Original Research Article

Evaluation of mulching methods and legume intercropping on weed control efficiency and agronomic traits of pearl millet (*Pennisetum glaucum*)

ABSTRACT:

Aim: To evaluate the weed control efficiencies of different mulching practices and legume intercropping in transplanted pearl millet.

Study Design: Randomized Complete Block Design (RBD).

Place and Duration of Study: The field trial was conducted during the *Rabi* season of 2022 at the school of agricultural sciences in Karunya Institute of technology and sciences, Coimbatore, Tamil Nadu

Methodology: The field trial consists of 8 treatments viz., T_1 - PE of Atrazine 0.5kg/ ha +1 Hand Weeding at 30 DAT, T_2 - Two Hand Weeding at 15 and 30 DAT, T_3 - Paddy straw mulching at 5t/ ha 3 DAT, T_4 - Black polythene mulching at 3 DAT, T_5 - Black silver polythene mulching at 3 DAT, T_6 - Intercropping of pulses (cowpea) (1:1), T_7 - Intercropping of pulses (cowpea) (1:1) + PE Pendimethalin 0.75 kg/ ha, T_8 - Un weeded check.

Results: Results of the experiment proves that the intercropping of cowpea in pearl millet along with the pre-emergence application of pendimethalin proves to be beneficial and advantageous in terms of returns per rupee invested for profitable crop production, rather than going for polythene mulches. Hence adoption of legume intercropping in pearl millet, along with the usage of mild herbicides like pendimethalin, will be an economically viable and environmentally sustainable weed management practice for improving the yield of pearl millet.

Keywords: *Pearl millet, Plastic mulching, Paddy straw mulching*, *Weed management, Pendimethalin, Atrazine*

1. INTRODUCTION

Pearl millet [*Pennisetum glaucum*] commonly known as Bajra, is one of the most important cereal crops grown worldwide after rice, wheat and maize. Pearl millet ranks as the fourth most significant staple food crop. Pearl millet stands out from other cereals for its distinctive characteristics, like exceptional photosynthetic efficiency, because of its C4 nature of carbon fixation and a

remarkable capacity for high dry matter production. The crop is highly versatile, well adaptable to stress intensive environments, and highly responsive to inputs. Pearl millet serves as an excellent source of energy, protein, as well as essential vitamins and minerals. It contains about 12.4% moisture, 11.6% protein, 5% fat, 72.2% carbohydrates, 2.7% mineral matter and gives 360 calories per 100 grams. Due to its superior nutritional composition, pearl millet has been designated as "Nutri-cereals" by the Ministry of Agriculture, Government of India. Pearl millet accounts for about 50% of the total production of millets. India is the larger producer of pearl millet. Pearl millet encompasses a land area of 7.55 million hectares; with an average annual production reaching 9.22 million tonnes and productivity level of 1374 kg/ha.

Weed infestation in pearl millet is one of the major causes for low productivity. Initial slow growth with wider spacing of the crop causes severe infestation of weeds in pearl millet. The Major weeds of pearl millet are *Trianthema protulacastrum, Tribulus terrestris, Cyprus rotundus, Amaranthus sp, Echinochloa colona, Cynodan dactylon*, etc. Weed infestation in pearl millet drastically reduces the grain yield and stover yield of the crop up to 40% and more [1]. Weed infestation during the early stages of the crop growth is a major constrain because it severely impacts the yield and income. If the weed infestation gets addressed advertently during the critical crop weed competition period, the reduction in crop yield can be reversed effectively.

