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Mohan I Naik

Professor and Scheme Head, All India Network Project (AINP) on Vertebrate Pest Management, GKVK, University of Agricultural Sciences (UAS), Bangalore, Karnataka, India

Basavadarshan AV

Senior Research Fellow, AINP on Vertebrate Pest Management, GKVK, UAS Bangalore, Karnataka, India

Incidence and efficacy of crop protection measures against wild boar (*Sus scrofa* L.) in groundnut (*Arachis hypogaea* L.)

Mohan I Naik and Basavadarshan AV

Abstract

Wild boar (*Sus scrofa* L.) has emerged as a serious vertebrate pest in India. Wild boar damages the sown seeds, developing pods and mature nuts of the groundnut (*Arachis hypogaea* L.) which is grown throughout the country and is an important food and cash crop of India. Though a lot of management measures are available to combat wild boar they are cumbersome and not economical. Hence, eco-friendly, cost-effective methods such as artificial barriers, border crops, and traditional methods were evaluated during 2017, 2018, and 2019 to know their efficacy in groundnut crop. The results revealed that the percent area crop damage ranged from 8.62 to 30.52 percent and it was peak during the harvesting stage (30.52%) followed by pod formation (26.12%) and sowing stages (20.93%). Among the different management measures the yield increased by 42.33, 18.04 and 14.86 percent over the control with the yield of 1022.27, 847.93 and 825.00 kg per ha when the crops were protected with nylon net, safflower as a border crop and used sarees spread around the crop border respectively, and served as the best treatments in controlling the wild boar menace whereas, in control the yield was 719.60 kg per ha.

Keywords: Wild boar, groundnut, nylon net, used sarees, border crop

1. Introduction

India is one of the largest producers of oilseeds in the world and contributes to the country's agricultural economy, among the oilseed's groundnut is called as the 'King' of oilseeds. It is one of the most important foods and cash crops of India [8, 11]. The production of groundnut is ruined by a series of diseases, insect and vertebrate pests, among the vertebrate pests' rodents, wild boar, and birds that cause vulnerable damage [3]. The wild boar is one of the most widely distributed mammals native to North Africa, Europe, and Asia [13]. Due to a reduction in preferred habitats and hunting the population of wild boar is getting fragmented and these isolated populations have become locally abundant, and have forced them to depend upon crops [14]. Wild boars are prolific breeders and breed throughout the year. The reproduction period in wild boar is seasonal and mostly correlated with the availability of food and other climatic factors [5]. Its activity is peculiarly at dawn and dusk than in the actual day period [4, 22]. They also have a unique feature of identifying cropped areas through their smell sensory mechanism [17]. The head of the wild boar is elongated with truncated mobile snout which ends in a flattened disk containing the nostrils. The head is very strong and used in fighting, digging, and damaging vegetation [12]. Wild boar has been regarded as a serious pest of agriculture crops and more pronounced in crop fields accounting for 70 percent damage which are near adjoining forest areas [10]. Crop depredation by wild boars is enormous and includes agricultural crops like millets (Ragi, groundnut, maize, sorghum, bajra), rice, wheat, pulses, sugarcane, vegetable crops (tomato, brinjal, chilies, cucurbits and tuber crops). The initial damage to crops was by eating away the sprouted seeds and further damage is seen at crop maturity, mature crops were highly susceptible to damage [1]. Under IUCN status wild boar is listed in the least concern category and has been included in the Wildlife protection act of India (1972) Schedule III [20, 22]. Many of the physical, chemical, traditional, biological, and sonic methods are innovated [19] for the management of wild boar in which they are highly cumbersome and unavailable to the economically backward farming community. The plant contains secondary metabolites such as alkaloids, phenols, essential oils, terpenoids, and tannins, etc. which produce strong undesirable odor have a greater impact on vertebrates by deterring them [7, 15].

