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Effect of mulching on growth and yield of Sesame under Custard apple based Agri-horticulture system

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Abstract
Subabool leaf mulch revealed significantly tallest plant, maximum dry matter accumulation plant^{-1}, higher leaf area plant^{-1}, maximum number of branches plant^{-1} as compared to other leaf mulching treatments. The number of capsules plant^{-1} varied significantly due to leaf mulching. The number of capsules plant^{-1} was observed significantly highest with Subabool leaf mulching than rest of mulching treatments. Subabool leaf mulching recorded significantly higher capsule length as compared to other mulch treatments. Seed yield, Stover yield, and biological yield (kg ha^{-1}) of sesame was observed maximum in Subabool leaf mulching followed by, Cassia, Albizia and Control (no mulching) respectively.

Keywords: Agroforestry system, mulching, growth attributes and yield

Introduction
Agroforestry is a land use that involves deliberate retention, introduction, or mixture of trees or other woody perennials in crop and or animal production fields to benefit from the resultant ecological and economic interactions (Nair, 1992) [10]. Custard apple (*Annona squamosa* L) (Family: Annonaceae), is also known as the sugar apple or custard apple (in India) or sweetsop. Custard apple is a fruit tree cultivated in different tropical countries around the world for its sweet and delicious fruits. This plant is a rich source of pharmaceutically important anticancer compound acetogenins (AGEs) (Liaw *et al*., 2010) [9]. In India, an estimated area and production of custard apple is 44,000 ha and 3,67000 tons. The area under custard apple in Karnataka is 1,800 ha with production of 13,400 tons and productivity of 7.4 tons ha^{-1} (NHB, 2017-18). The leaves are used as a vermicide, for treating cancerous tumors and are applied to abscesses, insect bites and other skin complaints. Rubbings of root-bark are used for toothache. This paper attempts to congregate the nutritional value, phytochemical composition, and medicinal uses of custard apple, (Nair *et al*., 2017) [11]. Sesame (*Sesamum indicum* L.) is an ancient oilseed crop of the world. It is recognized by various names like *Gingely, Til, Simsim, Gergelim, Biniseed* etc. It has earned a poetic label "Queen of Oilseeds" because the seeds have poly un-saturated stable fatty acids, which offer resistance to rancidity. Moreover, its seed is a rich source of edible oil (48-52%) and protein (18-25%). It consists of methionine; tryptophan, vitamin (niacin) and minerals. Hence sesame seeds are called "seeds of immortality". The expeller cake not only serves as good feed concentrate for livestock but also used as organic manure. It is highly esteemed as a livestock feed and also valued as an ingredient of poultry feed because of its high methionine content. India ranks first in area and production of sesame in the world. In 2017-18, current sesame production of India is 0.66 million hectare. The average yield of sesame in India is very low (426.1 kg ha^{-1}). It is widely cultivated in the states of Maharashtra, Uttar Pradesh, Rajasthan, Orissa, Andhra Pradesh, Madhya Pradesh, Tamil Nadu, West Bengal, Gujarat and Karnataka. Gujarat is the leading Sesame producing state contributing 22.3% of total production, followed by West Bengal (19.2%), Karnataka (13.5%). The major management option for manipulating trees in agroforestry are based on the alteration of light (solar radiation) profile and moisture distribution. The option for managing trees are many e.g. pruning, coppicing, pollarding, lopping etc. The impacts of such practices can some time have drastic implication as the removal of above ground portion result in enormous decrease in photosynthesis and tree may die. Mulching is one of the most important ways to maintain healthy landscape plants. Materials known as mulch applied to the soil surface for protection or improvement of the area covered.

Nature produces large quantities of mulch all the time with fallen leaves, needles, twigs, pieces of bark, spent flower blossoms, fallen fruit and other organic material. In agroforestry, the potentially higher productivity could be due to the capture of more growth resources (Anittafanish and Satyapriya, 2013) [4]. The nature of interactions between two components can be described on the basis of observable net effect of one component on another in a system. In a system if the tree and crop components help each other, by creating favorable conditions for their growth in such a way that the Agroforestry systems provides an efficient land use and better economic returns than the corresponding sole crops during early phase of orchard establishment.

