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Impact of farmscaping on the comparative population of pestiferous insects of cowpea and their associated natural enemies

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Abstract
An investigation on "Influence of farmscaping on the diversity of major insect pests of cowpea [*Vigna unguiculata* (L.) Walp.] and the associated natural enemies" was carried out at the instructional farm, Rajasthan College of Agriculture, MPUAT, Udaipur, during the *kharif* seasons from 2012 and 2013. The experiment was conducted in two sets, one comprising treatment with plant oils against insect pests, termed protected condition, and the other without the use of any plant oil, termed natural condition. During both the years, under unprotected and protected conditions, the mean pest numbers per plant were significantly the minimum when cowpea was farmscaped with marigold (cowpea + marigold); whereas, mean pests numbers per plant were significantly the maximum under sole cowpea. In case of pod damage, under both untreated and plant oil treated conditions significantly maximum mean number of damage pod was recorded in sole cowpea while significantly minimum pod damage was recorded in cowpea + marigold farmscape treatment. Among the natural enemies, the mean coccinellid numbers per plant were significantly the maximum when cowpea was farmscaped with niger (cowpea + niger); whereas, it was significantly the minimum in sole cowpea. The mean numbers of syrphid fly, wasps, spiders and carabids as numbers per plant were significantly the highest when cowpea was farmscaped with marigold (cowpea + marigold); whereas, they were the minimum in sole cowpea.

Keywords: Farmscaping, pestiferious insects, cowpea, marigold, niger, *Maruca vitrata*

1. Introduction
Cowpea, *Vigna unguiculata* (Linnaeus) Walpers, is one of the important pulse crops, also known as black eyed bean or Southern pea in English, while *chola* or *choli*, *chavli, lobia* in various vernacular languages in India. Cowpea grains are well known for their protein content (20-30%) and they are source of cheap plant protein [2, 4, 10, 12, 17] to people who hardly can afford animal protein derived from meat, fish, milk and eggs. Cowpea is rich in minerals, fats, oils and vitamins. Insect pests happen to be key biotic limiting factors in cowpea productivity. The major insect pests reported on cowpea at different growth stages include: cowpea aphid (*Aphis craccivora* Koch), foliage beetles (*Ootheca* sp., *Medythia* spp.), the flower bud thrips (*Megalurothrips sjostedti* Trybom) the legume pod borer (*Maruca vitrata* Fabricius) and the sucking bug complex, of which *Clavigralla* spp., *Anoplocnemis* spp., *Riptortus* spp., *Mirperus* spp., *Nezara viridula* Fab. and *Aspavia armigera* Linnaeus are most important and prevalent; without their control, reasonable grain yield cannot be obtained [11, 24]. Pod bugs cause abnormal pod aamponnd seed formation and yield losses of 30-70 per cent have been reported [7]. In Africa insect pest infestation in cowpea can result into 90 to 100 per cent yield reduction [18]. The avoidable losses in yield due to insect pests have been recorded in the range of 66 to 100 per cent in cowpea [19]. Farmscaping is the holistic approach to pest control on farms that focus on increasing biodiversity in order to maintain healthy populations of beneficial insects, birds and other wildlife as part of an ecological pest management program [23]. Ecological engineering or habitat manipulation, the key element of farmscaping, has emerged as paradigm for considering pest management approaches that are based on cultural practices informed by ecological knowledge of arthropod pest management [8]. Farmscaping reduce the need of pesticides, lowering the cost and risks associated with indiscriminate application of pesticides. With these facts in view, the present study on Impact of farmscaping on the population of pestiferous insects of cowpea and their associated natural enemies was carried out.

