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Role of intercrops in wheat for the management of termites

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Abstract
Field studies were taken up to evaluate the efficacy of various intercrops in wheat for the management of *Odontotermes obesus* Rambur during November 2013 to March 2014 and November 2014 to March 2015 at Research Farm, Institute of Pesticide Formulation Technology, Gurgaon, Haryana. The termite population was recorded at fifteen days interval and at 15 DAS (Days after Sowing) the termite population ranged from 35.33 – 66.67 and 31.33- 61.67 in intercropped plots during first season and second season, respectively. On 135 DAS, the population density of termites were the least in safflower, mustard, gram and pea intercropped plots which recorded 41.33, 41.67, 42.00 and 43.00 numbers, respectively and were also on par with each other. The trend continued to be the same during second season and mustard intercropped plots recorded 28.33 numbers at 105 DAS, which was on par with the plots intercropped with safflower (28.33), gram (29.33) and pea (30.67). The order of intercrops influencing the reduction in termite population for both the season was safflower > mustard > pea > gram > fenugreek > coriander > ajowain > linseed.

Keywords: Intercrops, wheat, termites, population, reduction

1. Introduction
Wheat (*Triticum aestivum* L.) falling under Poaceae is one of the major cereal crops with annual global production of over 600 million tonnes from about 200 million hectares [1]. Wheat crop is attacked by 24 species of insect pests [2] and of these, termite ranks first as a pest of wheat not only in India, but in South Asia too [3]. Among the 16 termite species damaging wheat crop in India, *Odontotermes obesus* Rambur and *Microtermes obesi* Holmgren were found dominant [4] resulting in yield losses ranging from 43 to 80 per cent in wheat [4, 5].

There is a rising public concern about pesticides' non-target effects on humans and other organisms, and many pests have evolved resistance to some of the most commonly used pesticides. Together, these factors have led to increasing concern in non-chemical, ecologically sound ways to manage pests [6]. One pest management alternative is the diversification of agricultural fields by establishing "polycultures" that include one or more different crop varieties or species within the same field, to more closely match the higher species richness typical of natural systems [7, 8]. After all, destructive, explosive herbivore outbreaks, typical of agricultural monocultures, are rarely seen in highly diverse unmanaged communities. Efficacy of intercrops in reducing pest numbers has been demonstrated; fewer diamondback moths were found on Brussels sprouts, when intercropped with malting barley, sage or thyme [9]. Similarly, lower numbers of striped flea beetles were observed, when Chinese cabbage, *Brassica chinensis* L. was intercropped with green onions *Allium fistulosum* L.,[10] while significantly lower numbers of the cabbage aphid, *Brevicoryne brassicae* L. was recorded when spring onion *Allium cepa* L. was intercropped with collard, *Brassica oleracea* var. *acephala* De candolle [11].

In this context, the current study was taken up to find the efficacy of intercrops against *O. obesus* in wheat,

2. Materials and Methods
Field trials were conducted to assess the efficacy of intercropping in wheat for termite management during November 2013 to March 2014 and November 2014 to March 2015 at IPFT, Gurgaon, Haryana. The experiment was laid out in Randomized Block Design (RBD) with three replications and the plot size was 5×5 m^2. The treatments laid are depicted in Table 1. Observations on termite count were taken every fortnight once. Quadrats of 1m^2 were

randomly thrown five times in each plot and termite count was taken by digging the soil to 15 cm depth in the quadrat placed area using a shovel and soil was spread on a black cloth, observed carefully for termites (worker and soldier caste) present and the count was recorded.

Table 1: The details of the different intercrops used in the current experiment

S. No	Treatments	Ratio
1.	Wheat + Mustard (*Brassica nigra* L.)	3:1
2.	Wheat + Ajowain (*Trachyspermum ammi* L.)	3:1
3.	Wheat + Pea (*Pisum sativum* L.)	3:1
4.	Wheat + Linseed (*Linum usitatissimum* L.)	3:1
5.	Wheat + Gram (*Cicer arietinum* L.)	3:1
6.	Wheat + Safflower (*Carthamus tinctorius* L.)	3:1
7.	Wheat + Coriander (*Coriandrum sativum* L.)	3:1
8.	Wheat + Fenugreek (*Trigonella foenum-graecum* L.)	3:1
9.	Wheat alone	----

2.1 Statistical Analysis
The termite counts were taken every fortnight once and the density of termite population in each plot were assessed using AGRES analysis.

