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RESEARCH PAPER

Influence of mulching on soil moisture retention, weed dynamics and productivity of pigeonpea [*Cajanus cajan* (L.) Millsp.]

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Abstract: A field experiment was conducted to study the influence of mulching on soil moisture retention, weed dynamics and productivity of pigeonpea [*Cajanus cajan* (L.) Millsp.] at Instructional Farm of College of Agriculture, Vijayapura, during *kharif*- 2023. The experiment was laid out in RCBD with three replications. The experiment consisted of 10 treatments involving mulching with *in situ* sunhemp, bajra, cowpea and greengram at 50 DAS, respectively, *ex situ* mulching with glyricidia, subabul, pongamia at 10 t ha^{-1}, respectively. Dust mulching, Black polyethylene film (30 micron) and control (without mulching). Among the different mulching treatments, significantly higher soil moisture content (%) was recorded with the use of black polyethylene film as compared to all other treatments except *in situ* sunhemp mulching at 50 DAS. Use of black polyethylene film recorded significantly lower weed density as compared to all other treatments. Among the different mulching treatments, significantly higher seed yield (1934 kg ha^{-1}), stalk yield (4727 kg ha^{-1}) was recorded with the use of black polyethylene film as compared to all other treatments except the treatment *in situ* sunhemp mulching at 50 DAS. Significantly higher net return (₹ 101347 ha^{-1}) was recorded with the treatment *in situ* sunhemp mulching at 50 DAS as compared to all other treatments except use of black polyethylene film. *In situ* sunhemp mulching at 50 DAS was recorded significantly higher benefit cost ratio (3.72) as compared to all other treatments. The lower seed yield, net return and benefit cost ratio was recorded with control (without mulching) due to higher weed density and lower soil moisture retention as compared to all other treatments.

Key words: Black polyethylene, Mulching, Moisture, Pigeonpea, Sunhemp, Weed dynamics

Introduction

Pigeonpea [*Cajanus cajan* (L.) Millsp.] commonly known as redgram (Arhar or Tur). India is the world's largest producer of pigeonpea, accounting for 90 per cent of global production. Pigeonpea is one of the world's most significant multifunctional legume crop, planted between 30^0 N and 35^0 S latitudes in both tropical and subtropical conditions. However, the majority of pigeonpea-growing land in India is located between 14^0 and 28^0 north latitudes. It is an important pulse crop that is majorly grown in America, Africa, Australia, the West Indies, Hawaii, Sri Lanka and China. Pigeonpea is a good source of protein (22.3%), minerals (3.5%) and carbohydrates (57.6%) and it has 335 kcal per 100 grams.

India occupies an area of 4.9 million ha with production of 4.22 million tonnes and productivity of 861 kg ha^{-1} (Anon., 2022). Maharashtra, Uttar Pradesh, Madhya Pradesh, Karnataka and Gujrat are major states where pigeonpea is being grown and they occupy 87.9 per cent of area and contribute 86 per cent to the total production. Karnataka occupies an area of 1.63 million ha with the production of 1.23 million tonnes and average productivity of 759 kg ha^{-1} (Anon., 2022). Though pigeonpea may be cultivated in a variety of agro-ecological situations, its deep roots system and drought tolerance make it a desirable crop in locations where rainfall is scarce and unpredictable. Pigeonpea is mostly consumed as a split pulse known as 'dal,' which is high in iron, iodine and important amino acids such as tyrosine, lysine, arginine and cysteine.

Water scarcity is a significant challenge in arid and semi-arid regions. Due to insufficient and irregular rainfall patterns during the crop growth period, it becomes necessary to provide water to the crops through irrigation. With water becoming an increasingly expensive input in agricultural production, it is essential to optimize its usage based on scientific principles and modern concepts. In areas with limited water resources, employing appropriate irrigation methods with moisture conservation techniques is crucial for enhancing crop productivity.

