) and *dashparni ark* @ 10% (4.61 thrips/flower). *Neemastra* @ 10% (5.56 thrips/flower), *brahmastra* @ 10% (5.87 thrips/flower), *agniastra* @ 10% (6.16 thrips/flower)and *panchparni ark* @ 10% (7.38 thrips/flower) followed in effectiveness. The control had the highest thrips population (11.33

thrips/flower).Overall, combining data from both years, NSKE @ 5% + cow urine @ 10% was the most effective (3.54 thrips/flower), followed by NSKE @ 5% (3.87 thrips/flower) and *dashparni ark* @ 10% (4.18 thrips/flower). *Neemastra* @ 10% (5.22 thrips/flower), *brahmastra* @ 10% (5.54 thrips/flower), *agniastra*@ 10% (5.83 thrips/flower)and *panchparni ark* @ 10% (7.02 thrips/flower) were progressively less effective. The untreated control had the highest thrips population (10.97 thrips/flower).In past, Egho *et al*. (2010) revealed that the results indicated that 7 days after spray, there was a significant reduction in damage caused by thrips compared to the controlled by NSKE treatments in cowpea at Delta, Nigeria. Thus, the present findings on impact of botanicals on damage of thrips in pigeonpea are more or less in accordance with findings of above workers.

Leaf hopper

The pooled data from 2022-23 and 2023-24 on managing leaf hopper populations using various botanicals, presented in Table 3, showed initial leaf hopper populations were uniformly distributed across plots.For 2022-23, NSKE @ 5% + cow urine @ 10% was the most effective treatment (2.15 leaf hoppers/3 leaves), followed by NSKE @ 5% (2.39 leaf hoppers/3 leaves) and *dashparni ark* @ 10% (2.70 leaf hoppers/3 leaves). *Neemastra* @ 10% (3.37 leaf hoppers/3 leaves) and *brahmastra* @ 10% (3.67 leaf hoppers/3 leaves) were also effective. *Agniastra*@ 10% (3.93 leaf hoppers/3 leaves) and *panchparni ark* @ 10% (4.71 leaf hoppers/3 leaves) were less effective. The control had the highest population (7.63 leaf hoppers/3 leaves).For 2023-24, NSKE @ 5% + cow urine @ 10% again proved most effective (2.39 leaf hoppers/3 leaves), followed by NSKE @ 5% (2.85 leaf hoppers/3 leaves) and *dashparni ark* @ 10% (3.06 leaf hoppers/3 leaves). *Neemastra* @ 10% (3.77 leaf hoppers/3 leaves), *brahmastra* @ 10% (4.13 leaf hoppers/3 leaves), *agniastra*@ 10% (4.29 leaf hoppers/3 leaves)and *panchparni ark* @ 10% (5.26 leaf hoppers/3 leaves) followed in effectiveness. The control had the highest population (7.96 leaf hoppers/3 leaves). Overall, combining data from both years, NSKE @ 5% + cow urine @ 10% was the most effective (2.27 leaf hoppers/3 leaves), followed by NSKE @ 5% (2.62 leaf hoppers/3 leaves) and *dashparni ark* @ 10% (2.88 leaf hoppers/3 leaves). *Neemastra* @ 10% (3.57 leaf hoppers/3 leaves), *brahmastra* @ 10% (3.90 leaf hoppers/3 leaves), *agniastra* @ 10% (4.11 leaf hoppers/3 leaves)and *panchparni ark* @ 10% (4.98 leaf hoppers/3 leaves) were progressively less effective. The untreated control had the highest population (7.79 leaf hoppers/3 leaves).Earlier, Singh *et al.* (2021) at Bhubaneswar, Odisha found that the combined application of neem, chilli, garlic and cow urine extracts @ 10% w/v demonstrated the highest population reduction of leaf hopper (0.03 and 0.04/3 leaves) after two rounds of application in cowpea. Thus, the present findings were in close agreement with the report of earlier researchers.