The predominant methods of weed management in pearl millet are hand weeding, hoeing and inter-culturing. By following these mechanical measures, the benefits obtained are loosening of soil, aeration in roots, deep root penetration and conservation of moisture. However due to the limitations like nonavailability of labour during the critical stages of crop growth, high labour cost and unpredicted continuous rains often causes difficulties in managing the weeds manually. Though the use of pre-emergence chemical herbicides like atrazine and pendimethalin have proved to be economical and effective to a large extent, continuous use of single classes herbicides over a period of time opens the doors for the evolution of herbicide resistant weed species and shift in the weed flora. Under such circumstances opting for mulching practices and adopting other management practices like intercropping can prove to be an effective viable option for managing the weeds in pearl millet. Mulches contribute to weed management by affecting the germination of weed seeds, blocking weed growth, favouring the crop by conserving soil moisture and sometimes by moderating soil temperature. Organic mulching reduces the weed competition, suppress annual weed seedlings, conserve moisture and add organic matter to soil as they break down. Synthetic mulches like black polythene mulch and black silver polythene sheets blocks the light stimulus which is the major source for seed germination and reduces the evaporation losses. On the other hand, usage of inorganic mulches has its own drawback of leaving back the non-biodegradable plastic residue in the field which drastically affects the soil health and pollutes the environment. Intercropping of pulses in pearl millet can also be adopted as an effective weed control mechanism, it not only reduce the intensity of weeds but also gives additional yield and returns [2,3] Keeping in view with the above fact, the present investigation was carried out to study the influence of conventional weed management

practices of pearl millet alongside with the different mulching methods and legume intercropping practices on the weed control efficiency and agronomic traits of transplanted pearl millet.

2. MATERIALS AND METHODS

2.1. Location

The experiment was conducted at the Instructional farm, School of Agricultural Sciences, Karunya Institute of Technology and Sciences, Coimbatore which falls in the western agro zone of the Tamil Nadu. The experimental site is geographically located at 10^0 56' N latitude and 76^0 44' E longitude at an elevation of 474 m above mean sea level.

2.2. Season and crop variety

The pearl millet crop was raised under the irrigated condition during the *Rabi* season from September 2022 to December 2022. The pearl millet hybrid CO9 released by Tamil Nadu was chosen for the trial. For intercropping treatment, cowpea variety VBN3 was selected.

2.3. Experimental design

The field experiment was conducted in randomized block design (RBD) with three replications comprising of eight treatments. The treatments taken up for the experimental trial were : T_1 - Pre Emergence (PE) application of Atrazine 0.5kg/ ha +1 Hand Weeding at 30 Days After Transplanting (DAT), T_2 - Two Hand Weeding at 15 and 30 DAT, T_3 - Paddy straw mulching @ 5t/ ha at 3 DAT, T_4 - Black polythene mulching at 3 DAT, T_5 - Black silver polythene mulching at 3 DAT, T_6- Intercropping of cowpea (1:1), T_7- Intercropping of cowpea (1:1) + PE Pendimethalin 0.75 kg/ ha, T_8 - Unweeded check.

2.4. Cultural practices for the crop management

The sowing of pearl millet seeds were taken up in raised bed nurseries and the seedlings were raised in the nursery for 15 days. The main field was prepared by ploughing the soil thoroughly with tractor drawn rotavator to fine tilth and with the formation of ridges and furrows, which were 45 cm apart. The 15 days old seedlings were transplanted in the main field along the sides of the ridges with an intra row spacing of 15 cm (45×15 cm). In case of polythene mulching treatments, the polythene sheets were spread over the respective treatment plots on an end to end basis. Holes or punchers were made in the polythene sheets at 15 cm interval for transplanting the seedlings. Simultaneously for the intercropping treatments, 1:1 additive series of planting method was taken up by sowing the cowpea in between the pearl millet rows on the other side of the ridge at a spacing of 15 cms. Nutrient management practices were done as per the standard recommended package of practices. Irrigation was given to the crop according to the requirement.

2.5. Experimental observations

Weed observations such as weed density, weed control efficiency were recorded at 15 days after transplanting, 45 days after transplanting and at harvest stages The crop biometric observations on yield parameters viz., number of productive tillers, crop dry matter production, grain yield, stover yield and harvest index were recorded at harvest stages. ..

2.6. Statistical analysis

The data collected on various characters studied during the experiment were subjected to statistical analysis in randomized block design following the method of Fisher (1950). Critical difference was worked out at five per cent probability level whenever the treatments were significant.

