Performance of Offseason Okra underProtected Structures in Semi-Arid Region

ABSTRACT

Okra is a staple vegetable in Indian cuisine which is extensively cultivated year-round due to its rich composition of essential minerals, vitamins, carbohydrates, proteins and dietary fiber. The primary objective of this research was to investigate the impact of mulching and protective structures on okra cultivation during the winter period(off-season).Consequently, okra seeds were planted in three distinct environments: a Net-cum-poly house equipped with a ridge vent, Net-cum-poly house lacking a ridge vent and an open field. These environments were combined with three different mulch conditions: silver-black plastic mulch, black plastic mulch, and no-mulch. The experiment employed a two-factor large-plot design with four replications.The findings of this study revealed the substantial influence of mulching and protective structures on off-season okra cultivation. Key agronomic parameters, including stem diameter (17.20 mm), plant height (164 cm), internode length (18 cm), the number of fruits per plant (35), fruit weight per plant (367.31gm) and overall fruit yield (19755 kg/ha) exhibited statistically significant improvements in the combination of a Net-cum-poly house without a ridge vent and silver-black plastic mulch.In terms of water management, irrigation volumes delivered under mulched and non-mulched conditions were 387 mm and 446 mm respectively for the open field, while the corresponding figures for the protected environment were 319 mm and 366 mm. The highest water use efficiency was observed 61.97 kg/ha-mm in treatment combination with silver black plastic mulch and Net-cum-poly house without ridge vent.Notably, mulching resulted in a 13.34% reduction in water consumption compared to the non-mulched open field. In the protected environment, water savings reached 28.43% under mulch and 17.76% under no-mulch conditions relative to the non-mulched open field.

Key words: Net-cum-poly house, mulch, off season Okra, Water use efficiency

---

INTRODUCTION

Okra (*Abelmoschus esculentus* L. *Moench*), commonly referred to as *Bhindi* or Lady's finger, stands as a prominent vegetable crop in India. Okra boasts an average composition of 89% moisture, 33 calories of energy, 1.9 grams of protein, 0.2 grams of fat, 7.5 grams of carbohydrates, 0.7 grams of minerals, and 3.2 grams of fiber per 100 grams of edible portion (Anon., 2020a). It holds the distinction of being the most fiber-rich vegetable. Okra finds cultivation across various states in India, including Gujarat, where it is predominantly grown as a Kharif or summer crop. Winter, owing to its lower temperatures, is unsuitable for okra cultivation, as this crop thrives in warm conditions with abundant sunshine and an optimal temperature range of 25 to 35°C, with a minimum of 18°C and a maximum of 35°C. The lower temperatures during winter hamper the germination and growth of the okra crop, rendering winter cultivation in open field conditions unfeasible (Anon., 2020b).

The substantial economic value attached to okra crops necessitates the pursuit of enhanced quality and the extension of the growing season. The economic viability of summer okra cultivation could be significantly augmented through the realization of off-season production, specifically, winter season cultivation(Meenakshi and Chattopadhyay, 2017, Jayasurya *et al.*, 2021). An ideal environment for seed germination and robust okra crop growth can be achieved by employing a Net-cum-poly house with plastic mulching. However, research on okra cultivation with plastic mulches, in conjunction with Net-cum-poly houses, remains limited. Consequently, this study aims to assess the impact of plastic mulches in both protected and open field on the growth and early fruit production of okra.

The primary objectives of this experiment encompass evaluating the influence of plastic mulch on crop parameters and crop yield during off-season okra cultivation within Net-cum-poly houses, with and without ridge vents, as well as in open field conditions. Additionally, this

research seeks to determine water use efficiency under both plastic mulch and no-mulch conditions, both within and outside the structures.

MATERIALS AND METHODS

The Okra variety GJO-H4 was cultivated in raised beds with dimensions of 60 cm (top width), 75 cm (bottom width), and 20 cm (height). The spacing between beds was maintained at 100 cm, while plant spacing was set at 35 cm x 35 cm, with two rows per bed. Two types of GI pipe-framed modified greenhouse structures were employed, namely the Net-cum-poly house with a ridge vent and the Net-cum-poly house without a ridge vent, alongside an open field with dimensions of 12.0 m x 6.0 m as shown in Fig.1 and Fig.2 respectively ((Satasiya*et al.*, 2014)). The aim was to assess the performance of off-season okra cultivation under different structural and mulch conditions.

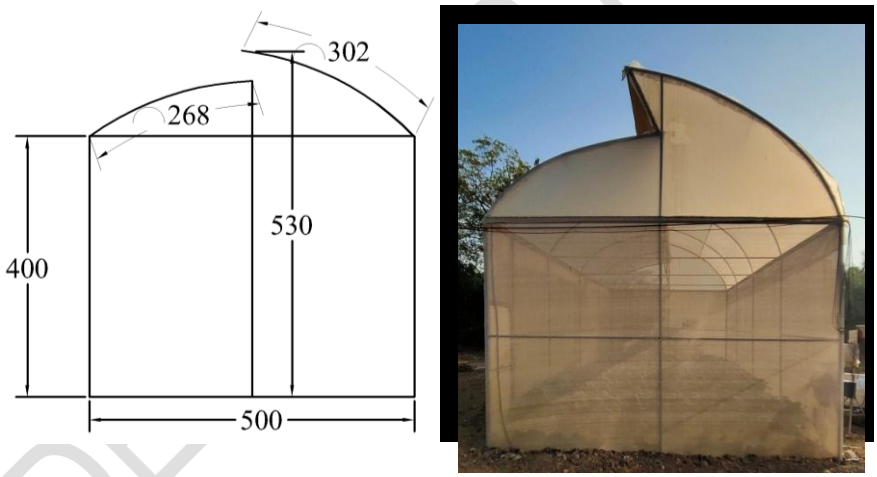


Fig.1 Net-cum-poly house with a ridge vent (all dimension are in cm)