Moisture is a major limiting factor in arid region so, crops are exposed to moisture stress. To alleviate water stress in agriculture, mulching plays a crucial role as a water-saving technique in rain-fed crop cultivation. The primary goal of mulching includes preventing and controlling soil erosion, runoff, reducing water evaporation, enhancing soil moisture levels and stabilizing soil temperature fluctuations. In India, applying mulch to the soil surface is a common practice to decrease evaporation rates and inhibit weed growth thus, conserving moisture. Organic mulches are frequently used to suppress weeds, retain soil moisture, regulate soil temperature and mitigate plant diseases. Inorganic mulching primarily consists of plastic mulch, which is extensively utilized in commercial crop production. The plastic materials commonly employed for mulching are polyvinyl chloride or polyethylene films. Polyethylene film mulch is favored due to its higher permeability to long-wave radiation, which can elevate temperatures around plants during winter nights. A black polyethylene layer serves as an effective weed barrier. It's dark color blocks light, preventing weed seeds from germinating and growing. Consequently, polyethylene film mulch is preferred as a mulching material for crop production.

Organic mulch serves multiple purposes, including soil moisture retention, temperature reduction, soil conservation, weed control and enhancement of soil fertility (Dushouyu *et al*., 1995). Mulching conserves soil moisture levels in the root zone and significantly lowers soil temperatures, creating a more favourable environment for seedling establishment and growth compared to unmulched soil (Osuiji, 1990). Additionally, mulches enhance water infiltration and storage in the rhizosphere, improve soil structure, macro-porosity, reduce runoff, evaporation losses and weeds. (Acharya and Kapur, 1993) given that moisture is the most critical factor limiting growth and development, conserving moisture proves beneficial for crop production.

Material and methods

A field experiment was conducted during *kharif*, 2023 at College of Agriculture, Vijayapura, Karnataka on *vertisol* having pH 8.21 and EC 0.23 dS m^{-1}. The soil was medium in organic carbon content (0.42%) and available P_2O_5 (29.2 kg ha^{-1}) and low in available N (178.5 kg ha^{-1}) with high available K_2O content (407.8 kg ha^{-1}). The experimental site was located at a latitude of 16° 49' North, longitude of 75° 43' East and an altitude of 593.8 meters above mean sea level in Northern Dry Zone of Karnataka (Zone 3). During the year 2023, a total rainfall of 327 mm was received in 30 rainy days from January 2023 to December 2023 as against the normal rainfall of 594.4 mm which was received in 38 rainy days. The highest rainfall of 98.0 mm was received in the month of September followed by July (92.0 mm).

The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. The experiment consisted of 10 treatments involving mulching with *in situ* sunhemp, bajra, cowpea and greengram at 50 DAS, respectively, *ex situ* mulching with glyricidia, subabul, pongamia at 10 t ha^{-1}, respectively. Dust mulching, Black polyethylene film (30 micron) and control (without mulching). The land was ploughed once after the harvest of the previous crop, followed by two harrowing. At the time of sowing, the land was prepared to a fine seedbed and the plots were laid out. The variety GRG 811 was used and fertilizer application was followed on the basis of the plant population occupied by crop. The full recommended dose of fertilizer (25:50:00 kg N:P, O… : K, O per hectare) was applied using urea and diammonium phosphate (DAP). The crop was sown on 19th July, 2023 with a spacing of 120 × 20 cm. Harvesting was done at physiological maturity of the crop. The net plot area as per the treatments was harvested by cutting the plants to the ground level. After harvesting, the plants were bundled and allowed for sun drying. After complete sun drying, the crop was threshed by beating with wooden sticks. The separated seeds were winnowed, cleaned and grain and haulm yield were expressed in kilogram per hectare. The harvest index was calculated using the formula suggested by Donald (1962).

The soil moisture content (%), weed components and yield parameters of pigeonpea were recorded from the net plots and seed yield was converted to hectare basis in kilograms. The economics of each treatment was computed with prevailing market prices of that year. The yield was further computed for gross and net return as well BC ratio to assess the productivity. The benefit-cost ratio was worked out by dividing the gross returns by the total cost of cultivation of respective treatments. The data collected from the experiment at different growth stages and at harvest were subjected to statistical analysis as described by Gomez and Gomez (1984). The level of significance used for 'F' and 't' tests was P=0.05. Critical Difference (CD) values were calculated at 5 per cent probability level if the F test was found to be significant.