Corresponding Author:**Mohan I Naik**

Professor and Scheme Head, All India Network Project (AINP) on Vertebrate Pest Management, GKVK, University of Agricultural Sciences (UAS), Bangalore, Karnataka, India

Hence the present study was conducted to know the status of wild boar menace in groundnut crop and innovate, to know the effectiveness of cost-effective methodologies like border crops and artificial barriers in managing the wild boar menace.

2. Material and methods:

2.1 Study area: The study was conducted in the farmer's agricultural fields of Arjunahalli (N12°23'57.141"; E77° 31' 5.84") and surrounding villages which were in the vicinity of the forest, Kanakapura Taluk, and Ramanagara District of Karnataka State (Plate 1).

2.2 Damage assessment: Damage to the crop by wild boar was assessed for three years (2017, 2018, 2019) of five hectares in the study area by recording the percent area damaged during the *Kharif* season at a weekly interval from sowing to harvesting stages of the crop. The area of crop damage is expressed as percent area crop damage [21].

2.3 Management of wild boar: The field evaluation was conducted at groundnut fields of the above-mentioned study area for three years (2017, 2018, 2019) *Kharif* seasons, with the following treatments.

T1- Sowing of four rows of safflower (*Carthamus tinctorius* L.) as border crop in close spacing around the groundnut field.

T2- Sowing of four rows of field bean (*Vicia faba* L.) as border crop in close spacing around the groundnut field.

T3- The nylon net was tied around the border of the groundnut field at 3 feet height and trailed on the ground, up to 2 feet distance, and fixed firmly with wooden pegs.

T4- Arrangement of used colored sarees around the border of the groundnut field as a barrier with the help of long wooden pegs.

T5- Arrangement of coconut ropes soaked in kerosene in three rows around the border of the groundnut field by keeping the first row at a height of 1/2 feet above ground level and subsequent rows at 1 foot above the first row with the help of wooden pegs.

T6- GI binding wire was tied around the border of the groundnut field in two rows where the first row at a height of ½ feet above ground level and the second row was placed at 1 foot above the first row.

T7- Unprotected field (Control).

The experiments were laid by randomized block design with four replications, each block measuring about one acre and the efficacy of treatments was assessed by recording percent area crop damaged at weekly interval and total yield obtained after the harvesting. The above-recorded data was subjected for statistical analysis, with the significance of differences ($P \leq 0.05$) using a one-way analysis of variance (ANOVA) followed by Duncan multiple range tests. The data in percentages were transformed using arc sign transformation [17, 19, 21].

3. Result

3.1. Crop damage

The study on the incidence of wild boar in groundnut in

various stages revealed that the maximum area damage was recorded during the harvesting stage followed by pod formation and sowing stages with percent area crop damage of 30.52, 26.12 and 20.93 respectively, and the damage was least during the growth stages with percent area crop damage of 8.62 percent (Table 1). During the pod formation stage and harvesting stage, the wild boar rooted out groundnuts from plants by scooping and the damage was followed from plant to plant with exposed roots and damaged empty groundnut shells. Whereas, after the sowing of seeds the damage was noted by consuming the sown and sprouted seeds by rooting out the soil and damaging the germinated seeds by wallowing.

