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Eco-feast crop plants for insect pest management in groundnut

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Abstract
Field experiment was conducted to test the effect of border crops in groundnut on different insect pests during *Kharif* 2016 and *rabi*/summer 2016-17 seasons at Regional Research Station, Vridhachalam, Tamil Nadu, India. The eight treatments were T1- Groundnut+cowpea, T2-Groundnut+sunflower, T3-Groundnut+sesame, T4-Groundnut+redgram, T5- Groundnut+pearl millet, T6-Groundnut+sorghum, T7-Groundnut+maize and T8- Sole groundnut crop -control. Among the seven combinations, border cropping of groundnut with sorghum, pearl millet and maize recorded significantly the lowest population of thrips, leafhopper and reduced *Spodoptera litura*, *Helicoverpa armigera* and *Aproaerema modicella* damage. The incidence ofPeanut Bud necrosis Disease (PBND) was reduced to the tune of 49.23-52.30% compared to control by these combinations. More number of natural enemies *viz*., coccinellids (3.8/plant) and spider (4.2/plant) were recorded in groundnut border cropped with these cereal crops. The same combinations (T6, T5 and T7) increased the economic returns of 1:4.35, 1:4.3 and 1:3.8, respectively. It could be inferred that the fast growing and taller cereals could reduce the pests' incidence in the main crop groundnut by acting as physical/mechanical barrier despite encouraging the natural enemies population.

Keywords: Sorghum, Pearl millet, Thrips, Leafhoppers, Coccinellids, Spiders, PBND, Border crops

Introduction
Groundnut (*Arachis hypogaea* L.) is the sixth most important oilseed crop in the world and one of the major oilseed crops cultivated in an area of 5.52 million ha with a production of 9.67 million tonnes and productivity of 1750 kg/ha. Six states namely Andhra Pradesh, Gujarat, Karnataka, Maharashtra, Rajasthan and Tamil Nadu account for about 90 per cent of the total groundnut area of the country (Venkataiah *et al*., 2015) [16]. Productivity of groundnut is very low (1750 kg/ha) in India when compared to the productivity of world (2,149 kg/ha). With the increasing period of time course area, production and productivity of groundnut has been dwindling. The reason might be due to many biotic, abiotic and socio economic constraints. Insect pests are one of the major biotic constraints in cultivation of economically important crops. For instance, sucking pests like thrips, hoppers and defoliators *viz*., cutworm *Spodoptera litura*, Gram pod borer *Helicoverpa armigera* and groundnut leafminer (GLM) *Aproaerema modicella* are considered as an important constraint in groundnut production. Among the various methods of insect pest management, use of insecticides forms the first line of crop protection against insect pests. Though synthetic insecticides stands first in the chain, eco-friendly method of insect pest management offers adequate level of pest control with the reduction of 3R (residue, resistance and resurgence) problems.

Ecological engineering has recently emerged as a new avenue for considering pest management approaches that rely on the use of cultural methods to effect habitat manipulation and to enhance biological control. In groundnut eco-system it has been proven that raising pearl millet as intercrop reduces the leafminer incidence by encouraging *Goniozus* and lady bird beetle activities (Shanower *et al*., 1992) [11]. In the recent years, there has been renewed interest in utilization of natural enemies in pest management. It could be achieved by exploring the ecological engineering through cropping system approach to avoid the use of chemical insecticides to encourage the natural enemies' population and their activity. In light of this, tested the effect of cropping system approach on insect pests and natural enemies population in groundnut ecosystem.

Materials and Methods
Field experiment was conducted during *Kharif* 2016 (June to September 2016) and *rabi*-summer 2016-17 (December 2016-April 2017) at Regional Research Station (11.30°N and 79.26°E and 46.7 m above MSL), Vridhachalam, Cuddalore District, Tamil Nadu, India.

The ratio of fertilizer (N:P:K) applied to the experimental field was 25:50: 75 kg/ha. N and K in three splits *viz.*, 50 % N & K as basal + 25% N and K at 20 days after sowing (DAS) + 25% N and K at 45 DAS were applied as per the recommendation. Gypsum 120kg/ha was applied during 2nd hand weeding done on 40 DAS.