2. Materials and methods

The experiment was conducted at the Instructional Farm of Rajasthan College of Agriculture, Udaipur. The trial was laid out in uniformly sized plots measuring 5m x 3m (15 sq. m) in Randomized Block Design containing six treatments [Cowpea Sole, Cowpea + Niger (2 :1), Cowpea + Marigold (2:1), Cowpea + Maize (No border 2:1), Cowpea + Maize + Marigold Border (2:1) and Cowpea + Maize + Niger Border (2:1)] with four replications of each; thus in all, there were 24 plots. The row to row distance and plant to plant spacing for cowpea were 30 cm and 10cm respectively. Sowing of the recommended variety of cowpea (RC-19) and niger (RCR 317) were done in the second week of July, 2012-13 and 2013-14 as sole crop and farmscaping crop combination. The seeds of early flowering marigold variety Pusa Narangi were sown in well prepared, raised nursery beds. The usual floriculture operations were followed while raising the seedlings. The nursery was raised in the last week of June; mature seedlings of marigold were transplanted in between two rows of cowpea at a distance of 30cm. The experiments were conducted in two sets, one comprising treatment with plant oils against insect pests, termed protected condition (*A. indica and P. pinnata* (3.0%) and the other without the use of any bio-pesticide, termed natural condition. Population of jassids/white flies were estimated by Vortis suction sampler technique during early hours of the day from 10 plants per replication, selected at random and tagged. Aphids, the nymphs and adults were counted on the plants directly taking at least a 10cm twig sampling. The observation on blister beetles (10 am to 12 noon), pod bugs, leaf miner and semilooper were also recorded from the same10 plants per replication. To note the damage of pod borers, healthy and damaged pods were counted from the tagged plants and the data expressed as numbers. The associated natural enemies like syrphid flies, coccinellids, etc., were recorded by the visual count technique from the same 10 plants per replication randomly tagged, during early hours of the day. For the estimation of population of soil dwelling predators, especially carabids, pitfall traps were laid out in each replication and at least 3 traps were randomly placed in each plot of 15sq.m. Suitable statistical analyses were done for computing the data.

3. Results and discussion

3.1 Comparative mean population of pestiferous insects on untreated cowpea under different farmscape treatments

During both the years, all the farmscape treatments were significantly superior over sole cowpea. For the period of *kharif* 2012, the comparative population data showed that the mean pest numbers per plant were significantly the maximum being 12.46 (aphids), 4.74 (jassids), 2.15 (whitefly), 2.56 (thrips), 3.36 (blister beetle), 0.92 (coreid bug), 1.36 (semilooper), 2.00 (leaf miner) and 2.17 (pod borer) in sole cowpea than in the other farmscape treatments while, the mean pest numbers per plant were significantly the minimum when cowpea was farmscaped with marigold and corresponding values were 3.72 (aphids), 2.11 (jassids), 0.90 (whitefly), 1.40 (thrips), 1.69 (blister beetle), 0.43 (coreid bug), 0.59 (semilooper), 0.94 (leaf miner) and 1.21 (pod borer) [Table 1]. Similarly, during *kharif*, 2013 the mean pest numbers per plant were significantly the maximum being 5.89 (aphids), 5.00 (jassids), 3.12 (whitefly), 3.72 (thrips), 2.91 (blister beetle), 1.41 (coreid bug), 1.45 (pentatomid bug), 1.51 (semilooper), 1.73 (leaf miner) and 1.66 (pod borer) in sole cowpea than in the other farmscape treatments; whereas, the pest population was minimum when cowpea was farmscaped with marigold and corresponding values were 1.53 (aphids), 3.34 (jassids), 2.23 (whitefly), 1.96 (thrips), 1.59 (blister beetle), 0.80 (coreid bug), 0.82 (pentatomid bug), 0.97 (semilooper), 1.04 (leaf miner) and 0.87 (pod borer) [Table 2].