3. RESULTS AND DISSCUSSION

3.1 Effect of mulching methods and legume intercropping on weed density and weed control efficiency in transplanted pearl millet

The measurement of weed density involves quantifying the number of weed species present within a specific area and the data recorded on weed density observed in the field trial are furnished in the Table 1. The weed density exhibits variations not only across different weed species but also across various stages of crop growth. Throughout the entire crop growth stage, the average data clearly indicates that all weed control treatments exhibited significant efficacy in managing weeds when compared to the weedy check treatment. Particularly, noteworthy is the substantial reduction in weed density or no weed was observed in the polythene mulching treatments (T_4 & T_5) at all the stages of the crop growth. As there were no weeds observed in black polythene mulching and black silver polythene mulching treatments, eventually these treatments have reflected the highest weed control efficiency of 99.9% (Fig1) during all the stages of the crop growth. This was followed by the treatment T_7 - intercropping of cowpea along with the application of pendimethalin, which exhibited a moderately reduced total weed count of 7.19, 3.37 and 3.49 per square meter at 15, 45 and havest stages of the crop respectively and a weed control efficiency almost 90% of was observed at all the stages of the crop growth, which was statistically on par with the paddy straw mulching (T_3).

The decreased weed density and the higher weed control efficiency recorded during all the stages of the crop growth under the polythene mulching treatments can be attributed to the prevention of light or filtering the photosynthetically active radiation from the sun falling over the soil surface by the polythene sheets, because of its opaque nature, hinders the germination of weed seeds in the soil and leading to a reduction in weed population. Similar findings of achieving complete weed management, to an extent of 100% control rate by using agricultural photo selective films were also reported by Vineet and Yadav [4], Gangaiah et al. [5] and Patel et al. [6].through their research findings. The reduction of weeds when intercropped with legumes is due to the interactive effect between the pearl millet and cowpea. The dense vegetation of cowpea creates a smothering effect on weeds. Intercropping with legumes like cowpea hinder the nutrients uptake of weeds by cutting off the weed growth and thus reduces the crop weed competition which leads to reduced weed dry matter production. Usually the most of the effective herbicides of pearl millet are not suitable under legume intercropping system as they are detrimental over broad leaved vegetation, but the pre- emergence spray of pendimethalin can be effectively used to controls the weeds. Further it improves the soil fertility through atmospheric nitrogen fixation and increases the soil microbiome activities. These findings were in agreement with the study made by Aasha et al. [7], Kiroriwal. [8], Asodewine. [9], Meena. [10].

3.2 Effect of mulching methods and legume intercropping on the yield attributes of transplanted pearl millet

The data on the yield attributes and the yield of pearl millet as influenced by the mulching methods and the legume intercropping are presented in Table 2. It is evident from the results that the inorganic mulching with black polythene sheets (T_4) significantly influenced the agronomic traits of pearl millet by registering a higher values of productive tillers (4.11 tillers / plant), earhead length (29.42cm), earhead girth (13.94cm), test weight (13.97g), grain yield (3553.11 kg/ha), stover yield (6473.05 kg/ha) and harvest index (35%). This was statisticallyon par with black silver polythene mulching treatment (T_5.) This was followed by the treatment T_7 - intercropping of cowpea along with the application of pendimethalin, which was statistically on par with the paddy straw mulching treatment (T_3). The unweeded check plot (T_8) register the lower values of yield parameters among all the treatments.

The increased in yield under polythene mulching treatments T_4 and T_5This might be due to the reason that the inorganic polythene mulching materials could have created a favourable micro environment that would have enhanced the plant growth and development by providing perfect weed control, conserving soil moisture, and maintaining stable soil temperatures. The enhanced grain yield and stover yield observed under polythene mulch could be also attributed to the elevation in soil temperature, which could have consequently facilitated an accelerated crop development and biomass accumulation with the increased photosynthetic activity, and efficient translocation of photosynthates from source to sink. This is in line with the findings of Shamla et al. [11],Timsina et al. [12] and Tiwari et al. [13] who also reportedsimilar results from their research work.

3.3. Effect of mulching methods and legume intercropping on the economics of transplanted pearl millet

A non-statistical data on the economics of mulching methods and legume intercropping of transplanted pearl millet is presented in the fig.2.

It is evident from the computation of economics that the higher cost of cultivation per hectare was observed in the treatment T_4 - black polythene mulching (₹ 1, 05,690 ha^{-1}) , but the benefit cost ratio of polythene mulching treatment was very low to an extent of almost comparable with the unweeded control treatment T_8. On the other hand, the treatment T_7 - intercropping of Cowpea along with Pre-emergence application of Pendimethalin 0.75 kg ha^{-1} , registered a higher benefit cost ratio of 2.3. From these result it could be inferred that though the polythene mulches are effective in controlling the weeds and improving yields, they are not economical.