3. Results and Discussion
3.1 First season (November 2013 to March 2014)
Population of termites were noted every fifteen days after sowing (DAS) and the population density of *O. obesus* was the least in safflower intercropped plots which recorded 43.00 numbers 30 DAS, followed by mustard intercropped plots (46.33) and fenugreek intercropped plots (48.00). The highest termite population was recorded in ajowain intercropped plots (62.00) and linseed intercropped plots (63.33) which were on par with the population density recorded in control (60.00) (Table 2). The termite population gradually went down, once the winter season started and 60 DAS, *i.e.* during the month of January 2014, the population recorded in safflower plots was 10.67 numbers closely followed by mustard (12.00) and pea (16.00). The population drastically reduced even in wheat alone plots, where the population density went down from 34.00 to 23.00 numbers on 60 DAS. The trend continued to be the same the end of February 2014, where the population was less. The termite population was seen on an increasing note, on the onset of summer *i.e.* from March to April 2014. The population density of termites at 105 DAS was the least in safflower intercropped plots which recorded 22.67 numbers that was on par with mustard intercropped plots (23.00) and gram intercropped plots (23.33). Wheat intercropped with pea recorded 23.67 numbers, whereas other plots intercropped with linseed, ajowain, coriander and fenugreek recorded 31.67, 40.00, 27.33 and 27.00 respectively. On 135 DAS, the population density of termites were the least in safflower, mustard, gram and pea intercropped plots which recorded 41.33, 41.67, 42.00 and 43.00 numbers, respectively and were also on par with each other. The order of effective intercrop for wheat ecosystem for the management of *O. obesus* in terms of number of termites per plot 135 DAS is
safflower > mustard > gram > pea > fenugreek > coriander > ajowain > linseed (Table. 2). The current investigation falls in line with previous studies where it was observed that cassava/yam as an intercrop in legumes suppressed termite population, as low incidence of termites were observed at 8 and 12 weeks after planting respectively [12]. The results of the current investigation were in closer proximity with the previous findings where soybean intercropped with maize reduced termite damage and increase yield [13].

3.2 Second season (November 2014 to March 2015)
During the second season at 15 DAS the highest number of termite population was recorded in linseed intercropped plots which recorded 61.67 numbers followed by ajowain (57.67) and coriander (50.67). Thirty days after sowing, the least termite population was recorded in safflower intercropped plots (44.33) followed by plots intercropped with gram (51.33), mustard (52.00), coriander (53.67) and pea (54.33). The reduction in termite population density continued to be the same as of first season, where the population density went down due to prevalence of winter. The termite population was at minimal level till 90 DAS *i.e.* till the first week of March after which the termite population again increased. Mustard intercropped plots recorded 28.33 numbers at 105 DAS, which was on par with the plots intercropped with safflower (28.33), gram (29.33) and pea (30.67). The order of intercrops influencing the reduction in termite population is the same as that of the first season as safflower > mustard > pea > gram > fenugreek > coriander > ajowain > linseed (Table 3). The effect of intercropping garlic (*Allium sativum* L.), linseed *(Linum usitatissimum* L.), oilseed (*Brassica compestris* L.) and Methi (*Trigonella foenumgraecum* L.) in sugarcane field and on ridges at the time of setts placement in the furrows was studied earlier [14] and the results revealed that garlic and oilseed intercropped plots had significantly high germination, less bud damage and non-significant termite counts in comparison with other intercrops and sugarcane alone which strengthens the present findings. Further, it was also suggested in a study [5] to grow turmeric around the field of sugarcane to repel the termites.