3.2 Comparative mean population of pestiferous insects on treated cowpea under different farmscape treatments during

As like un- treated set of experiment, under treated conditions during both the years, all the farmscape treatments were significantly reduced the pest's population than sole cowpea. During *kharif*, 2012 the mean pest numbers per plant were significantly the maximum being 8.64 (aphids), 3.52 (jassids), 1.43 (whitefly), 2.22 (thrips), 2.88 (blister beetle), 0.73 (coreid bug), 1.00 (semilooper), 1.67 (leaf miner) and 1.89 (pod borer) in sole cowpea; whereas, the pest population was minimum when cowpea was intercropped with marigold and corresponding mean numbers per plant were 3.28 (aphids), 1.60 (jassids), 0.59 (whitefly), 1.08 (thrips), 1.31 (blister beetle), 0.29 (coreid bug), 0.40 (semilooper), 0.46 (leaf miner) and 0.86 (pod borer) [Table 3]. Likewise, in the crop seasons *kharif* 2013 the mean pest numbers per plant were significantly the highest for the major pests being 4.19 (aphids), 4.54 (jassids), 2.53 (whitefly), 3.07 (thrips), 2.55 (blister beetle), 0.93 (coreid bug), 1.06 (pentatomid bug), 1.30 (semilooper), 1.36 (leaf miner) and 1.11 (pod borer) in sloe cowpea while, the pest population was lowest in cowpea + marigold farmscape treatment and corresponding values were 1.12 (aphids), 2.86 (jassids), 1.60 (whitefly), 1.41(thrips), 1.30 (blister beetle), 0.44 (coreid bug), 0.35 (pentatomid bug), 0.53 (semilooper), 0.64 (leaf miner) and 0.49 (pod borer) [Table 4].

A number of workers have reported that enhanced plant diversity reduced the abundance of pestiferous insects in different crops. Mixed cropping of cowpeas with maize reduced significantly the population density and activity of legume flower bud thrips (*Megalurothrips sjostedti*) compared with sole cowpea crop (Kyamanywa and Ampofo, 1988) [13]. Black aphid (*Aphis fabae*) infestation of beans was greatly reduced when beans was intercropped with older and taller maize plants that interfered with aphid colonization and only small proportions of beans were infested by the aphid (Ogenga-Latigo *et al.,* 1993) [16]. Intercropping sorghum and cowpea reduced the numbers of *Chilo partellus* in sorghum and *Megalurothrips sjostedti* in cowpea (Ampong *et al.,* 1994) [1]. Rekha Das Dutta (1996) [20] observed that intercropping *Vigna radiata* with maize resulted in reduced populations of the pests *viz*., *Monolepta signata*, *Aphis craccivora*, *Nacolea vulgaris*, *Nezara viridula* and *Riptortus linearis* on *V. radiata* than when intercropped with other legumes like *Vigna umbellata* (rice bean), *Glycine max* (soybean), *Vigna mungo* (blackgram) and *Arachis hypogea* (groundnut). Soundararajan and Chitra (2012) [22] observed that the sucking pests, *B. tabaci* and *E. kerri* population was low in the intercropped blackgram when compared to sole crop. Legume pod borer and other pod borer damage were low in the sorghum intercropped blackgram. The non-leguminous cereals intercropped blackgram plants had lower pest incidence as well as higher coccinellid population. Lower pest pressure on cowpea crop, higher abundance of predators and higher cowpea yields were observed to be associated with cowpea/greengram cropping systems; therefore, cowpea/greengram should be promoted among other biological control conservation strategies, aiming at enhancing natural enemies in cowpea systems, through habitat manipulation (Munyulia *et al.,* 2006) [15]. Hassan (2009) [9] reported that population of aphids (*Aphis craccivora* Koch.)

and thrips (*Megalarothrips sjostedi* Trybom) were significantly ($P>0.05$) lower in cowpea + sorghum intercrop in 2006 and 2007 cropping season than sole cowpea crop. Similarly in 2007 cropping season population of pod borer (*Maruca vitrata*) was significantly ($P>0.05$) lower in cowpea + sorghum intercrop than sole crop of cowpea. Chakravorty and Yadav (2013) [3] reported that intercrops subdued the population build up of jassids on greengram, lowest incidence of jassid adults and nymphs and lowest per cent affected leaves by jassid feeding was recorded from greengram + sesamum (1.56, 1.65 & 2.08 insect/ plant & 19.9, 23.6 & 15.6 % leaf damage in 2007, 2008 & 2009, respectively).