Material and Methods

Site Location: The present investigation was carried out at the Agriculture Research Farm of Rajiv Gandhi South Campus, Banaras Hindu University, Barkachha, Mirzapur which is situated in Vindhyan region (25º 10') latitude, 82º 37' longitude and altitude of 147 meters above mean sea level) occupying over an area of more than 1000 ha, where variety of crops like agricultural, horticultural, medicinal and aromatic plants are grown. Vindhyan region comes under rainfed and invariably poor fertility status. This region comes under agro-climatic zone III A (semi-arid eastern plain zone). The climate of Barkachha is typically semi-arid, and characterized by extremes of temperature both in summer and winter with moderate humidity and low rainfall. March to May is generally dry, maximum temperature in summer is as high as 45 ^{0}C and minimum temperature in winter fall up to 10 ^{0}C. The normal period for onset of monsoon in this region is the third week of June and lasts up to end of September or sometimes extends to the first week of October. The annual rainfall of Barkachha was 975 mm in 2018, out of 90% was contributed through south-west monsoon between July to September.

Experiment layout: The experiment was laid out during *kharif* season of the year 2018 in eleven years old custard apple plantation which was planted in August, 2006 at a spacing of 5 × 5 m. Experiment was laid out in Factorial randomized block design having four mulching (Control, Subabol, Cassia, Albezia).

Subabool (*Leucaena leucocephala*) mulch: Soil was covered with *Leucaena leucocephala* mulch thickness 3 cm in between the rows of sesame after 18 days after sowing. Recommended quantity of *Leucaena leucocephala* mulching is 8 ton ha^{-1}. *Leucaena leucocephala* is the best for mulching because it conserves the soil moisture, fastly decomposes in the soil, increase the soil fertility and maintains of C:N ratio also.

***Cassia siamea* mulch:** *Cassia siamea* mulch was used as *Cassia siamea* cover the soil in between the rows of sesame. The thickness of mulching was 3.0 cm. This practice was done 15 days after sowing. It plays a major role in controlling the evaporation losses, conserves the soil moisture and regulates the soil temperature.

***Albezia lebbeck* mulch:** *Albizia lebbeck* leaves were used as mulch to cover the soil in between the rows of sesame. The thickness of mulching was 3.0 cm. This practice was done 15 days after sowing. It plays a major role in controlling the evaporation losses, conserves the soil moisture and regulates the soil temperature.

Results and Discussion

Plant height (cm): Analysis of data revealed that variations in plant height due to different mulches were found significant. It was observed that at 20 DAS, significantly tallest plant (12.57) was recorded with Subabool mulch. However at 20 DAS, all mulches type was found statistically at par among themselves. At 40 DAS (63.44) and 60 DAS (76.05), significantly highest plant height was recorded with Subabool mulch.

Table 1: Effect of mulching level on plant height.

Treatment	Plant Height (cm)		
Mulching	**20 DAS**	**40 DAS**	**60 DAS**
M_1 (Control)	11.00	55.50	66.53
M_2 (Subabool)	12.57	63.44	76.05
M_3 (Cassia)	12.11	61.12	73.26
M_4 (Albizia)	12.15	61.53	73.49
S.Em±	0.20	0.98	1.23
CD (P=0.5)	0.57	2.87	3.60

Dry weight plant^{-1}: There was significant variation found in dry weight plant^{-1} due to mulching at all the growth stages of the observation. At 20 DAS, the maximum dry weight plant^{-1} was observed with Subabool leaf mulch (1.09) and it was significantly at par with Cassia and Albizia leaf mulch. At 40 DAS and 60 DAS, significantly highest dry weight plant^{-1} was found with Subabool leaf mulch and it was also significantly at par with Cassia and Albizia leaf mulch at both the stages.

Table 2: Effect of mulching on dry weight.

Mulching	Dry weight plant^{-1} (g)		
M_1 (Control)	0.96	2.27	5.51
M_2 (Subabool)	1.09	2.60	6.29
M_3 (Cassia)	1.05	2.51	6.06
M_4 (Albizia)	1.05	2.51	6.08
S.Em±	0.02	0.04	0.10
CD (P=0.5)	0.05	0.12	0.29

Leaf area (cm): Subabool leaf mulch at 20 DAS, recorded significantly (58.15) maximum leaf area plant^{-1} as compared to other leaf mulch treatments whereas Cassia (56.02) and Albizia leaf mulch(56.20) found significantly at par with each other. At 40 DAS and 60 DAS Subabool leaf mulch observed significantly (153.61) larger leaf area plant^{-1}and both the stages Cassia (147.99) and Albizia leaf mulch (148.45) were at par with each other.