Pod bug

The pooled data from 2022-23 and 2023-24 on the efficacy of various botanicals in managing pod bug populations, presented in Table 4, showed that the initial pod bug populations were uniformly distributed across plots.For 2022-23, NSKE @ 5% + cow urine @ 10% was the most effective treatment (1.81 pod bugs/plant), closely followed by NSKE @ 5% (2.05 pod bugs/plant). *Dashparni ark* @ 10% (2.51 pod bugs/plant), *neemastra* @ 10% (2.93 pod bugs/plant), *brahmastra* @ 10% (3.19 pod bugs/plant)and *agniastra* @ 10% (3.44 pod bugs/plant) were moderately effective. *Panchparni ark* @ 10% was the least effective (4.19 pod bugs/plant). The untreated control recorded the highest population (6.91 pod bugs/plant).For 2023-24, NSKE @ 5% + cow urine @ 10% remained the most effective (2.05 pod bugs/plant), followed by NSKE @ 5% (2.30 pod bugs/plant) and *dashparni ark*@ 10% (2.55 pod bugs/plant). *Neemastra* @ 10% (3.24 pod bugs/plant), *brahmastra* @ 10% (3.54 pod bugs/plant), *agniastra* @ 10% (3.75 pod bugs/plant)and *panchparni ark* @ 10% (4.55 pod bugs/plant) followed in effectiveness. The untreated control had the highest population (7.59 pod bugs/plant).Overall, combining data from both years, NSKE @ 5% + cow urine @ 10% was the most effective (1.93 pod bugs/plant), followed by NSKE @ 5% (2.17 pod bugs/plant) and *dashparni ark*@ 10% (2.53 pod bugs/plant). *Neemastra* @ 10% (3.08 pod bugs/plant), *brahmastra* @ 10% (3.37 pod bugs/plant), *agniastra* @ 10% (3.60 pod bugs/plant) and *panchparni ark* @ 10% (4.37 pod bugs/plant) were progressively less effective. The untreated control had the highest population (7.25 pod bugs/plant).In past, Chethan *et al*. (2021) at Raichur, Karnataka revealed that the NSKE 5 per cent maintained their efficacy by recording the lowest pod bug populations (1.13 pod bugs/plant). Taggar *et al*. (2022) at Punjab found that the seven days after spray, the incidence of the pod bug and seed damage were significantly lower in the treatments using homemade neem extract compared to the untreated control, showing a reduction of 41.99 per cent and 34.25 per cent over the control, respectively. Thus, the present findings were in close agreement with the report of earlier researchers.

Yield

The data on pigeonpea yield after applying various treatments, as presented in Table 5, showed variation in yield across different treatments. For the 2022-23 season, the highest yield was recorded with the treatment of NSKE @ 5% + cow urine @ 10% (1307 kg/ha), which was comparable to NSKE @ 5% (1287 kg/ha) and *dashparni ark* @ 10% (1270 kg/ha). Moderate yields were observed for *neemastra* @ 10% (1090 kg/ha), *brahmastra* @ 10% (1087 kg/ha), *agniastra*@ 10% (1027 kg/ha)and *panchparni ark* @ 10% (1020 kg/ha). The untreated control had the lowest yield (727 kg/ha). In the 2023-24 season, the highest yield was again recorded with NSKE @ 5% + cow urine @ 10% (1293 kg/ha), followed by NSKE @ 5% (1277 kg/ha) and *dashparni ark* @ 10% (1247 kg/ha). *Neemastra* @ 10% (1100 kg/ha), *brahmastra* @ 10% (1073 kg/ha), *agniastra* @ 10% (1060 kg/ha)and *panchparni ark* @ 10% (1027 kg/ha) showed moderate yields, while the untreated control had the lowest yield (750 kg/ha). The combined results for both years indicated that NSKE @ 5% + cow urine @ 10% had the highest yield (1300 kg/ha), followed by NSKE @ 5% (1282 kg/ha) and *dashparni ark* @ 10% (1258 kg/ha). Treatments with *neemastra* @ 10% (1095 kg/ha), *brahmastra* @ 10% (1080 kg/ha), *agniastra*@ 10% (1043 kg/ha)and *panchparni ark* @ 10% (1023 kg/ha) were statistically similar in yield. The untreated control had the lowest yield (738 kg/ha). Overall, NSKE @ 5% + cow urine @ 10%

consistently provided the highest pigeonpea yield across both years, followed closely by NSKE @ 5% and *dashparni ark* @ 10%, while the untreated control plots had the lowest yield.

Increase in yield over control (%)

The pooled results on increase in yield over control are presented in Table 5 exhibited that yield of pigeonpea increased over control was ranged from 38.60 to 76.07 per cent. Highest per cent increase in yield over control was observed in the treatment of NSKE @ 5 per cent + cow urine @ 10 per cent (76.07%). Among the rest of treatments, thedescending order of increase in yield over control was NSKE @ 5 per cent (73.59%) >*dashparni ark* @ 10 per cent (70.43%) >*neemastra*@ 10 per cent (48.31%) >*brahmastra* @ 10 per cent (46.28%) >*agniastra* @ 10 per cent (41.31%) >*panchparni ark* @ 10 per cent (38.60%).