4. CONCLUSION

Based on the results of the experiment it can be concluded that the intercropping of cowpea in pearl millet along with the pre-emergence application of pendimethalin proves to be beneficial and advantageous in terms of returns per rupee invested for profitable crop production, rather than going for polythene mulches. Though the polythene mulches are 99.9 per cent effective in controlling the weeds and enhancing the yield of the crop, at the moment they are not cost effective for a profitable crop production. On the other hand, usage of inorganic mulches has its own drawback of leaving back the non-biodegradable plastic residue in the field which drastically affects the soil health and pollutes the environment. Hence adoption of legume intercropping in pearl millet, along with the usage of mild herbicides like pendimethalin, will be an economically viable and environmentally sustainable weed management practice for improving the yield of pearl millet when compared with the practice of polythene mulching. In this circumstance, there is a desperate need to develop cost effective biodegradable and environment friendly polythene sheets exclusively for mulching purposes in agriculture.

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TABLE 1. Weed density in response to weed management practices (No. m^{-2})

TREATMENT	15 DAT				45 DAT				HARVEST			
	GRASSES	SEDGES	BROAD-LEAF WEEDS	TOTAL	GRASSES	SEDGES	BROAD-LEAF WEEDS	TOTAL	GRASSES	SEDGES	BROAD-LEAF WEEDS	TOTAL
T1- PE of Atrazine 0.5kg/ha on 3 DAT+ 1 HW AT 30 DAT	2.33 (4.92)	2.41 (5.33)	1.77 (1.46)	3.49 (11.71)	1.95 (3.31)	2.37 (5.10)	2.14 (4.08)	3.60 (12.49)	1.96 (3.34)	2.20 (4.35)	2.10 (3.92)	3.48 (11.60)
T2- Two hand weeding at 15 DAT and 30 DAT	3.54 (12.01)	3.39 (10.98)	2.76 (7.12)	5.53 (30.11)	2.20 (4.32)	2.45 (5.51)	2.18 (4.25)	3.82 (14.08)	2.21 (4.39)	2.47 (5.59)	2.26 (4.62)	3.89 (14.60)
T3-Paddy straw mulching at 5t/ha at 3 DAT	1.86 (2.97)	1.96 (3.33)	1.33 (1.27)	2.84 (7.55)	1.40 (1.46)	1.64 (2.18)	1.45 (1.60)	2.40 (5.24)	1.39 (1.42)	1.62 (2.12)	1.58 (2.01)	2.46 (5.53)
T4-Black polythene mulching	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)
T5- Black silver polythene mulching	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)
T6- Intercropping of pulses (Cowpea) (1:1)	2.93 (8.07)	2.99 (8.45)	2.37 (5.75)	4.77 (22.27)	2.92 (8.01)	3.11 (9.19)	2.65 (6.52)	4.92 (23.73)	2.76 (7.10)	3.23 (9.93)	2.67 (6.63)	4.91 (23.65)
T7- Intercropping of pulses (Cowpea) (1:1) + PE pendimethalin 0.75 kg/ha	1.81 (2.79)	1.93 (3.21)	1.30 (1.19)	2.77 (7.19)	1.25 (1.06)	1.32 (1.23)	1.26 (1.09)	1.97 (3.37)	1.27 (1.10)	1.35 (1.31)	1.26 (1.08)	2.00 (3.49)
T8-Unweeded check	3.58 (12.32)	3.45 (11.38)	2.80 (7.34)	5.62 (31.04)	3.85 (14.32)	3.66 (12.89)	3.13 (9.30)	6.08 (36.50)	4.11 (16.42)	3.89 (14.67)	3.45 (11.42)	6.56 (42.51)
SE(d)	**0.29**	**0.21**	**0.08**	**0.13**	**0.22**	**0.2**	**0.17**	**0.37**	**0.23**	**0.2**	**0.18**	**0.39**
CD (5%)	**0.59**	**0.45**	**0.17**	**0.27**	**0.48**	**0.42**	**0.37**	**0.8**	**0.5**	**0.42**	**0.38**	**0.84**

Data are root transformation values of x + 0.5

Data in the parenthesis are raw values.