Results and discussion

Soil moisture content (%) at 0 - 15 cm and 15 - 30 cm depth of pigeonpea as influenced by mulching treatments during different growth stages (Table 1.)

At 30 DAS, significantly higher soil moisture content was recorded in the treatment (T_9) mulching with black polyethylene film (20.42, 23.42 % at 0 - 15 cm and 15 - 30 cm depth, respectively)

Table 1. Soil moisture content (%) at 0 - 15 cm and 15 - 30 cm depth of pigeonpea as influenced by mulching treatments during different growth stages

Treatments	Soil moisture content (%)					
	30 DAS		60 DAS		90 DAS	
	0 – 15 cm	15 – 30 cm	0 – 15 cm	15 – 30 cm	0 – 15 cm	15-30 cm
T_1: Mulching with *ex situ* subabul loppings at 10 t ha^{-1}	16.01	20.76	16.14	18.12	13.03	16.05
T_2: Mulching with *ex situ* glyricidia at 10 t ha^{-1}	17.43	20.94	17.62	19.56	13.28	15.21
T_3: Mulching with *ex situ* pongamia at 10 t ha^{-1}	15.64	18.83	15.79	18.17	11.48	13.58
T_4: Mulching with *in situ* bajra at 50 DAS	14.95	17.43	18.47	22.27	16.94	18.34
T_5: Mulching with *in situ* cowpea at 50 DAS	16.28	19.48	17.83	19.34	15.95	17.63
T_6: Mulching with *in situ* sunhemp at 50 DAS	19.92	21.61	22.12	23.54	18.91	20.86
T_7: Mulching with *in situ* greengram at 50 DAS	14.69	17.86	16.28	18.35	12.86	14.28
T_8: Dust mulching (repeated intercultivation upto 120 DAS)	18.01	21.12	21.94	22.96	17.15	18.93
T_9: Mulching with black polyethylene film (30 micron)	20.42	23.42	22.67	24.48	19.63	21.56
T_{10}: Control (without weeding and mulching)	12.26	15.14	13.10	15.63	9.17	10.54
S. E m. ±	0.64	0.76	0.71	0.83	0.61	0.60
C. D. (P=0.05)	1.91	2.27	2.10	2.45	1.80	1.77

DAS - Days After Sowing

and was on par with the treatment (T_6) mulching with *in situ* sunhemp at 50 DAS (19.92, 21.61% at 0 - 15 cm and 15 - 30 cm depth, respectively) as compared to all other treatments. Whereas, significantly lower soil moisture content was recorded in the treatment (T_{10}) control (12.26, 15.14% at 0 - 15 cm and 15 - 30 cm depth, respectively) than rest of the treatments. At 60 DAS, significantly higher soil moisture content was recorded in the treatment (T_9) mulching with black polyethylene film (22.67, 24.48% at 0 - 15 cm and 15 - 30 cm depth, respectively) and it was found to be on par with the treatment (T_6) mulching with *in situ* sunhemp at 50 DAS (22.12, 23.54% at 0 - 15 cm and 15 - 30 cm depth, respectively) and the treatment (T_8) dust mulching (21.94, 22.96% at 0 - 15 cm and 15 - 30 cm depth, respectively) compared to all other treatments. Whereas, significantly lower soil moisture content was recorded in control (13.10, 15.63% at 0 - 15 cm and 15 - 30 cm depth, respectively) than rest of the treatments. At 90 DAS, significantly higher soil moisture content was recorded in the treatment (T_9) mulching with black polyethylene film (19.63, 21.50% at 0 - 15 cm and 15 - 30 cm depth, respectively) and was on par with the treatment (T_6) mulching with *in situ* sunhemp at 50 DAS (18.91, 20.86% at 0 - 15 cm and 15 - 30 cm depth, respectively) as compared to all other treatments. Significantly lower soil moisture content was recorded in the treatment (T_{10}) control (9.17, 10.54 % at 0 - 15 cm and 15 - 30 cm depth, respectively) than rest of the treatments. The significant variation in soil moisture content among different mulching treatments is due to covering the soil surface with different crop biomass. Mulch acts as a physical barrier that reduces water evaporation from the soil surface. By covering the soil, the mulch minimizes direct exposure to air and sunlight, which are key drivers of evaporation and also the polyethylene film can create a micro-environment where moisture that evaporates from the soil condenses on the underside of the mulch and drips back into the soil, thus conserving the moisture. Polyethylene films are impermeable, effectively preventing direct soil evaporation and minimizing water losses and erosion from the soil surface. They play a crucial role in conserving soil moisture during dry periods and redirecting excess water away from the crop root zone during periods of heavy rainfall. Polyethylene film significantly decreased water evaporation from the soil surface by 50-80% compared to other mulches. These findings are in line with Allen *et al.* (1998), Aujla and Cheema (1983) and Vinay (2021).