Avoidable loss (%)

The pooled data on avoidable losses in yield of pigeonpea ranged from 1.41 to 43.21 per cent (Table 5).The avoidable losses in pigeonpea yield were minimum in the plots treated with NSKE @ 5 per cent (1.41%) followed by *dashparni ark* @ 10 per cent (3.21%). On the other hand, the highest avoidable loss in pigeonpea yield was recorded in untreated control (43.21%).The ascending order of avoidable loss of remaining treatments were *neemastra*@ 10 per cent (15.77%) <*brahmastra* @ 10 per cent (16.92%) <*agniastra* @ 10 per cent (19.74%) <*panchparni ark* @ 10 per cent (21.28%).

Economics

The protection cost benefit ratio of the different treatments was worked out from the pooled yield data of 2022-23 and 2023-24 presented in Table 6. Considering the economics of treatments, highest (1:16.12) protection cost benefit ratio obtained in plots treated with NSKE @ 5 per cent and it was followed by NSKE @ 5 per cent + cow urine @ 10 per cent (1:9.25). the lowest (1:4.03)PCBR was recorded in the treatments of *agniastra* @ 10 per cent. On the basis of PCBR the various treatments were arranged in the following descending order *i.e.*, *neemastra* @ 10 per cent (1:7.03) >*brahmastra* @ 10 per cent (1:6.90) >*dashparni ark* @ 10 per cent (1:6.70) >*panchparni ark* @ 10 per cent (1:5.59).

Conclusion

The experiment showed that NSKE @ 5% + cow urine @ 10% was the most effective treatment, consistently resulting in the lowest pest populations and highest pigeonpea yields. This treatment achieved the minimum populations of aphids (1.91/10 cm shoot), thrips (3.54/flower), leaf hoppers (2.27/3 leaves) and pod bugs (1.93/plant). In contrast, *panchparni ark* @ 10% recorded higher pest populations across these categories.In terms of yield, NSKE @ 5% + cow urine @ 10% produced the highest pigeonpea yield (1300 kg/ha), followed by NSKE @ 5% (1282 kg/ha) and *dashparni ark* @ 10% (1258 kg/ha). Other treatments, such as *neemastra* @ 10%, *brahmastra* @ 10%, *agniastra* @ 10%and *panchparni ark* @ 10%, were less effective but still superior to the untreated control (738 kg/ha).The greatest yield increase over control was seen with NSKE @ 5% + cow urine @ 10% (76.07%), followed by NSKE @ 5%

(73.59%) and *dashparni ark* @ 10% (70.43%). The highest cost-benefit ratio was also achieved with NSKE @ 5% (1:16.12), followed by NSKE @ 5% + cow urine @ 10% (1:9.25).

DECLARATION

We, the undersigned authors of field efficacy of botanicals against sucking pests in pigeonpea [*Cajanus cajan* (L.) Millsp.] under organic cultivation, declare that we have fully participated in the research work and writing of this manuscript. We confirm that the content presented in this paper is original and has not been published elsewhere. Furthermore, we affirm that there are no conflicts of interest, financial or otherwise, that could influence the objectivity or integrity of our work.

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Table 1: Bio-efficacy of botanicals against aphid in pigeonpea