During the course of the study, a drastic recession in termite population during cold temperature period was observed and this sudden slump in termite population during winter season was well justified by the previous findings[15] where it was stated that most termites die off during the winter in areas where the ground freezes. Most species cannot survive sustained temperatures below nine degrees Celsius and scientists don't know exactly how termites spend the winter in areas where the depth to which the soil freezes (the frost line) is significantly deep. But, researchers assume that termites survive in soil below the frost line, due to the central heating which helps termites to survive. The present data on the decline of termite population during winter was also supported by earlier findings [16, 17] where it was revealed that seasonal changes in the foraging behavior of subterranean termites may influence the efficacy of baiting programs due to decline of termite activities during winter. Studies have also affirmed that, foraging activity of *Macrotermes obesi* Holmgren and *Odontermes lokanandi* Chatterjee and Thakur were higher during summer than in winter, because much water was retained in the soil during the winter period of the study [18]. It was also confirmed by previous findings[19] that subterranean termites will not forage in areas where soil surface temperature is too hot or too cold.

Table 2: Density of termite population in wheat cropped with different intercrops (I season)

Crop	Ratios	*Population of termites per five quadrat plot^{-1}								
		15 DAS	30 DAS	45 DAS	60 DAS	75 DAS	90 DAS	105 DAS	120DAS	135DAS
Wheat + Mustard	3:1	38.67 (6.27)^{ab}	46.33 (6.81)^{ab}	14.00 (3.74)^{a}	12.00 (3.46)^{b}	8.67 (2.94)^{a}	12.67 (3.56)^{a}	23.00 (4.80)^{a}	35.00 (5.92)^{a}	41.67 (6.45)^{a}
Wheat + Ajowain	3:1	64.00 (8.00)^{d}	62.00 (7.87)^{de}	24.00 (4.90)^{d}	18.00 (4.24)^{d}	15.33 (3.92)^{d}	19.33 (4.40)^{c}	31.67 (5.63)^{c}	49.33 (7.02)^{b}	61.33 (7.83)^{c}
Wheat + Pea	3:1	39.33 (6.27)^{ab}	58.33 (7.64)^{d}	18.33 (4.28)^{b}	16.00 (4.00)^{c}	11.67 (3.42)^{b}	14.67 (3.83)^{b}	23.67 (4.86)^{a}	37.33 (6.11)^{a}	43.00 (6.56)^{a}
Wheat + Linseed	3:1	66.67 (8.16)^{d}	63.33 (7.96)^{e}	28.00 (5.29)^{e}	22.00 (4.69)^{e}	18.00 (4.24)^{e}	25.00 (5.00)^{d}	40.00 (6.32)^{d}	55.00 (7.42)^{c}	64.67 (8.04)^{d}
Wheat + Gram	3:1	51.67 (7.19)^{c}	48.33 (6.95)^{bc}	22.00 (4.69)^{cd}	15.33 (3.92)^{c}	9.33 (3.06)^{a}	13.00 (3.61)^{ab}	23.33 (4.83)^{a}	35.67 (5.97)^{a}	42.00 (6.48)^{a}
Wheat + Safflower	3:1	43.33 (6.58)^{abc}	43.00 (6.56)^{a}	13.33 (3.65)^{a}	10.67 (3.27)^{a}	8.33 (2.89)^{a}	12.33 (3.51)^{a}	22.67 (4.76)^{a}	34.67 (5.89)^{a}	41.33 (6.43)^{a}
Wheat + Coriander	3:1	35.33 (5.94)^{a}	52.00 (7.21)^{c}	23.00 (4.80)^{c}	18.67 (4.32)^{d}	13.00 (3.61)^{c}	20.33 (4.51)^{c}	27.33 (5.23)^{b}	47.00 (6.86)^{b}	57.33 (7.44)^{b}
Wheat + Fenugreek	3:1	45.00 (6.71)^{bc}	48.00 (6.93)^{bc}	21.67 (4.65)^{c}	19.00 (4.36)^{d}	15.00 (3.87)^{d}	21.00 (4.58)^{c}	27.00 (5.20)^{b}	46.00 (6.78)^{b}	55.33 (7.44)^{b}
Wheat alone	----	49.00 (7.00)^{c}	60.00 (7.75)^{de}	34.00 (5.83)^{f}	23.00 (4.80)^{e}	20.33 (4.51)^{f}	24.67 (4.97)^{d}	46.67 (6.83)^{e}	60.67 (7.79)^{d}	76.00 (8.72)^{e}

*Mean of three replications; DAS- Days after sowing
In a column, means followed by same letter(s) are not significantly different at P=0.05 by LSD
Values in parentheses are square root transformed values