Weed flora in experimental area

The important weed flora observed in association with pigeonpea crop grown in the experimental field of pigeonpea includes monocot weeds like *Cynodon dactylon, Setaria italica, Dinebra retroflexa,, Pennesetum cladertinum* and dicot weeds like *Abutilon indicum, Alternanthera echinata, Argemone mexicana, Amaranthus viridis, Cassia tora, Commelina benghalensis, Convovulus arvensis, Cynotis cucullata, Euphorbia geniculata, Euphorbia hirta, Lagascea mollis, Phyllanthus maderaspatensis, Physalis minima, Portulaca oleraceae, Parthenium hysterophorus* .

Total weed dry weight and weed control efficiency of pigeonpea as influenced by mulching treatments at different growth stages (Table 2.)

Total weed dry weight (g m^{-2})

At 30 DAS, the total weed dry weight differed significantly due to various mulching treatments. Among the different mulching treatments, use of black polyethylene film (T_9) recorded significantly lower (1.85 g m^{-2}) total weed dry weight and it was significant over all other treatments. At 60 DAS, among the different mulching treatments, significantly lower total weed dry weight was recorded in the treatment (T_9) mulching with black polyethylene film (2.13 g m^{-2}) and it was found to be on par with the treatment (T_6) mulching with *in situ* sunhemp at 50 DAS (2.26 g m^{-2}) and the treatment (T_4) mulching with *in situ* bajra at 50 DAS (2.27 g m^{-2}) compared to all other treatments. At 90 DAS, among the different mulching treatments, significantly lower total weed dry weight was recorded in the treatment (T_9) mulching with black polyethylene film (2.43 g m^{-2}) which was significant over all other treatments. Whereas, significantly higher total weed dry weight was recorded in the treatment (T_3) mulching with *ex situ* pongamia at 10 t ha^{-1} (3.12, 4.45, 6.31 g m^{-2} at 30, 60, 90 DAS, respectively) compared to all other treatments. This might be due to black polyethylene film provides a complete barrier to sunlight, which is essential

Table 2. Dry weight of total weeds and weed control efficiency of pigeonpea as influenced by mulching treatments at different growth stages

Treatments	Dry weight of total weeds (g m^{-2})			Weed control efficiency (%)		
	30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS
T_1: Mulching with *ex situ* subabul loppings @ 10 t ha^{-1}	3.07*(8.96)	4.42*(19.13)	5.81*(33.29)	79.60	69.58	74.36
T_2: Mulching with *ex situ* glyricidia @ 10 t ha^{-1}	3.05(8.79)	4.40(18.88)	5.86(33.97)	79.99	69.98	73.84
T_3: Mulching with *ex situ* pongamia @ 10 t ha^{-1}	3.12(9.25)	4.45(19.34)	6.31(39.39)	78.94	69.25	69.66
T_4: Mulching with *in situ* bajra at 50 DAS	2.25(4.57)	2.27(4.66)	3.28(10.27)	89.60	92.59	92.09
T_5: Mulching with *in situ* cowpea at 50 DAS	2.30(4.80)	2.62(6.40)	3.34(10.67)	89.07	89.82	91.78
T_6: Mulching with *in situ* sunhemp at 50 DAS	2.25(4.56)	2.26(4.62)	3.21(9.82)	89.62	92.65	92.44
T_7: Mulching with *in situ* greengram at 50 DAS	2.65(6.53)	2.63(6.43)	3.86(14.47)	85.14	89.78	88.86
T_8: Dust mulching (repeated intercultivation upto 120 DAS)	0.71(0.00)	0.71(0.00)	0.71(0.00)	100.00	100.00	100.00
T_9: Mulching with black polyethylene film (30 micron)	1.85(2.93)	2.13(4.05)	2.43(5.42)	93.33	93.56	95.83
T_{10}: Control (without weeding and mulching)	6.65(43.93)	7.94(62.89)	11.39(129.85)	0.00	0.00	0.00
S. Em. ±	0.13	0.16	0.22	3.11	2.86	2.96
C. D. (P=0.05)	0.18	0.47	0.64	9.24	8.50	8.79