TABLE 2. No. of productive tillers, Earhead length, Earhead girth, Test weight, Grain yield and Straw yield in response to weed management practices

Treatment Details	Number of productive tillers / Plant	Earhead length (cm)	Earhead girth (cm)	Test weight (g)	Grain yield (kg/ha)	Straw yield (kg/ha)	Harvest index (%)
T1- PE of Atrazine 0.5kg/ha on 3 DAT+ 1 HW AT 30 DAT	2.69	21.41	9.07	13.83	2629.33	5255.51	33
T2- Two hand weeding at 15 DAT and 30 DAT	2.67	20.46	9.01	13.79	2438.51	5171.72	32
T3-Paddy straw mulching at 5t/ha at 3 DAT	3.29	24.92	10.75	13.85	3025.67	5805.45	34
T4-Black polythene mulching	4.11	29.42	13.94	13.97	3553.11	6473.05	35
T5- Black silver polythene mulching	3.90	29.13	13.58	13.94	3465.00	6371.65	35
T6- Intercropping of pulses (Cowpea) (1:1)	2.17	17.72	8.05	13.76	1987.64	4624.80	30
T7- Intercropping of pulses (Cowpea) (1:1) + PE pendimethalin 0.75 kg/ha	3.32	25.32	10.86	13.87	3062.17	5821.42	34
T8-Unweeded check	1.63	14.23	7.08	13.64	1537.21	4098.63	27
SE(d)	0.22	1.10	0.41	1.21	182.72	77.93	-
CD	0.46	2.36	0.88	2.60	391.89	167.14	-