3.3 Occurrence of natural enemies of pestiferous insects on untreated cowpea under different farmscape treatments during

Under un- treated condition, during both the years *kharif* 2012 and 2013 data indicated that [Table 5] the mean coccinellid numbers per plant were significantly the maximum (1.37) and (1.10) under cowpea + niger farmscape treatment, respectively; whereas, it was significantly the minimum 0.52 and 0.67 in sole cowpea, respectively. The mean numbers of syrphid fly, wasps, spiders and carabids as numbers per plant were significantly the highest (0.70, 1.52, 3.52 and 3.22) and (0.67, 1.17, 8.08, and 6.78) in cowpea + marigold farmscape treatment, respectively. Likewise, the mean numbers of syrphid fly, wasps, spiders and carabids were the lowest (0.28, 0.62, 0.28 and 1.04) and (0.33, 0.50, 0.37, and 1.69) in sole cowpea, respectively.

3.4 Occurrence of natural enemies of pestiferous insects on treated cowpea under different farmscape treatments

Similarly under treated condition, during both the years *kharif* 2012 and 2013 data showed that [Table 6] the mean coccinellid numbers per plant were significantly the maximum (1.28) and (1.08) under cowpea + niger farmscape treatment, respectively; whereas, it was significantly the minimum (0.51) and (0.65) in sole cowpea, respectively. The mean numbers of syrphid fly, wasps, spiders and carabids as numbers per plant were significantly the highest (0.66, 1.53, 3.39 and 3.09) and (0.67, 1.15, 7.92 and 6.34) in cowpea + marigold farmscape treatment, respectively, likewise, the mean numbers of syrphid fly, wasps, spiders and carabids were the lowest (0.28, 0.61, 0.20 and 1.07) and (0.33, 0.50, 0.33, and 2.00) in sole cowpea, respectively. Earlier, a number of workers have reported that enhanced plant diversity and intercropping of flowering plants within the main crop increased the abundance of natural enemies. Distinctly more aphidophagous syrphids were observed in the weed strips than in the adjacent fields. The weed strips contained a high density of flowering plants and, therefore, proved to be very attractive feeding places for all syrphids (Frank, 1999)[6]. Predator/prey population balances are influenced by the timing of availability of nectar, pollen and alternate prey/hosts for the beneficial arthropods; therefore, efforts must be made to have year-round beneficial organism habitat and food sources. The beneficial habitat season may be extended by adding plants that bloom sequentially throughout the growing season or the whole year (Dufour, 2000) [5]. The abundance of predators (Coccinellidae, Staphylinidae, Syrphidae, Anthocoridae, Mantidae, Dermaptera, ground beetles, predatory mites, lygaeid bugs, dragonflies and spiders) were considerably affected by insecticides and the cropping system. Higher numbers of arthropod pests were observed in onion plants 30m from the marigold strip, while higher numbers of predators and parasitoids were found at 5 m distance. Species richness and Shannon's diversity index were higher at 5m from marigold; therefore, marigold rows next to onion fields resulted in higher number of entomophagous species, potentially enhancing the natural control of onion pests. Marigold strips may be an alternative to crop sprays for organic control of onion pests (Silveira, 2009) [21]. The presence of predatory and parasitic insects and spiders that migrate into the crop from field margins reduce pest populations (Labanowska-Bury *et al.*, 2009) [14].

Table 1: Comparative mean population of pestiferous insects on untreated cowpea under different farmscapings (FS) during *kharif,* 2012

Treatments	Mean/plant								
	Aphid	Jassid	Whitefly	Thrips	Blister beetle	Coreid bug	Semilooper	Leaf miner	Pod borer
Sole cowpea	12.46	4.74	2.15	2.56	3.36	0.92	1.36	2.00	2.17
FS-1	6.04	3.32	1.31	1.87	2.45	0.59	0.90	1.36	1.77
FS-2	9.71	2.98	1.74	2.31	2.97	0.80	1.17	1.79	1.94
FS-3	3.72	2.11	0.90	1.40	1.69	0.43	0.59	0.94	1.21
FS-4	4.44	2.50	1.10	1.65	2.04	0.48	0.78	1.11	1.51
FS-5	7.55	3.70	1.50	2.07	2.68	0.69	1.07	1.57	1.85
S. Em. ±	0.300	0.039	0.030	0.036	0.038	0.041	0.055	0.030	0.058
C. D. at 5%	0.903	0.118	0.091	0.109	0.114	0.124	0.165	0.091	0.176

Legend: FS-1= Cowpea + Niger; FS-2= Cowpea + Maize; FS-3= Cowpea + Marigold; FS-4= Cowpea + Maize + Bordered with Marigold; FS-5= Cowpea + Maize + Bordered with Niger