Table 3: Effect of mulching on leaf area

Mulching	Leaf area (cm)		
	20 DAS	**40 DAS**	**60 DAS**
M_1 (Control)	50.87	135.05	222.56
M_2 (Subabool)	58.15	153.61	253.13
M_3 (Cassia)	56.02	147.99	243.87
M_4 (Albizia)	56.20	148.45	244.62
S.Em±	0.95	2.51	4.24
CD (P=0.5)	2.79	7.36	12.45

Number of primary branches plant^{-1}: Primary branches plant^{-1} as affected by mulching was found significant at all the crop growth stages. Primary branchesplant^{-1} at 40 DAS was observed maximum (10.66) with Subabool leaf mulch whereas Albizia and cassia leaf mulch was found statistically at par with each other. At 60 DAS, primary branches plant^{-1} was observed highest (14.59) with Subabool leaf mulch and it was also significantly at par with cassia and Albizia leaf mulch.

Table 4: Effect of mulching on primary branch.

Mulching	Primary branch	
	40 DAS	60 DAS
M_1 (Control)	9.32	12.73
M_2 (Subabool)	10.66	14.59
M_3 (Cassia)	10.27	14.06
M_4 (Albizia)	10.33	14.10
S.Em±	0.16	0.23
CD (P=0.05)	0.48	0.67

Number of secondary branches plant^{-1}: Number of secondary branches plant^{-1} with Subabool leaf mulch was recorded statistically maximum at all the growth stages. At 40 DAS (10.92) and 60 DAS (8.73), higher secondary branches plant^{-1} was recorded with subabool leaf mulch and it as statistically at par with cassia and Albizia leaf mulch respectively.

Number of capsules plant^{-1}: Data on number of capsules plant^{-1} revealed that the effect of mulching was found significant. Subabool leaf mulch recorded significantly highest (34) number of capsule plant^{-1} whereas cassia and Albezia leaf mulch was statistically at par to each other.

Number of seeds capsule^{-1}: The significantly maximum number of seeds (62.49) capsule^{-1} was recorded with Subabool leaf mulch and Albizia and Cassia leaf mulch was found significantly at par with each other.

Capsule length (cm): Critical analysis of data showed that the Subabool leaf mulch recorded maximum length (2.70) of capsule and Albizia and cassia leaf mulch was found statistically at par with each other.

Table 5: Effect of Mulching on yield attributes at harvest

Treatment	Yield attributes at Harvest		
Mulching	No. of capsules (plant^{-1})	Capsule length (cm)	No. seeds (capsule^{-1})
M_1 (Control)	29.97	2.36	54.89
M_2 (Subabool)	34.00	2.70	62.49
M_3 (Cassia)	32.76	2.60	60.20
M_4 (Albizia)	32.86	2.61	60.94
S.Em±	0.54	0.04	0.98
CD (P=0.05)	1.59	0.12	2.87

Seed yield (kg ha^{-1}): Data indicates that the effect of mulching on seed yield was observed statistically significant. Higher seed yield (521.89) was found with Subabool leaf mulch and it was statistically significant.

Biological yield: The statistical examination of data reflected significant variations were found on biological yield (kg ha^{-1}) due to mulching. Maximum biological yield (3458.81 kg ha^{-1}) was observed with Subabool leaf mulch whereas minimum yield (2746.47 kg ha-1) recorded in control.

Stover yield (kg ha^{-1}): Examination of data pertained that significant variations on Stover yield (kg ha^{-1}) were found due to mulching and phosphorus levels. Subabool leaf mulch was produced higher Stover yield (2936.92 kg ha^{-1}).

Harvest index (%): Harvest index (%) as affected by leaf mulch was found significant and Subabool leaf mulch gain highest harvest index (17.09%) as compared to other leaf mulch treatments and it was also found statistically at par with Cassia and Albizia leaf mulch treatments.