DAS - Days After Sowing

* Square root (“x+0.5) transformed values and the figures in parenthesis indicate the original values

Table 3. Yield and yield parameters of pigeonpea as influenced by mulching treatments recorded at harvest

Treatments	No.of pods plant^{-1}	Seed yield plant^{-1} (g)	Seed yield (kg ha^{-1})	Stalk yield (kg ha^{-1})
T_1: Mulching with *ex situ* subabul loppings @ 10 t ha^{-1}	150.53	26.97	1134	2781
T_2: Mulching with *ex situ* glyricidia @ 10 t ha^{-1}	156.00	29.29	1179	2913
T_3: Mulching with *ex situ* pongamia @ 10 t ha^{-1}	143.13	23.24	1089	2715
T_4: Mulching with *in situ* bajra at 50 DAS	211.44	42.27	1430	3860
T_5: Mulching with *in situ* cowpea at 50 DAS	202.96	40.97	1380	3850
T_6: Mulching with *in situ* sunhemp at 50 DAS	245.14	52.40	1733	4466
T_7: Mulching with *in situ* greengram at 50 DAS	182.98	37.10	1352	3508
T_8: Dust mulching (repeated intercultivation upto 120 DAS)	224.04	47.10	1507	4037
T_9: Mulching with black polyethylene film (30 micron)	269.07	58.53	1934	4727
T_{10}: Control (without weeding and mulching)	92.85	17.02	657	1958
S. Em. ±	8.68	2.07	68.51	162.19
C. D. (P=0.05)	25.77	6.15	203.57	481.90

DAS - Days After Sowing

for the germination and growth of many weed species. By blocking sunlight, black polyethylene film prevents photosynthesis in weed seeds and seedlings, thereby inhibiting their development and reducing weed biomass. It makes difficult for emerging weeds to penetrate and reach the surface. This resulted in lower weed emergence and subsequently lower weed dry weight. These findings are in line with Hamzei *et al*. (2017), Mahajan *et al*. (2007).

Weed control efficiency (%)

At all the crop growth stages, dust mulching (T_8) recorded significantly higher weed control efficiency (100% at 30, 60, 90 DAS) compared to all other treatments. Whereas, Control (T_9) (Weedy check) recorded the lowest (0%) weed control efficiency compared to all other treatments. At 30 DAS significantly higher weed control efficiency was recorded with the use of black polyethylene film (T_9) recorded significantly higher weed control efficiency (93.33%) compared to all other treatments and it was found to be on par with the treatment (T_6) mulching with *in situ* sunhemp at 50 DAS (89.62%), treatment (T_4) mulching with *in situ* bajra at 50 DAS (89.60%), treatment (T_5) mulching with *in situ* cowpea at 50 DAS (89.07%) and the treatment (T_4) mulching with *in situ* green gram at 50 DAS (85.14 %). Whereas, lower weed control efficiency was recorded with the treatment (T_3) mulching with *ex situ* pongamia at 10 t ha^{-1} (78.94%) compared to all other treatments. At 60 DAS, use of black polyethylene film (T_9) recorded significantly higher weed control efficiency (93.56%) compared to all other treatments and it was found to be on par with the treatment (T_6) mulching with *in situ* sunhemp at 50 DAS (92.65%), treatment (T_4) mulching with *in situ* bajra at 50 DAS (92.59%), treatment (T_5) mulching with *in situ* cowpea at 50 DAS (89.82%) and the treatment (T_4) mulching with *in situ* greengram at 50 DAS (89.78 %).Whereas, lower weed control efficiency (69.25%) was recorded with the treatment (T_3) mulching with *ex situ* pongamia at 10 t ha^{-1} compared to all other treatments. At 90 DAS, use of black polyethylene film (T_9) recorded significantly higher weed control efficiency (95.83%) compared to all other treatments and it was found to be on par with the treatment (T_6) mulching with *in situ* sunhemp at 50 DAS (92.44%), treatment (T_4) mulching with *in situ* bajra at 50 DAS (92.09%), treatment (T_5) mulching with *in situ* cowpea at 50 DAS (91.78 %) and the treatment (T_4) mulching with *in situ* greengram at 50 DAS (88.86 %). Whereas, lower weed control efficiency (69.66%) was recorded with the treatment (T_3) mulching with *ex situ* pongamia at 10 t ha^{-1} compared to all other treatments. This was primarily caused by decreased weed dry matter as a result of the mulching effect at the appropriate growth stage. The combination of reduced light availability and increased soil temperature under black polyethylene film synergistically suppresses weed growth throughout the growing season. The results are in conformity with the findings of Barla *et al*. (2018), Waseem *et al*. (2018).