The experiment had 8 treatments in a randomized block design, and each treatment was replicated thrice with a plot size of 5.0 m x 4.0 m per replicate. A buffer zone of the same plot size was maintained between the plots. In each plot spacing of 30 cm x 10 cm was maintained. The border crops such as cowpea (Vbn 1), sunflower (SFK1605), sesame (VRI 2), redgram (Vbn 4), pearl millet (PM(H)1548), sorghum (Co 1), maize (MH16(K)001) were sown on the same day of main crop groundnut (VRI 2) sown on 29.06.2016 during *kharif* 2016 and on 21.12.2016 during *rabi*-summer 2016-17. Hence, the treatments with border crops were as follows: T1-Groundnut+cowpea, T2-Groundnut+sunflower, T3-Groundnut+sesame, T4-Groundnut+redgram, T5-Groundnut+pearl millet, T6-Groundnut+sorghum, T7-Groundnut+maize and T8- Sole groundnut crop – control without any border crop. All the recommended package of practices for groundnut was followed except plant protection measures.

Observations on insect pests and natural enemies

Observations on number of aphids in 2 cm shoot length, no of thrips/3 terminal buds/plant and no. of leafhopper/leaves/plant were made on top, middle and bottom leaves of 10 randomly selected plants from each plot. For defoliators per cent damage was calculated based on no of plants damaged out of 100 plants in a plot. Population of sucking insect pests and defoliators damage were recorded on vegetative to flowering stage (20-30 DAS), reproductive stage (45-60 DAS) and on 90 DAS - a week before harvest. Simultaneously, natural enemies *viz*., lady bird beetles, spiders and its egg masses/plant also was recorded. Peanut bud necrosis disease incidence was observed. The percent incidence was calculated by no. of diseased plants/total no. of plants in a plot multiplied with 100. The dry pod yield was recorded on the net plot area basis which was converted to kg/ha for statistical interpretations.

Statistical analysis

The data were analysed by OPSTAT (Sheoran *et al*., 1998) [12]. Population data were square root transformed and the percentage infestation data were arcsine transformed. Based on the pod and halum yield cost benefit ratio was worked out.

Results and Discussion

The results of the experiment conducted during *kharif* 2016 and *rabi*/summer 2016-17 revealed that the combination of groundnut with border crops showed significant differences with each other (Tables 1&2). Thrips and leafhopper population was significantly lesser in pearl millet, soghum and maize border cropped treatments (T5-T7) than in the sole groundnut crop which was served as control (T8). The cumulative mean number of thrips was founde to be lesser in T6 (3.2 insects/terminal bud/plant), followed by treatments T7<T5<T2<T1<T4<T3<T8. Thus, the sole crop control T8 had the more thrips population (12.0) during *kharif* 2016. During *rabi*/summer 2016-17 (Table 2) also the same trend has been observed. That is cereals border cropped treatments T5 – T7 were on par with each other for thrips population (6.0 thrips/terminal bud/plant) followed by the treatments T2<T4=T1 (6.3) < T3 (6.6) < T8 (10.3 thrips/terminal bud/plant). It has been shown that, groundnut main crop, when raised with sorghum as intercrop significantly reduced the thrips population by harbouring natural enemies like *Cheilomenus septumpunctata* and *C. sexmaculata* (Singh *et al*., 1991). The maximum population of coccinellids 3.8 and 3.6/plant were recorded during *kharif* 2016 and *rabi*/summer 2016-17 respectively (Fig.1.) in T6 (groundnut+sorghum) was concurrent with the earlier findings (Singh *et al.*, 1991). In the present study, spider population also higher in T6 (groundnut+sorghum) followed by T5 (groundnut+pearl millet) in both the seasons (Fig. 2). Result of the present study was also in concurrence with the report of Midega & Khan (2003) [7]. They reported that border crops increased the abundance of natural enemies like *Cheilomenes* sp. *Chrysoperala* sp, ants, ear wigs and spiders concurrently with reducing target insect pests in main crop.

With reference to leafhopper population, during *kharif* 2016 season (Table 1), treatments T5-T7 had the lesser population and on par with each other (2.0 insects/top three leaves/plant) as against the maximum population 7.2 in sole groundnut crop (T8). During rabi/summer also the same trend was observed for leafhopper population. Thetreatments contained cereals *viz*., pearl millet, sorghum and maize as border crop (T5, T6 and T7) recorded lesser population of sucking insect pests (thrips and leafhopper) than pulses (cowpea and redgram) and oilseeds (sunflower and sesame). Pearl millet, sorghum and maize likely acted as a barrier crop for the movement of thrips and leafhoppers as those were taller than main crop groundnut. Simons (1957) [13]; Alegbejo and Uvah (1986) [1] suggested that high, tall, barrier crops may act as mechanical barriers that impede insect colonization on the protected crop. Sujayanand *et al*. (2015) [15] reported the reduction of fruit borer and leafhopper incidences in main crop brinjal, when raised with maize as border crop.