Table 2: Comparative mean population of pestiferous insects on untreated cowpea under different farmscapings (FS) during *kharif,* 2013

Treatments		Mean/plant								
	Aphid	Jassid	Whitefly	Thrips	Blister beetle	Coreid bug	Pentatomid bug	Semilooper	Leaf miner	Pod borer
Sole cowpea	5.89	5.00	3.12	3.72	2.91	1.41	1.45	1.51	1.73	1.66
FS-1	3.04	3.85	2.51	2.77	2.13	1.14	1.04	1.19	1.37	1.08
FS-2	4.57	3.71	2.95	3.42	2.66	1.31	1.27	1.37	1.63	1.46
FS-3	1.53	3.34	2.23	1.96	1.59	0.80	0.82	0.97	1.04	0.87
FS-4	1.76	3.49	2.31	2.21	1.84	0.93	0.93	1.07	1.20	0.98
FS-5	3.76	4.14	2.72	2.96	2.32	1.20	1.17	1.27	1.49	1.28
S. Em. ±	0.04	0.03	0.04	0.02	0.06	0.02	0.03	0.01	0.03	0.01
C. D. at 5%	0.11	0.09	0.12	0.05	0.17	0.07	0.09	0.03	0.08	0.04

Legend: FS-1= Cowpea + Niger; FS-2= Cowpea + Maize; FS-3= Cowpea + Marigold; FS-4= Cowpea + Maize + Bordered with Marigold; FS-5= Cowpea + Maize + Bordered with Niger

Table 3: Comparative mean population of pestiferous insects on treated cowpea under different farmscapings (FS) during *kharif*, 2012

Treatments	Mean/plant								
	Aphid	Jassid	Whitefly	Thrips	Blister beetle	Coreid bug	Semilooper	Leaf miner	Pod borer
Sole cowpea	8.64	3.52	1.43	2.22	2.88	0.73	1.00	1.67	1.89
FS-1	4.86	2.54	0.84	1.51	2.04	0.42	0.63	0.94	1.30
FS-2	6.96	2.20	1.22	2.00	2.57	0.61	0.83	1.48	1.51
FS-3	3.28	1.60	0.59	1.08	1.31	0.29	0.40	0.46	0.86
FS-4	3.86	1.92	0.73	1.25	1.63	0.34	0.49	0.74	1.09
FS-5	5.55	2.78	1.02	1.72	2.25	0.50	0.75	1.23	1.33
S. Em. ±	0.133	0.045	0.030	0.048	0.026	0.022	0.035	0.037	0.053
C. D. at 5%	0.401	0.137	0.091	0.144	0.078	0.065	0.106	0.112	0.160

Legend: FS-1= Cowpea + Niger; FS-2= Cowpea + Maize; FS-3= Cowpea + Marigold; FS-4= Cowpea + Maize + Bordered with Marigold; FS-5= Cowpea + Maize + Bordered with Niger

Table 4: Comparative mean population of pestiferous insects on treated cowpea under different farmscapings (FS) during *kharif*, 2013

Treatments		Mean/plant								
	Aphid	Jassid	Whitefly	Thrips	Blister beetle	Coreid bug	Pentatomid bug	Semilooper	Leaf miner	Pod borer
Sole cowpea	4.19	4.54	2.53	3.07	2.55	0.93	1.06	1.30	1.36	1.11
FS-1	1.84	3.45	1.99	1.97	1.83	0.65	0.56	0.86	0.90	0.75
FS-2	3.34	3.24	2.32	2.73	2.32	0.85	0.80	1.05	1.26	0.92
FS-3	1.12	2.86	1.60	1.41	1.30	0.44	0.35	0.53	0.64	0.49
FS-4	1.39	3.00	1.79	1.58	1.54	0.54	0.46	0.68	0.78	0.62
FS-5	2.56	3.77	2.12	2.31	2.03	0.73	0.67	0.93	1.07	0.83
S. Em. ±	0.11	0.03	0.03	0.03	0.03	0.02	0.03	0.03	0.06	0.02
C. D. at 5%	0.32	0.10	0.08	0.09	0.08	0.05	0.10	0.09	0.17	0.07