Effect of mulching treatments on yield and yield attributes of pigeonpea as influenced by mulching treatments (Table 3.)

Significantly higher number of pods per plant was observed in the treatment (T_9) use of black polyethylene film (269 pods plant^{-1}) which was found to be superior over all other treatments except the treatment mulching with *in situ* sunhemp at 50 DAS (245 pods plant^{-1}). This might be due to an increased number of branches with more flowers per plant, leading to a higher number of pods formed per plant. The improvement in yield attributes under black polyethylene film can be attributed to the prevention of evaporation loss and weed suppression, better availability of moisture and moderation of the hydrothermal regime, which leads to greater nutrient uptake. These results are in consonance with the findings of Savani *et al*. (2017), Jadav *et al*. (2020) and Kumar *et al*. (2022). The seed yield per plant (g) varied significantly with different mulching practices. Use of black polyethylene film (30 micron) recorded significantly higher seed yield per plant (58.53 g plant^{-1}) compared to all other treatments except with *in situ* sunhmep mulching at 50 DAS (52.40 g plant^{-1}). This was due to a higher number of pods per plant and more seeds per pod. Whereas, significantly lower seed yield per plant was recorded in control (17.02 g plant^{-1}) than other treatments. This might be due to the suppression of growth by weeds, consequently fewer pods per plant and lower seed yield per plant. These findings are in line with the findings of Awodoyin *et al*. (2007) and Ashrafuzzaman *et al*. (2011).

Among the different mulching treatments, use of black polyethylene film (30 micron) recorded significantly higher seed yield (1934 kg ha^{-1}) as compared to all other treatments. However, it was on par with the treatment (T_6) *in situ* sunhemp mulching

Table 4. Economics of pigeonpea as influenced by mulching treatments at harvest

Treatments	Cost of cultivation (₹ ha^{-1})	Gross returns (₹ ha^{-1})	Net returns (₹ ha^{-1})	B C Ratio
T_1: Mulching with *ex situ* subabul loppings @ 10 t ha^{-1}	39907	90693	50786	2.27
T_2: Mulching with *ex situ* glyricidia @ 10 t ha^{-1}	40907	94285	53378	2.30
T_3: Mulching with *ex situ* pongamia @ 10 t ha^{-1}	41907	87109	45202	2.08
T_4: Mulching with *in situ* bajra at 50 DAS	37276	114408	77132	3.07
T_5: Mulching with *in situ* cowpea at 50 DAS	37371	110427	73056	2.95
T_6: Mulching with *in situ* sunhemp at 50 DAS	37280	138627	101347	3.72
T_7: Mulching with *in situ* greengram at 50 DAS	37471	108192	70721	2.89
T_8: Dust mulching (repeated intercultivation upto 120 DAS)	38407	120584	82177	3.14
T_9: Mulching with black polyethylene film (30 micron)	60557	154714	94157	2.55
T_{10}:Control (without weeding and mulching)	28307	52523	24216	1.86
S. Em. ±	-	5481.11	5481.11	0.13
C. D. (P=0.05)	-	16285.23	16285.23	0.40