The cutworm *Spodoptera litura* is a ubiquitous, polyphagous, multivoltine, lepidopterous pest that feeds on 112 cultivated crops across the world (Moussca *et al*., 1960). *Spodoptera* is a destructive pest that damages groundnut crop extensively by defoliating the plants and thus reducing the photosynthetic capacity of the plant. For defoliators incidence, the lowest mean damage percent was recorded in treatments T6 and T7. The treatment effect (2%) was on par with each other *S. litura* and *H. armigera* and followed by T5, where in the damage percent was 3% for both the defoliators during *kharif* 2016 (Table 1). In blackgram+sorghum combination, incidence of the major pod borer *Maruca vitrata* was very less (Soundarajan and Chitra, 2012). It showed that altering the cropping system either by intercrops or border crops; will significantly influences the insect rather larval feeding or ovipisition by the adult insects. The damage in harvested blackgram pods was low in sorghum+blackgram followed by pearl millet+blackgram (Soundarajan and Chitra, 2012). It indicates that all non-host cereals were good physical barriers (Ganapathy and Narayanasamy, 1991). In addition, results elsewhere revealed that intercropping with pearl millet significantly increased the natural enemies like coccinellid members. The mechanisms by which intercrops/border crops affect insect pest dynamics may include attraction of natural enemies, alteration of wind and vector dispersal; modification of microclimate, especially temperature and moisture; and direct barrier for arresting insect movement.

The groundnut leaf miner, *A. modicella* is an oligophagous pest and feeds only on leguminous host plants and a serious pest of groundnut during both rainy and post rainy season in

India and on both groundnut and soybean in South and South East Asia. The leafminer is considered as the most important insect pest of groundnut in India and particularly in rainfed situations (Gadad *et al*., 2013) [5]. The pest initially appears as a leaf miner causing short blister like mines. Older larvae fold the leaflets and feed by being inside the folds. As a result, the leaflets turn brown, shrivel and dry up. Severely infested crop gives a burnt up appearance and yield losses can reach up to 76 per cent (Anon, 1986). Studies indicated that crop diversification through intercropping/border cropping, such as cereals with legumes, was effective in reducing insect pest damage (Degri *et al*., 2014) [2]. For instance, intercropping of groundnut with pearl millet (*Pennisetum glaucum* L.) has particularly been found to increase the population of *Goniozus* sp., a parasitoid species that effectively manages leaf miner pest populations in groundnut (Shanower *et al*., 1992; Daliwal and Arora 1996) [11]. T5 (groundnut+pearl millet) recorded lowest GLM damage (2.6%) followed by T6=T7 (3%) as against 6 percent in T8-sole groundnut crop. Result of the present study is in concurrent with the earlier findings (Daliwal and Arora 1996). In addition to natural enemy effects, the pearl millet component crop as non-host plants could have further constituted a physical barrier to leafminer pests in groundnut that possibly inhibits their movements in border cropped systems (Degri *et al*., 2014) [2]. Among the border crops treatments T3-groundnut+sesame recorded more damage percent for all the three defoliators (Table 1) in *kharif* 2016 and for *S. litura* and *H. armigera* in *rabi*/summer 2016-17 (Table 2). Paras and Singh, (2004) [9] recorded more incidence of bihar hairy caterpillar- *Spilaractia oblique* in groundnut + sesame combination. In the present study also the same combination recorded more incidence of sucking and delfoliators incidence.