3.2 Management

The year-wise yield and damage data indicated that all the treatments were statistically significant ($P \leq 0.05$) and were effective in reducing the wild boar menace in groundnut compared to control plots. In 2017 among the various treatments the fields protected with nylon net was more effective followed by used color sarees as a physical barrier and safflower as border crop was more effective in controlling the wild boar entry in the groundnut fields than the other treatments (Table 2) with the highest yield of 1041.60 kg per ha and 1.30 percent area damage was recorded in plot protected with nylon net (T3) followed by field protected with safflower as a border crop (T1) (852.80 kg/ha, 6.96%) and fields protected with used color sarees as a barrier (T4) (833.00 kg/ha, 8.60%) compared to 23.42 percent area crop damage and a yield of 720.40 kg per ha in control plot (T7). The next best treatment was fencing with GI wire (T6) which recorded crop damage of 11.42 percent and yield of 785.60 kg per ha followed by T5 (placement of jute ropes soaked in kerosene) and T2 (field bean as border crop) however, there were no significant differences in yield between them. In plot fenced with jute ropes soaked in kerosene the crop area damage was 13.88 percent and yielded 765.80 kg per ha and in plots protected with field bean as the boarder crop the crop damage was 15.60 percent and yield were 761.0 kg per ha against 23.42 percent damage in the unprotected field. The control field recorded the lowest yield of 720.40kg per ha due to frequent crop-raiding by wild boar. The percent increase in yield was highest in plots protected with nylon net (44.59%) followed by safflower as a border crop (18.38%), used color sarees as a barrier (15.63%), fencing with GI wire (9.05%), placement of jute ropes soaked in kerosene (6.30%) and plots protected with field bean as the boarder crop (5.64%) compared to unprotected plot (Table 2).

During 2018 all the treatments except the placement of jute ropes soaked in kerosene and plots protected with field bean as the boarder crop were significantly effective in reducing wild boar menace compared to control plots (Table 2). The area damaged by wild boar varied from 1.56 to 26.18 percent and the highest crop area damage was recorded in the unprotected plot. The plot protected with nylon net followed by safflower as a border crop and used color sarees as a barrier were the best treatments and reduced the crop raids from wild boar in groundnut and recorded a yield of 1000.40, 840.60 and 820.60 kg per ha respectively. It was followed by fencing with GI wire (787.80 kg/ha), placement of jute ropes soaked in kerosene (762.00 kg/ha), and plots protected with field bean as the boarder crop (749.00 kg/ha) as against 718.80 kg/ha in control plots. The percent increase in yield was highest in plots protected with nylon net (39.18%) followed by safflower as a border crop (16.86%), used color

sarees as a barrier (14.08%), fencing with GI wire (9.60%), placement of jute ropes soaked in kerosene (6.40%) and plots protected with filed bean as the boarder crop (4.20%) as compared to control plot (Table 2).

Similar trends in yield and area crop damage were also followed in 2019. All the treatments except the placement of jute ropes soaked in kerosene and plots protected with field bean as the boarder crop were significantly effective over control by reducing the wild boar menace and increasing the yield of the crop (Table 2). The field protected with nylon net followed by safflower as a border crop and used color sarees as a barrier reduced the wild boar attack and recorded the highest yield of 1024.40 kg per ha, 851.00kg per ha and 822.00kg per ha respectively, followed by fencing with GI wire (783.00kg/ha), placement of jute ropes soaked in kerosene (768.60kg/ha) and plots protected with filed bean as the boarder crop (741.80kg/ha). The percent increase in yield was highest in plots protected with nylon net (43.23%) followed by safflower as a border crop (18.94%), used color sarees as a barrier (14.88%), fencing with GI wire (9.43%), placement of jute ropes soaked in kerosene (7.42%) and plots protected with filed bean as the boarder crop (3.68%) as compared to control plots. The highest crop damage was recorded in control plots (20.18%) followed by plots protected with filed bean as the boarder crop (15.46%), placement of jute ropes soaked in kerosene (13.94%), and fencing with GI wire (13.30%). The least damage was recorded in a field protected with nylon net (1.70%) followed by safflower as a border crop (7.08%) and used color sarees as a barrier (8.02%).

However, the results of the pooled data (Table 3) indicated that T3 (field protected with nylon net) (1022.27 kg/ha; 1.52% crop area damage) followed by T2 (safflower as a border crop) (847.93 kg/ha; 7.08% crop area damage), and T4 (used color sarees as a barrier) (825.0 kg/ha; 8.23% crop area damage) were found effective in mitigating the wild boar incidence in groundnut with an increase in yield of 42.33, 18.04 and 14.86 percent respectively.