Tr. No.	Treatments	Conc. (%)	Before Spray	Aphids/10 cm shoot		
				2022-23	2023-24	Pooled over year
T_1	NSKE	5	2.26^{a} (4.62)	1.60^{ef} (2.05)	1.71^{e} (2.42)	1.65^{f} (2.23)
T_2	NSKE + Cow urine	5 +10	2.26^{a} (4.62)	1.52^{f} (1.80)	1.59^{f} (2.03)	1.55^{g} (1.91)
T_3	*Agniastra*	10	2.36^{a} (5.07)	1.96^{c} (3.35)	2.11^{c} (3.94)	2.04^{c} (3.65)
T_4	*Neemastra*	10	2.30^{a} (4.77)	1.84^{d} (2.87)	1.94^{d} (3.25)	1.89^{d} (3.06)
T_5	*Brahmastra*	10	2.36^{a} (5.08)	1.90^{cd} (3.10)	2.06^{c} (3.74)	1.98^{c} (3.41)
T_6	*Panchparni ark*	10	2.40^{a} (5.25)	2.12^{b} (4.00)	2.25^{b} (4.55)	2.19^{b} (4.27)
T_7	*Dashparni ark*	10	2.32^{a} (4.86)	1.68^{e} (2.34)	1.79^{e} (2.72)	1.74^{e} (2.52)
T_8	Untreated control	-	2.31^{a} (4.85)	2.67^{a} (6.62)	2.89^{a} (7.84)	2.78^{a} (7.22)
S. Em. ±		T	0.079	0.030	0.031	0.022
		P	-	0.018	0.019	0.013
		S	-	0.018	0.019	0.013
		Y	0.044	-	-	0.011
		T×P	-	0.052	0.054	0.037
		T×S	-	0.052	0.054	0.037
		P×S	-	0.032	0.033	0.023
		Y×T	0.123	-	-	0.030
		Y×P	-	-	-	0.019
		Y×S	-	-	-	0.019
		T×P×S	-	0.090	0.093	0.065
		Y×S×T	-	-	-	0.053
		Y×S×P	-	-	-	0.032
		Y×P×T	-	-	-	0.053
		Y×S×P×T	-	-	-	0.091
C. D. at 5%		T	NS	0.083	0.087	0.060
		Y×T	NS	-	-	NS
C. V. %			9.19	8.12	7.92	8.02

Figures in parentheses are retransformed values of $\sqrt{X + 0.5}$ transformation

Treatment means with the letter(s) in common are not significantby DNMRT at 5% level of significance

Table 2: Bio-efficacy of botanicals against thrips in pigeonpea

Tr. No.	Treatments	Conc. (%)	Before Spray	Thrips/flower 2022-23	Thrips/flower 2023-24	Thrips/flower Pooled over year
T_1	NSKE	5	2.94^{a} (8.16)	2.01^{ef} (3.54)	2.17^{ef} (4.21)	2.09^{f} (3.87)
T_2	NSKE + Cow urine	5 +10	2.93^{a} (8.08)	1.94^{f} (3.24)	2.09^{f} (3.85)	2.01^{g} (3.54)
T_3	*Agniastra*	10	3.01^{a} (8.58)	2.45^{c} (5.51)	2.58^{c} (6.16)	2.52^{c} (5.83)
T_4	*Neemastra*	10	2.99^{a} (8.45)	2.32^{d} (4.90)	2.46^{d} (5.56)	2.39^{d} (5.22)
T_5	*Brahmastra*	10	3.00^{a} (8.51)	2.39^{cd} (5.22)	2.52^{cd} (5.87)	2.46^{cd} (5.54)
T_6	*Panchparni ark*	10	3.07^{a} (8.90)	2.68^{b} (6.66)	2.81^{b} (7.38)	2.74^{b} (7.02)
T_7	*Dashparni ark*	10	3.01^{a} (8.54)	2.07^{e} (3.78)	2.26^{e} (4.61)	2.16^{e} (4.18)
T_8	Untreated control	-	3.04^{a} (8.71)	3.33^{a} (10.62)	3.44^{a} (11.33)	3.39^{a} (10.97)
S. Em. ±		T	0.083	0.034	0.036	0.025
		P	-	0.021	0.022	0.015
		S	-	0.021	0.022	0.263
		Y	0.046	-	-	0.012
		T×P	-	0.059	0.063	0.043
		T×S	-	0.059	0.063	0.043
		P×S	-	0.036	0.038	0.026
		Y×T	0.130	-	-	0.035
		Y×P	-	-	-	0.022
		Y×S	-	-	-	0.022
		T×P×S	-	0.103	0.108	0.075
		Y×S×T	-	-	-	0.061
		Y×S×P	-	-	-	0.037
		Y×P×T	-	-	-	0.061
		Y×S×P×T	-	-	-	0.105
C. D. at 5%		T	NS	0.096	0.101	0.069
		Y×T	NS	-	-	NS
C. V. %			7.50	7.41	7.38	7.40

Figures in parentheses are retransformed values of $\sqrt{X + 0.5}$ transformation

Treatment means with the letter(s) in common are not significantby DNMRT at 5% level of significance