Peanut bud necrosis disease (PBND) is an economically important disease of groundnut in India. The disease can cause yield losses of over 50 percent and its incidence ranges from 5 to 80 percent in all major groundnut growing areas of India. The causal virus of PBND in India was shown to be a serologically distinct tospovirus, now referred to as peanut bud necrosis virus (PBNV), transmitted by *Thrips palmi* (Reddy *et al*., 1995) [10]. PBND incidence was less in groundnut combined with cereals (pearl millet, sorghum and maize) and redgram. During *kharif* 2016 the PBND level of incidence in groundnut with different crop combination ranged from 2.1 to 4% as against 5.7% in sole groundnut crop. The percent incidence was ranged from 4.1-4.3% in groundnut border cropped with pearl millet, sorghum and maize when compared to 8% in sole groundnut during *rabi*/summer 2016-17. Gururaj *et al*. (2005) [6] reported that intercropping of groundnut with pearl millet, sorghum, redgram and maize significantly reduced the incidence of PBND by 60.3 to 69.1 percent. In the present study also PBND incidence was reduced to the tune of 49 to 52 percent, when groundnut redgram, pearl millet, sorghum and maize as border crops (table 4). Reduction in the disease incidence might be due to reduction in flights of thrips vector brought about by border crop as a physical/mechanical barrier which was observed in the present study also (Gururaj *et al*., 2005) [6]. Maximum PBND incidence 5 percent was noticed in treatment T3- groundnut+sesame followed by 4 and 3.5 percent respectively in T1 (groundnut+cowpea) and T2-groundnut+sunflower. In earlier studies also groundnut+sunflower (Gururaj *et al*., 2005) [6] and groundnut+sesame (Paras and Singh, 2004) [9] were found to not be effective in reducing the diseases incidence and vector population. Fereres (2000) [4] reported that use of fast growing and tall cereal crops as barrier crops can be an effective crop management strategy to protect against virus infection.

The influences of various intercrops on pod yield of groundnut are given in Table 2. The dry pod yield of groundnut was inversely proportional to disease incidence. It was observed that decrease in insect pest population and damage increased the pod yield of groundnut. The pooled data of two years showed that the treatments T6-groundnut+sorghum and T5- groundnut+pearl millet gave significantly higher pod yield (3063 and 3062 kg/ha) followed by T7- groundnut+maize (2683 kg/ha) compared to T8- sole groundnut (1511kg/ha). Our finding with reference to pod yield was in line of Gururaj *et al*. (2005) [6] and Degri *et al*. (2014) [2]. They recorded maximum of dry pod yield from groundnut+pearl millet combination tested against PBND and stem borer management in the respective crops.

From this study, it could be concluded that groundnut crop combined with taller and fast growing cereals like sorghum, pearl millet and maize would reduce the pest population and increase the activity of natural enemies and ultimately realized increased economic returns. Hence, the border crops found effective in the present study can be used alone or they may be integrated with other management practices so that insect pests and vector borne PBND does not pose threat to groundnut cultivation. In the ensuing period the best border crops screened from the current study will be tested along with the organic amendments (farm yard manure, poultry manure, vermicompost and biofertilizers like *Rhizobium* and phosphobacteria) to reduce the use of chemical pesticides and fertilizers in groundnut production to realize more income.

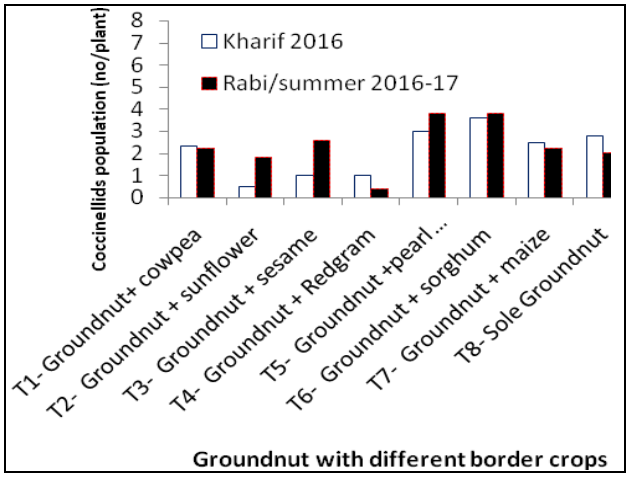

Fig 1: Coccinellids population in groundnut with different border crops during *kharif* 2016 and *rabi*/summer 2016-17

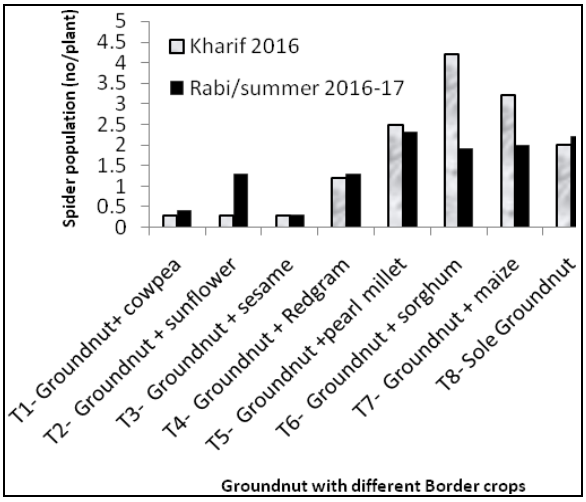

Fig 2: Spider population in groundnut with different border crops during *kharif* 2016 and *rabi*/summer 2016-17