4. Discussion

Wild boars prefer nuts, berries, bulbs, and roots for their diet, the strong smell of the crops attract them into the crop fields [20, 22] in the present study the results of damage assessment in groundnut by wild boar were on par with the study conducted by Brooks *et al.*, [3] who illustrated that wild boar roots out groundnuts from under the plants, and prefer the groundnuts

when they are soft and sweet before the shells harden. which indicates the management measures have to be taken up from the sowing stage and has to last throughout the crop cycle.

In the management of wild boar in groundnut as per the available information on management measures as described by Rao *et al.*; Lakshmi *et al.*, [19, 9] biological barriers such as border crops and physical barriers such as GI wire fence, chemical barriers such as the arrangement of coconut ropes or niwar soaked in kerosene and traditional methods such as fixing the used colored sarees were found to be effective in reducing the wild boar menace and cost-effective to the farming community.

Rao *et al.*, Lakshmi *et al.*, [9, 17] reported that border crops such as castor, safflower around the crop reduced the crop raids and increased the yield by creating the inconvenience due to thorny nature (safflower) and strong smell emitted by them by the presence of secondary metabolites in them as described by Hansen *et al.*, [7] which would mask the odor of the main crop.

The efficacy of physical barriers such as nylon net (T3) and GI wire fence (T6) was well documented by Sreeja and Chellappan; Rao *et al.*, [18, 21] in Chinese potato and other crops. The GI wire fence scares by confusing with electric fences and nylon net gives the complete protection where the boars get entangled in net and calls by the net railed boars avoided the raids by the other boars which were found effective in reducing the wild boar menace and increasing the yield in all the years among which the effectiveness of nylon net was on high when compared with rest of the treatments but GI wire fence showed the fewer effectiveness in controlling the boars in which the boars regularly attempted to jump over the fence and got habituated. However, as per the study conducted by Guinness and Taylor [6] reported that physical barriers such as fences, can protect crop damage by animals but their widespread use is limited by the costs, maintenance, and efficacy.

Concerning chemical and traditional methods arrangement of coconut ropes soaked in kerosene (T6) avoided wild boar by the dominant smell of kerosene and used sarees around the crop (T4) deterred by illuminating the false presence of humans and was well illustrated by Rao *et al.*, [18]. The arrangement of sarees around the crop was found to be effective in reducing the crop raids and enhanced the yield but in the case of coconut ropes soaked in kerosene around the crop was less effective where there was the habituation of the odor and it needed repetitive application.

Table 1: Incidence of wild boar in groundnut at different stages of the crop

Stage	Area damaged (%)			Mean \pm SD
	2016	2017	2018	
Sowing	22.08 \pm 03.58	19.49 \pm 04.03	21.23 \pm 01.89	20.93 \pm 1.32
Growth	09.37 \pm 01.56	08.95 \pm 06.21	07.54 \pm 05.46	8.62 \pm 0.96
Pod formation	26.15 \pm 01.37	28.56 \pm 01.87	23.64 \pm 03.23	26.12 \pm 2.46
Harvesting	29.48 \pm 04.20	34.74 \pm 04.08	27.34 \pm 03.58	30.52 \pm 3.81

(Standard mean \pm standard deviation);

Table 2: Efficacy of different crop protection measures against wild boar in groundnut during 2017-2019 Kharif.