Legend: FS-1= Cowpea + Niger; FS-2= Cowpea + Maize; FS-3= Cowpea + Marigold; FS-4= Cowpea + Maize + Bordered with Marigold; FS-5= Cowpea + Maize + Bordered with Niger

Table 5: Comparative mean population of natural enemies of insect pests on cowpea as sole and with different farmscapings (FS)

Treatments	Mean/plant									
	Un-Treated - 2012					Un-Treated-2013				
	Coccinellids	Syrphid fly	Wasps	Spiders	Carabids	Coccinellids	Syrphid fly	Wasps	Spiders	Carabids
Sole cowpea	0.52	0.28	0.62	0.28	1.04	0.67	0.33	0.50	0.37	1.69
FS-1	1.37	0.47	1.15	2.63	2.19	1.10	0.54	0.88	6.03	4.09
FS-2	0.82	0.35	0.90	1.47	1.47	0.77	0.39	0.70	4.92	2.69
FS-3	1.15	0.70	1.52	3.52	3.22	0.96	0.67	1.17	8.08	6.78
FS-4	1.02	0.59	1.29	2.93	2.56	0.86	0.60	0.98	7.02	5.16
FS-5	1.25	0.41	1.00	2.25	1.75	1.01	0.45	0.79	5.35	3.38
S. Em. ±	0.023	0.029	0.026	0.074	0.098	0.02	0.01	0.03	0.04	0.24
C. D. at 5%	0.068	0.087	0.077	0.222	0.296	0.07	0.04	0.09	0.11	0.72

Legend: FS-1= Cowpea + Niger; FS-2= Cowpea + Maize; FS-3= Cowpea + Marigold; FS-4= Cowpea + Maize + Bordered with Marigold; FS-5= Cowpea + Maize + Bordered with Niger

Table 6: Comparative mean population of natural enemies of insect pests on cowpea as sole and with different farmscapings (FS)

Treatments	Mean/plant									
	Treated-2012					Treated-2013				
	Coccinellids	Syrphid fly	Wasps	Spiders	Carabids	Coccinellids	Syrphid fly	Wasps	Spiders	Carabids
Sole cowpea	0.51	0.28	0.61	0.20	1.07	0.65	0.33	0.50	0.33	2.00
FS-1	1.28	0.44	1.16	2.50	2.34	1.08	0.52	0.87	5.92	4.25
FS-2	0.78	0.33	0.83	1.35	1.41	0.74	0.40	0.70	4.82	2.53
FS-3	1.09	0.66	1.53	3.39	3.09	0.93	0.67	1.15	7.92	6.34
FS-4	0.96	0.56	1.36	2.87	2.66	0.83	0.59	1.00	6.92	4.91
FS-5	1.17	0.39	1.01	2.14	1.91	0.99	0.47	0.78	5.23	3.28
S. Em. ±	0.029	0.024	0.047	0.075	0.096	0.03	0.02	0.03	0.03	0.29
C. D. at 5%	0.088	0.072	0.140	0.226	0.289	0.09	0.06	0.09	0.10	0.88

Legend: FS-1= Cowpea + Niger; FS-2= Cowpea + Maize; FS-3= Cowpea + Marigold; FS-4= Cowpea + Maize + Bordered with Marigold; FS-5= Cowpea + Maize + Bordered with Niger

4. Conclusion

During the two successive crop seasons of *kharif* 2012 and 2013, under both plant oil treated and untreated conditions, the mean density of all the major insect pests was relatively more in sole cowpea than in the other farmscape treatments. Farmscaping cowpea with marigold resulted in the lowest mean density values for the major insect pests. The mean pest numbers per plant were significantly the maximum in sole cowpea than in the other farmscape treatments; whereas, when cowpea was farmscaped with marigold the pestiferous insect populations were the minimum. During the crop seasons *kharif* 2012 and 2013, under both the set of conditions (unprotected and plant oil protected) significant maximum mean per cent pod damage was recorded in sole cowpea, but significantly minimum pod damage was noted from cowpea + marigold farmscape treatment.

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