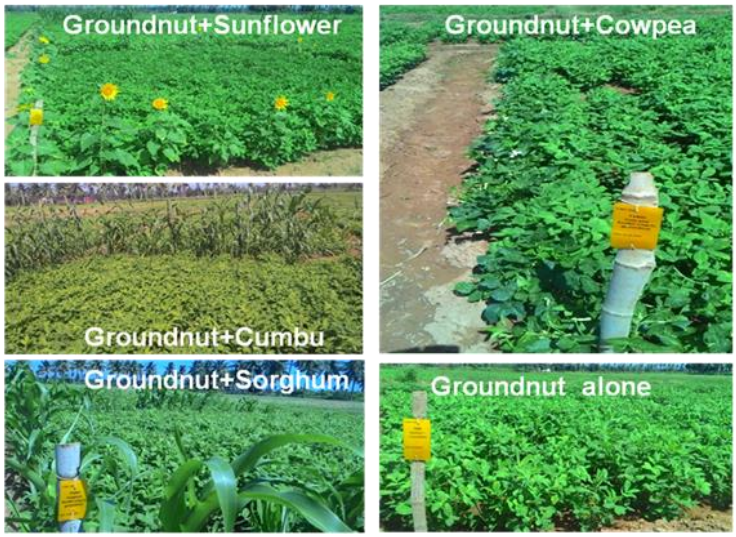

Plate 1: Field view of groundnut bordered with different crops

Coccinellids beetle – *Micraspis* sp in sorghum

Orb spider in pearl millet

Table 1: Effect of cropping system approach on insect pests and natural enemies population in groundnut – *Kharif* 2016

Treatments	Sucking pest population		Defoliators Damage (%)		
	Thrips (no/terminal bud/ plant)	Hopper (no/top 3 leaves/plt)	*S. litura*	*H. armigera*	*A. modicella*
T1- Groundnut+ cowpea	8.0 (2.98)	2.5 (1.8)	3.0 (9.5)	4.0 (11.27)	4.3 (2.3)
T2- Groundnut + sunflower	7.0 (2.81)	3.2 (2.0)	3.0 (9.5)	4.0 (11.27)	2.6 (1.8)
T3- Groundnut + sesame	9.0 (3.15)	5.2 (2.4)	5.0 (12.7)	5.0 (12.74)	4.6 (2.3)
T4- Groundnut + Redgram	8.5 (3.07)	4.0 (2.2)	4.0 (11.2)	4.0 (11.27)	4.0 (2.2)
T5- Groundnut +cumbu	5.5 (2.53)	2.0 (1.6)	3.0 (9.5)	3.0 (9.54)	2.6 (1.8)
T6- Groundnut + sorghum	3.2 (2.00)	2.0 (1.6)	2.0 (6.5)	2.0 (6.55)	3.0 (2.0)
T7- Groundnut + maize	4.5 (2.31)	2.0 (1.6)	2.0 (6.5)	2.0 (6.55)	3.0 (2.0)
T8- Sole Groundnut	12.0 (3.59)	7.2 (2.8)	5.0 (12.7)	6.0 (14.04)	6.0 (2.6)
CD	0.13	0.18	2.4	2.54	0.11
SE(m)	0.04	0.06	0.7	0.83	0.04
SE(d)	0.06	0.08	1.1	1.17	0.05
CV%	2.61	5.21	13.7	13.8	2.9

Values are mean of three replications of each treatment. Values in the paranthesis are arcsine transformed values for % damage.

Tabel 2: Effect of cropping system approach on insect pests population and damage in groundnut rabi*/summer* 2016-17