DAS – Days After Sowing, BC ratio- Benefit cost ratio

at 50 DAS (1733 kg ha^{-1}). Whereas, lower seed yield was recorded with the control (657 kg ha^{-1}). The higher seed yield in these treatments could be attributed to higher available soil moisture, higher weed control efficiency resulting in lesser crop-weed competition. Mulching helps to reduce moisture evaporation from the soil, maintains optimum temperature and reduces weed growth, thereby creating a favorable environment for better crop growth and higher yield. These above results were in conformity with findings of Solanki *et al.* (2012), Shah *et al.* (2014), Savani *et al.* (2017) and Jadav *et al.* (2020).

Significantly higher stalk yield was recorded in the plots where mulching with (4727 kg ha^{-1}) black polyethylene film (30 micron) was done and it was on par with the treatment (T6) mulching with *in situ* sunhemp at 50 DAS (4466 kg ha^{-1}). Whereas, significantly lower stalk yield was recorded in the treatment control (1958 kg ha^{-1}). The increased stalk yield in these treatments could be attributed to improved plant growth and an increased number of branches, which allowed the crop to utilize resources more efficiently, resulting in higher dry matter production. Total dry matter production is a function of photosynthetic activity. The rate of photosynthesis was higher due to optimal moisture and nutrient availability throughout the entire crop growth period under black polyethylene film. This may also be attributed to increased moisture availability, resulting in taller plants, more branches per plant, higher leaf area per plant and ultimately higher stalk yield. Mulching reduces competition for nutrients and space by suppressing weeds, which promotes vigorous plant canopy growth and increases stalk yield. These findings are in line with Ghadage *et al.* (2005), Swathi *et al.* (2018) and Solanki *et al.* (2019).

Effect of different mulching treatments on economics of pigeonpea (Table 4.)

Higher cost of cultivation was recorded in the treatment (T_9) use of black polyethylene film (₹ 60557 ha^{-1}) which was followed by the treatment (T_3) mulching with *ex situ* pongamia at 10 t ha^{-1} (₹ 41907 ha^{-1}) and treatment (T_2) mulching with *ex situ* glyricidia at 10 t ha^{-1} (₹ 40907 ha^{-1}) compared to all other treatments.

Higher gross return was recorded in the treatment (T_9) use of black polyethylene film (₹ 154714 ha^{-1}) and it was found to be on par with treatment (T_6) mulching with *in situ* sunhemp at 50 DAS (₹ 138627 ha^{-1}) compared to all other treatments. Whereas, lower gross return was recorded in the treatment (T_{10}) control (₹ 52523 ha^{-1}) than rest of the treatments. Higher gross income obtained in these treatments was attributed by higher economic yield. However, higher net return was recorded in the treatment (T_6) mulching with *in situ* sunhemp at 50 DAS (₹ 101347 ha^{-1}) and it was found to be on par with treatment (T_9) mulching black polyethylene film (₹ 94157 ha^{-1}) compared to all other treatments. Whereas, lower net return was recorded in the treatment (T_{10}) control (₹ 24216 ha^{-1}) than rest of the treatments. The higher net returns in these treatments could be due to lower cost of cultivation and higher seed yield of pigeonpea.

With regard to benefit cost ratio, it differed significantly due to various mulching treatments. Significantly higher B:C was recorded with (T_6) *in situ* sunhemp mulching at 50 DAS as compared to all other treatments. Even though, the highest yield was recorded from black polyethylene film but, the benefit–cost ratio was higher from *in situ* sunhemp mulching at 50 DAS because higher cost of polyethylene film leads to lower cost of cultivation. Similar results were obtained with Nooli (2001), Chavan (2020) and Venkatalakshmi *et al.* (2023).

Conclusion

The use of black polyethylene film (30 microns) resulted significantly higher soil moisture content, weed control efficiency, higher seed yield but, initial cost was high. While, *in situ* sunhemp mulching at 50 days after sowing (DAS) recorded same level of seed yield, soil moisture content, weed control efficiency and output energy along with higher benefit–cost ratio due to its low cost.

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