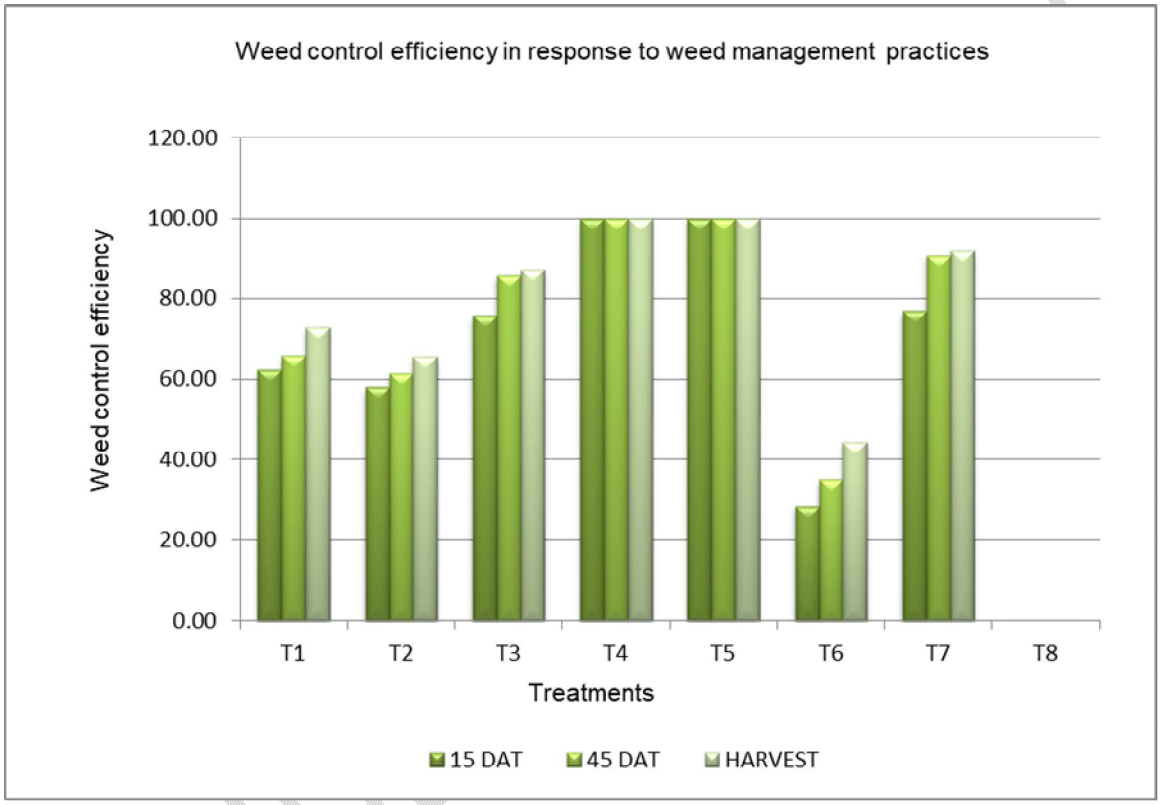

Fig.1. Weed control efficiency (%) in response to weed management practices

The treatments are T_1 - PE of Atrazine 0.5kg/ ha +1 Hand Weeding at 30 DAT, T_2- Two Hand Weeding at 15 and 30 DAT, T_3- Paddy straw mulching at 5t/ ha 3 DAT, T_4- Black polythene mulching at 3 DAT, T_5- Black silver polythene mulching at 3 DAT, T_6- Intercropping of pulses (cowpea) (1:1), T_7- Intercropping of pulses (cowpea) (1:1) + PE Pendimethalin 0.75 kg/ ha, T_8- Un- weeded check.

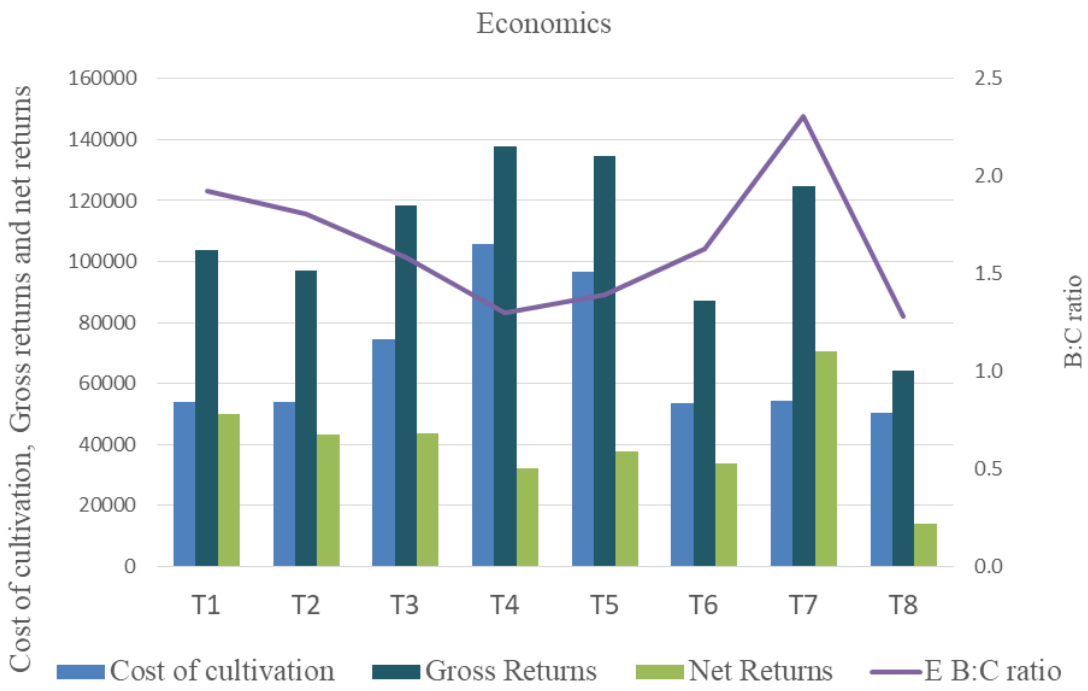

Fig.2. Economics of pearl millet in response to weed management practices

The treatments are T_1 - PE of Atrazine 0.5kg/ ha +1 Hand Weeding at 30 DAT, T_2- Two Hand Weeding at 15 and 30 DAT, T_3- Paddy straw mulching at 5t/ ha 3 DAT, T_4- Black polythene mulching at 3 DAT, T_5- Black silver polythene mulching at 3 DAT, T_6- Intercropping of pulses (cowpea) (1:1), T_7- Intercropping of pulses (cowpea) (1:1) + PE Pendimethalin 0.75 kg/ ha, T_8- Un- weeded check.