Treatments	Sucking pest population		Defoliators Damage (%)		
	Thrips (no/terminal bud/ plant)	Hopper No/top 3 leaves/plt)	*S. litura*	*H. armigera*	*A.modicella*
T1 Groundnut+ Cowpea	6.3 (2.69)	6.3 (2.70)	8.7 (17.09)	7.3 (15.67)	0.8 (5.10)
T2- Groundnut+ Sunflower	6.1 (2.65)	6.0 (2.64)	6.7 (14.32)	7.3 (15.46)	0.6 (4.24)
T3- Groundnut+ Sesame	6.6 (2.70)	6.6 (2.75)	11.3 (19.64)	10.0 (18.37)	0.8 (5.12)
T4- Groundnut+ Redgram	6.3 (2.75)	6.3 (2.70)	10.7 (19.03)	8.0 (16.42)	0.7 (7.32)
T5- Groundnut+ +Pearl millet	5.9 (2.62)	6.1 (2.65)	6.7 (14.79)	7.3 (15.67)	0.7 (4.83)
T6- Groundnut+ Sorghum	5.9 (2.61)	5.9 (2.63)	7.3 (15.67)	8.7 (17.00)	0.8 (5.10)
T7- Groundnut+ Maize	6.0 (2.64)	5.9 (2.62)	8.7 (17.09)	6.7 (14.92)	0.7 (6.57)
T8- Sole Groundnut	10.3 (3.35)	9.4 (3.22)	15.7 (23.27)	16.0 (23.55)	1.0 (5.33)
CD	0.32	0.28	4.43	3.380	1.74
SE(m)	0.10	0.09	1.44	1.103	0.57
SE(d)	0.15	0.13	2.04	1.561	0.80
CV	6.59	5.81	14.23	11.154	18.09

Values are mean of three replications. Values in the paranthesis are arcsine transformed values of % damage.

Table 3: Peanut bud necrosis disease incidence in groundnut during *Kharif* 2016 and *rabi*/summer 2016-17

Treatments	PBND Diseasen (%)		Mean of two seasons	Percent reduction over control
	Kharif 2016	*Rabi*/summer 2016-17		
T1- Groundnut+ Cowpea	3.0 (9.87)	5.0 (13.0)	4.0 (11.43)	38.46
T2- Groundnut + Sunflower	4.0 (11.37)	4.5 (12.2)	3.5 (11.78)	46.15
T3- Groundnut + Sesame	3.9 (11.37)	6.0 (14.0)	5.0 (12.68)	23.07
T4- Groundnut + Redgram	2.1 (8.12)	4.1 (11.6)	3.1 (9.86)	52.30
T5- Groundnut +Pearl millet	2.1 (8.44)	4.1 (11.8)	3.1 (10.12)	52.30
T6- Groundnut + Sorghum	2.3 (8.71)	4.3 (12.0)	3.3 (10.35)	49.23
T7- Groundnut + Maize	2.2 (8.35)	4.2 (11.8)	3.2 (10.07)	50.76
T8- Sole Groundnut	5.7 (13.84)	8.0 (16.5)	6.5 (15.17)	-
CD	2.48	1.8	2.14	-
SE(m)	0.81	0.6	0.70	-
SE(d)	1.14	0.84	0.99	-
CV%	14.44	8.06	11.25	-

Table 4: Economic returns of groundnut in cropping system approach during *kharif*-2016 and *rabi*/summer 2016-17

Treatments	*Kharif* 2016			*Rabi*/Summer 2016-17			Mean of *Kharif* 2016 and *Rabi/Summer* 2016-17		
	Pod (kg/ha)	Haulm (t/ha)	B:C	Pod (kg/ha)	Haulm (t/ha)	B:C ratio	Pod (kg/ha)	Haulm (t/ha)	B:C
T1- Groundnut+ Cowpea	2333	10.5	3.3	1533	3.3	2.2	1933	6.9	2.75
T2- Groundnut + Sunflower	3441	15.4	4.9	1691	4.4	2.4	2566	9.9	3.65
T3- Groundnut + Sesame	3208	15.8	4.6	1691	3.0	2.4	2450	9.4	3.5
T4- Groundnut + Redgram	2508	11.6	3.6	1641	4.7	2.3	2075	8.15	2.95
T5- Groundnut +Pearlmillet	4491	14.1	6.3	1633	5.3	2.3	3062	9.7	4.3
T6- Groundnut + Sorghum	3850	13.8	5.5	2275	4.5	3.2	3063	9.15	4.35
T7- Groundnut + Maize	3733	13.8	5.3	1633	4.5	2.3	2683	9.15	3.8
T8- Sole Groundnut	1983	14.1	2.8	1038	2.9	2.2	1511	8.5	2.5
CD	889.41	N/A	-	590.8	1.3	-	740.105	NA	
SE(m)	290.4	1.4	-	192.9	4.4	-	241.65	2.9	-
SE(d)	410.7	2.088	-	272.8	6.2	-	341.75	4.144	-
CV%	3850.0	19.4	-	20.3	18.5	-	1935.15	18.95	-

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