Table 6: Effect of Mulching on yield & Harvesting Index

Treatment	Yield			Harvesting index (%)
	Seed yield (kg ha^{-1})	Stover yield (kg ha^{-1})	Biological (kg ha^{-1})	
Mulching				
M_1 (Control)	372.41	2374.06	2746.47	14.80
M_2 (Subabool)	521.89	2936.92	3458.81	17.09
M_3 (Cassia)	429.17	2766.48	3195.65	14.80
M_4 (Albizia)	423.15	2583.03	3006.18	15.57
S.Em±	7.02	46.75	48.82	0.29
CD (*P*=0.5)	20.59	137.12	143.18	0.86

Discussion

Growth attributes: Results of experiment revealed that growth of sesame showed significant variations due to tree leaf mulch and different phosphorus levels. Type of leaf mulch *Leucaena leucocephala* recorded higher growth parameters viz., plant height, leaf area index plant^{-1}, dry weight plant^{-1}, primary branches plant^{-1}and secondary branches plant^{-1}.The increase growth parameters may be attributed to increased cell division on one hand due to sufficient supply of nitrogen, phosphorus and potassium by different fertility levels and genetic character of variety. Vegetative growth mainly consist of the formation of new leaves, stem, root and these meristematic tissues have a very active protein metabolic and photosynthetic transported to these sites are used predominantly in the synthesis of protein.Mulching brings about moisture conservation at the root zone and hence prevent leaching of fertilizer nutrients thereby promoting growth and yield parameters (Eifediyi *et al.*, 2016) [5]. Mulch is a rich basis of organic matter to the soil and when it decays with successive mineralization discharges nutrients that are useful to plants; hence increased growth attributes of sesame (Liasu and Achakzai, 2007) [8]. It is obvious that mulching leads to better plant growth by changing the micro-climate by conserving more moisture through reducing evaporation, modifying soil temperature, controlling weeds and thus, economizing the use of irrigation water. More ever, adequate presence of moisture to plants results in full cell turgidity and eventually higher meristematic activity, leading to more foliage development, greater photosynthetic rate and consequently better plant growth. This may be due to antagonistic behaviour of one nutrient over the other, which may have promoted vegetative growth at the expense of seed formation. Sesame as very sensitive to water stress at seedling stage. The no mulch treated plot showed poor soil moisture conservation as compared to treated plots. This could be due to poor infiltration via impact of raindrop on soil physical characteristics or high evaporation rate. The mulching had sealed significant amount of soil moisture created favourable atmosphere for escaping water stress in this sensitive stage. Our finding with agree Silva *et al.*, 2016

[14], El Harfi *et al.*, 2016 [16]. The higher dry matter accumulation @ 8 t ha^{-1} of Subabool mulch be possible by the result of growth periods 60 DAS and at harvest were significant. A higher leaves $plant^{-1}$ under the influence of quality of Subabool mulch at harvest was recorded. It seems to have increased absorption and utilization of radiant energy resulting high dry matter accumulation by crop. Under field condition, the rate of mulch decomposition was primarily dictated, among other factors, by environment and mulch quality. The decomposition process is normally accompanied by release of both nutrients and Phyto-toxic products. Where the release of nutrients is sufficient to offset the inhibitory effects of Phyto-toxic compounds, there would be net increase in dry matter yield. The maximum dry matter accumulation in plant at those treatments could be due to significant soil moisture conservation and reduced weed infestation. The non-mulch covered plot showed poor overall dry matter accumulation a symptom that consistently occurred in flat land preparation without mulch. This result is in line agree with Amoghein *et al.* (2013) [3] Ozkan and Kulak, (2013) [13].

Yield attributes and yield: Yield attributes *viz*, number of capsule $plant^{-1}$, no. of grain $capsule^{-1}$, capsule length, test weight etc. as influenced by mulching. Subabool mulching significant increase the number of grains per capsule, test weight and grain yield. Enhanced vegetative growth in term of dry matter production and capsules $plant^{-1}$ provided more sites for the translocation of photosynthetic and ultimately resulted in increased the yield attributes with increase in dry matter and photosynthetic products, coupled with efficient translocation, plant produced more grain weight per capsule with more number of grains $capsule^{-1}$ and higher test weight. The significant increase in grain yield, straw yield, biological yield, and harvest index appeared to be an account of the beneficial effect of mulch on growth and yield attributes which finally reflected in higher yield of sesame. The highest yield produced at those treatments could be due to their significant effect on plant height, stand per m^2, number of capsule per plant, number of seed per capsule and thousand seed weight, while the bare treatment showed poor performance on yield component. This result agreed with Ajibola *et al.* (2014) [2], Adesina *et al.* (2014) [1] and Gruber *et al.* (2008) [7].

Conclusion
On the basis of experimental findings, the following conclusion may be drawn: Application of subabool leaf mulch proved most effective for increasing growth and yield in the agro-ecological conditions of district Mirzapur.

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