Treatment	2017			2018			2019		
	Area damaged (%)	Mean yield (kg/ha)	Yield increase over control (%)	Area damaged (%)	Mean yield (kg/ha)	Yield increase over control (%)	Area damaged (%)	Mean yield (kg/ha)	Yield increase over control (%)
T1	06.96 (15.17±2.24) ^d	852.80±22.90 ^b	18.38	7.20 (15.55±0.69) ^d	840.60±26.25 ^b	16.86	7.08 (15.42±0.57) ^c	851.00±41.45 ^b	18.94
T2	15.88 (23.44±0.1.24) ^b	761.00±18.51 ^{de}	05.64	14.98 (22.72±0.1.87) ^b	749.00±14.83 ^{de}	04.20	15.46 (23.13±0.1.22) ^b	741.80±22.39 ^{de}	03.68
T3	01.30 (06.49±0.94) ^e	1041.60±85.13 ^a	44.59	01.56 (7.10±0.1.16) ^e	1000.40±70.59 ^a	39.18	01.70 (7.28±0.1.96) ^d	1024.40±23.91 ^a	43.23
T4	08.60 (17.01±0.1.30) ^d	833.00±31.61 ^{bc}	15.63	08.08 (16.49±0.0.88) ^d	820.60±26.66 ^{bc}	14.08	08.02 (16.41±0.1.22) ^c	822.00±24.45 ^b	14.88
T5	13.88 (21.86±0.88) ^b	765.80±03.56 ^{de}	06.30	14.54 (22.37±0.1.76) ^b	762.00±30.25 ^{de}	06.04	13.94 (21.89±1.47) ^b	768.60±11.63 ^{de}	09.43
T6	11.42 (19.72±0.1.19) ^c	785.60±20.79 ^{cd}	09.05	12.26 (20.47±0.1.15) ^c	787.80±25.53 ^{cd}	09.60	13.30 (21.36±0.1.19) ^b	783.00±13.73 ^c	07.42
T7	23.42 (28.87±0.2.69) ^a	720.40±13.41 ^e	-	26.18 (30.76±0.0.92) ^a	718.80±20.13 ^e	-	20.18 (26.60±0.2.97) ^a	719.60±11.08 ^e	-
SEM ±	0.70	20.52	-	00.57	15.39	-	0.64	10.9	-
F test (P≤0.05)	*	*	-	*	*	-	*	*	-
CV %	8.58	05.57	-	6.72	04.24	-	07.61	03.00	-
CD (0.05)	2.12	59.90	-	1.70	44.93	-	01.87	32.01	-

(Standard mean ±standard deviation); F test-*significant *significant at P≤0.05; 1- Figure in parenthesis indicates the ARCSIN⁰ value.

Table 3: Efficacy of different crop protection measures against wild boar in groundnut pooled data (2017, 2018, 2019) Kharif

Treatment	Area damaged (%)	Mean yield (kg/ha)	Yield increase over control (%)
T1	7.08 (15.38±0.19) ^d	847.93±6.93 ^b	18.04
T2	15.44 (23.10±0.36) ^b	755.00±11.45 ^f	4.51
T3	1.52 (6.96±0.41) ^e	1022.27±20.72 ^a	42.33
T4	8.23 (16.64±0.33) ^d	825.00±7.00 ^c	14.86
T5	14.12 (22.04±0.29) ^{bc}	761.13±10.60 ^e	7.26
T6	12.33 (20.52±0.82) ^c	785.47±2.40 ^d	8.69
T7	23.26 (28.74±2.08) ^a	719.60±0.80 ^g	-
SEM ±	0.52	4.6	-
F test (P≤0.05)	*	*	-
CV %	4.82	0.98	-
CD (0.05)	1.63	14.35	-

(Standard mean ±standard deviation); F test-*significant at P≤0.05; 1- Figure in parenthesis indicates the ARCSIN⁰ value.



Plate 1: Study area Arjunahalli, Kanakapura taluk, Ramanagara district @Google maps.

5. Conclusion

The results of the present study indicate that the management aspects have to be taken up throughout the crop cycle where groundnut crop was so susceptible to crop raids by wild boar at all the stages. Among the treatment’s plot protected with

the nylon net was highly effective in reducing the wild boar followed by safflower as a border crop and arrangement of colored sarees around the crop was promising than the rest of the treatments to enhance the yield of the groundnut crop and all the treatments were cost-effective.

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