Table 3: Density of termite population in wheat cropped with different intercrops (II season)

Crop	Ratios	*Population of termites per five quadrat plot^{-1}								
		15 DAS	30 DAS	45 DAS	60 DAS	75 DAS	90 DAS	105DAS	120DAS	135DAS
Wheat + Mustard	3:1	31.33 (5.60)^{a}	52.00 (7.21)^{b}	18.00 (4.24)^{ab}	11.00 (3.32)^{a}	9.33 (3.06)^{a}	14.00 (3.74)^{a}	28.33 (5.32)^{a}	40.67 (6.38)^{a}	53.00 (7.28)^{a}
Wheat + Ajowain	3:1	57.67 (7.59)^{de}	63.00 (7.94)^{c}	24.33 (4.93)^{d}	18.67 (4.32)^{cd}	14.33 (3.79)^{c}	20.67 (4.55)^{c}	38.33 (6.19)^{bc}	51.00 (7.14)^{cd}	65.67 (8.10)^{cd}
Wheat + Pea	3:1	40.67 (6.38)^{b}	54.33 (7.37)^{b}	19.67 (4.43)^{bc}	14.33 (3.79)^{b}	11.00 (3.32)^{b}	16.00 (4.00)^{b}	30.67 (5.54)^{a}	44.33 (6.66)^{b}	54.33 (7.37)^{a}
Wheat + Linseed	3:1	61.67 (7.85)^{e}	65.00 (8.06)^{cd}	26.67 (5.16)^{e}	21.00 (4.58)^{d}	17.67 (4.02)^{d}	24.67 (4.67)^{d}	42.00 (6.48)^{c}	58.00 (7.62)^{e}	67.67 (8.23)^{d}
Wheat + Gram	3:1	38. 33 (6.19)^{b}	51.33 (7.16)^{b}	18.67 (4.32)^{bc}	13.00 (3.61)^{b}	10.33 (3.21)^{ab}	15.33 (3.92)^{ab}	29.33 (5.42)^{a}	42.33 (6.51)^{ab}	54.33 (7.37)^{a}
Wheat +Safflower	3:1	42.33 (6.51)^{b}	44.33 (6.66)^{a}	16.33 (4.04)^{a}	10.67 (3.27)^{a}	9.00 (3.00)^{a}	14.67 (3.83)^{ab}	28.33 (5.32)^{a}	43.00 (6.56)^{ab}	51.00 (7.14)^{a}
Wheat + Coriander	3:1	50.67 (7.12)^{c}	53.67 (7.33)^{b}	23.67 (4.86)^{d}	19.00 (4.36)^{cd}	16.00 (4.00)^{cd}	22.00 (4.69)^{c}	36.67 (6.06)^{b}	53.00 (7.28)^{d}	63.00 (7.94)^{bc}
Wheat + Fenugreek	3:1	43.33 (6.58)^{b}	59.67 (7.72)^{c}	21.33 (4.62)^{c}	17.00 (4.12)^{c}	16.33 (4.00)^{d}	20.00 (4.47)^{c}	36.33 (6.03)^{b}	48.33 (6.95)^{c}	60.00 (7.75)^{b}
Wheat alone	----	51.67 (7.19)^{cd}	67.00 (8.19)^{d}	31.00 (5.57)^{f}	25.67 (5.07)^{e}	21.33 (4.62)^{e}	25.33 (5.03)^{d}	47.00 (6.86)^{d}	64.00 (8.00)^{f}	78.67 (8.87)^{e}

*Mean of three replications; DAS- Days after sowing
In a column, means followed by same letter(s) are not significantly different at P=0.05 by LSD
Values in parentheses are square root transformed values

4. Conclusion

Intercropping is a way to increase diversity in an agricultural ecosystem and it is an example of sustainable agricultural systems following objectives such as: ecological balance, more utilization of resources, increasing the quantity and quality and reduce damage to pests, diseases and weeds. In the current study, Safflower exhibited as a suitable intercrop with wheat in reducing the termite population thereby avoiding the infestation and could be recommended as a farmer friendly intercrop in termite prone areas. A detailed investigation, however is required on the active principle of safflower would go a long way in confirming the mode of action.

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