Table 3: Bio-efficacy of botanicals against leaf hopper in pigeonpea

Tr. No.	Treatments	Conc. (%)	Before Spray	Leaf hopper/3 leaves		
				2022-23	2023-24	Pooled over year
T_1	NSKE	5	2.43^{a} (5.39)	1.70^{f} (2.39)	1.83^{e} (2.85)	1.77^{f} (2.62)
T_2	NSKE + Cow urine	5 +10	2.43^{a} (5.39)	1.63^{f} (2.15)	1.70^{f} (2.39)	1.66^{g} (2.27)
T_3	*Agniastra*	10	2.49^{a} (5.69)	2.11^{c} (3.93)	2.19^{c} (4.29)	2.15^{c} (4.11)
T_4	*Neemastra*	10	2.48^{a} (5.66)	1.97^{d} (3.37)	2.07^{d} (3.77)	2.02^{d} (3.57)
T_5	*Brahmastra*	10	2.51^{a} (5.79)	2.04^{cd} (3.67)	2.15^{cd} (4.13)	2.10^{c} (3.90)
T_6	*Panchparni ark*	10	2.52^{a} (5.87)	2.28^{b} (4.71)	2.40^{b} (5.26)	2.34^{b} (4.98)
T_7	*Dashparni ark*	10	2.43^{a} (5.39)	1.79^{e} (2.70)	1.89^{e} (3.06)	1.84^{e} (2.88)
T_8	Untreated control	-	2.51^{a} (5.79)	2.85^{a} (7.63)	2.91^{a} (7.96)	2.88^{a} (7.79)
S. Em. ±		T	0.068	0.029	0.033	0.022
		P	-	0.018	0.020	0.014
		S	-	0.018	0.020	0.014
		Y	0.038	-	-	0.011
		T×P	-	0.051	0.057	0.038
		T×S	-	0.051	0.057	0.038
		P×S	-	0.031	0.035	0.023
		Y×T	0.107	-	-	0.031
		Y×P	-	-	-	0.019
		Y×S	-	-	-	0.019
		T×P×S	-	0.088	0.099	0.066
		Y×S×T	-	-	-	0.054
		Y×S×P	-	-	-	0.033
		Y×P×T	-	-	-	0.054
		Y×S×P×T	-	-	-	0.094
C. D. at 5%		T	NS	0.082	0.092	0.062
		Y×T	NS	-	-	NS
C. V. %			7.50	7.47	8.02	7.77

Figures in parentheses are retransformed values of $\sqrt{X + 0.5}$ transformation
Treatment means with the letter(s) in common are not significantby DNMRT at 5% level of significance

Table 4: Bio-efficacy of botanicals against pod bug in pigeonpea

Tr. No.	Treatments	Conc. (%)	Before Spray	Pod bug/plant		
				2022-23	2023-24	Pooled over year
T_1	NSKE	5	2.26^{a} (4.61)	1.60^{f} (2.05)	1.67^{ef} (2.30)	1.63^{f} (2.17)
T_2	NSKE + Cow urine	5 +10	2.25^{a} (4.56)	1.52^{f} (1.81)	1.60^{f} (2.05)	1.56^{g} (1.93)
T_3	*Agniastra*	10	2.37^{a} (5.13)	1.99^{c} (3.44)	2.06^{c} (3.75)	2.02^{c} (3.60)
T_4	*Neemastra*	10	2.36^{a} (5.07)	1.85^{d} (2.93)	1.93^{d} (3.24)	1.89^{d} (3.08)
T_5	*Brahmastra*	10	2.38^{a} (5.14)	1.92^{cd} (3.19)	2.01^{cd} (3.54)	1.97^{c} (3.37)
T_6	*Panchparni ark*	10	2.40^{a} (5.25)	2.17^{b} (4.19)	2.25^{b} (4.55)	2.21^{b} (4.37)
T_7	*Dashparni ark*	10	2.34^{a} (4.98)	1.74^{e} (2.51)	1.75^{e} (2.55)	1.74^{e} (2.53)
T_8	Untreated control	-	2.34^{a} (4.98)	2.72^{a} (6.91)	2.85^{a} (7.59)	2.78^{a} (7.25)
S. Em. ±		T	0.080	0.031	0.031	0.022
		P	-	0.019	0.019	0.013
		S	-	0.019	0.019	0.013
		Y	0.044	-	-	0.011
		T×P	-	0.053	0.055	0.038
		T×S	-	0.053	0.055	0.038
		P×S	-	0.033	0.033	0.023
		Y×T	0.125	-	-	0.031
		Y×P	-	-	-	0.019
		Y×S	-	-	-	0.019
		T×P×S	-	0.092	0.094	0.066
		Y×S×T	-	-	-	0.054
		Y×S×P	-	-	-	0.033
		Y×P×T	-	-	-	0.054
		Y×S×P×T	-	-	-	0.093
C. D. at 5%		T	NS	0.086	0.088	0.061
		Y×T	NS	-	-	NS
C. V. %			9.23	8.24	8.13	8.18

Figures in parentheses are retransformed values of $\sqrt{X + 0.5}$ transformation

Treatment means with the letter(s) in common are not significantby DNMRT at 5% level of significance

Table 5: Impact of botanicals on seed yield, avoidable loss and increase in yield over control of pigeonpea during 2022-23 and 2023-24

Tr. No.	Treatments	Conc. (%)	Seed yield (kg/ha)			Increase in yield over control (%)			Avoidable loss (%)		
			2022-23	2023-24	Pooled over year	2022-23	2023-24	Pooled over year	2022-23	2023-24	Pooled over year
T_1	NSKE	5	1287[a]	1277[a]	1282[a]	77.06	70.22	73.59	1.53	1.29	1.41
T_2	NSKE + Cow urine	5 +10	1307[a]	1293[a]	1300[a]	79.82	72.44	76.07	-	-	-
T_3	*Agniastra*	10	1027[b]	1060[b]	1043[b]	41.28	41.33	41.31	21.43	18.04	19.74
T_4	*Neemastra*	10	1090[b]	1100[b]	1095[b]	50.00	46.67	48.31	16.58	14.95	15.77
T_5	*Brahmastra*	10	1087[b]	1073[b]	1080[b]	49.54	43.11	46.28	16.84	17.01	16.92
T_6	*Panchparni ark*	10	1020[b]	1027[b]	1023[b]	40.37	36.89	38.60	21.94	20.62	21.28
T_7	*Dashparni ark*	10	1270[a]	1247[a]	1258[a]	74.77	66.22	70.43	2.81	3.61	3.21
T_8	Untreated control	-	727[c]	750[c]	738[c]	-	-	-	44.39	42.01	43.21
S. Em. ±		T	57.43	47.00	33.485	-	-	-	-	-	-
		Y	-	-	18.553	-	-	-	-	-	-
		Y×T	-	-	52.474	-	-	-	-	-	-
C. D. at 5%		T	174.20	142.56	96.13	-	-	-	-	-	-
		Y×T	-	-	NS	-	-	-	-	-	-
C. V. %			9.03	7.38	8.24	-	-	-	-	-	-

Treatment means with the letter(s) in common are not significant by DNMRT at 5% level of significance

Table 6: Economics of various botanicals evaluated against sucking pests on pigeonpea

Tr. No.	Treatments	Conc. (%)	Qty. of material required for 3 sprays (L or kg/ha)	Cost of material (₹ /ha)	Labour cost (₹)	Total cost of treatment	Yield (kg/ha)	Gross realization (₹ /ha)	Net realization over control (₹ /ha)	Net gain (₹ /ha)	PCBR
T_1	NSKE	5	75	1500	2625	4125	1282	166617	70634	66509	1:16.12
T_2	NSKE + Cow urine	5 + 10	75 +150	4500	2625	7125	1300	169000	73017	65892	1:9.25
T_3	*Agniastra*	10	150	5250	2625	7875	1043	135633	39650	31775	1:4.03
T_4	*Neemastra*	10	150	3150	2625	5775	1095	142350	46367	40592	1:7.03
T_5	*Brahmastra*	10	150	3000	2625	5625	1080	140400	44417	38792	1:6.90
T_6	*Panchparni ark*	10	150	3000	2625	5625	1023	133033	37050	31425	1:5.59
T_7	*Dashparni ark*	10	150	6150	2625	8775	1258	163583	67600	58825	1:6.70
T_8	Untreated control	-	-	-	-	-	738	95983	-	-	-

NSKE : ₹ 20/L
Cow urine : ₹ 20/L
Agniastra : ₹ 35/L
Neemastra: ₹ 21/L

Brahmastra:₹ 20/L
Panchparni ark : ₹ 20/L
Dashparni ark : ₹ 41/L
Labours required : 2 labour /ha for one spray + 1 for extract preparation

Labour cost : ₹ 375/day
Water requirement : 500 L/ha
Pigeonpea : ₹ 130/kg