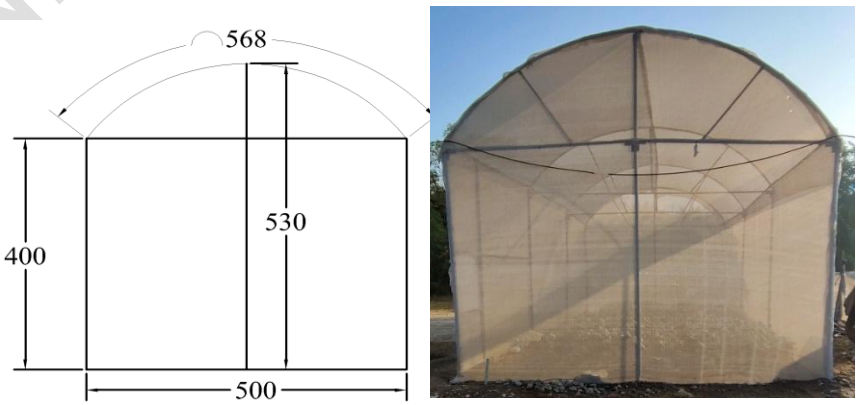


Fig.2 Net-cum-poly house with a ridge vent (all dimension are in cm)

The roof of these structures was covered with a 200 µm thick UVS polyethylene sheet to ensure adequate light levels within. For natural air circulation, the four sides were covered with white shade netting with a shading percentage of 50%. Moreover, the eastern and northern sides were clad with 200 µm thick UVS polyethylene sheets to retain heat during the winter season within the structures. In the Net-cum-poly house with a ridge vent, the ridge vent opening was fitted with insect netting to prevent the entry of insects. Subsequently, three mulch conditions were considered: silver-black plastic mulch, black plastic mulch, and no mulch.

The experimental design adopted was a two-factor large-plot technique with four replications, yielding a total of nine treatment combinations involving different structures and mulching conditions. The soil type used was medium black soil, with the application of nutrients at the rate of N_2: 100 kg/ha, P_2O_5: 50 kg/ha, K_2O: 50 kg/ha through Di Ammonia Phosphate (DAP), Urea (175 kg DAP, 108 kg Urea), and MOP 50 kg/ha as a basal dose before sowing. ~~Okra seeds were manually sown in the experimental plots ().~~ The Physiochemical properties of the soil of experimental site and chemical analysis of irrigation water are presented in Table 1.

Table 1: Physiochemical properties of the soil and irrigation water quality parameters

Sr. No.	Soil		Water	
	Particular	**Values**	**Constituents**	**Values**
1	Bulk density (g/cc)	1.26	Carbonate (meq/L)	1.52
2	Porosity (%)	42.75	Bicarbonate (meq/L)	9.44
3	EC (dS/m)	1.3	Calcium (meq/L)	2.92
4	pH	8.05	Chlorine(meq/L)	5.88
5	Organic Carbon (%)	0.90	Sodium (meq/L)	7.60
6	Potash (kg/h a)	256.7	EC (dS/m)	1.35
7	Phosphorus (kg/ha)	47.7	pH	7.40
8	Nitrogen (Kg.ha)	206.97	Magnesium (meq/L)	3.92
9	Calcium Carbonate (%)	43%	Sodium Absorption Ratio (SAR)	3.61
10	Saturation Percentage (%)	42.75	Salts (g/L)	0.864

Environmental parameters such as air temperature, relative humidity, and light intensity were monitored at 3-hour intervals (9:00, 12:00, 15:00, and 18:00) inside the

structures and in the open field. Okra plant responses were assessed in terms of plant height measured at 120 days after sowing (DAS) and stem diameter recorded at 90 DAS. The weight of fruits, the number of fruits per plant, and the weight of fruits per plant were measured at each picking, while internode length was recorded at the end of the study. An economic analysis was conducted to evaluate the financial viability of the structures compared to open-field okra cultivation under both mulch and no-mulch conditions.

Irrigation water requirement:

The daily crop water requirement was determined by employing the FAO-56 Penman-Monteith equation for both mulch and no-mulch conditions, as detailed by Allen *et al.* (1998). Irrigation was administered in accordance with the actual crop water requirement, utilizing a drip irrigation system.

RESULTS AND DISCUSSION

Crop parameters:

Various crop parameters, including the plant height of okra at 120 days after sowing (DAS), stem diameter at 90 DAS, internode length, the number of fruits per plant, the weight of fruits per plant and overall fruit yield were recorded at the time of harvest. This experiment was conducted during the winter seasons of year 2017 and 2018and the pool data are presented herein.

Effect of mulch on yield and yield attribute:

The effect of mulch on plant height, stem diameter, internodes length, number of fruits/plant, weight of fruits/plant and fruit yield are found significantly higher in silver black plastic mulch as Table 2. Mulching has become an important practice in modern field production due to benefits such as increase in soil temperature (Shilpa *et al.,* 2022, Prajapati and Subbaiah 2019), reduced weed pressure (Zhang *et al.,* 2022), moisture conservation (Khurshid *et al.,* 2006), water saving and increase water use efficiency (Satasiya*et al.,*

2022a), reduction of certain insect pests (Patil *et al.*, 2013), reducer soil erosion (Prosdocimi *et al.*, 2016), higher crop yields (Prajapati and Subbaiah 2018; ~~Nalayini, 2007~~) and more efficient use of soil nutrients. The stem diameter, plant height, internodes length, number of fruits/plant, weight of fruits/plant and fruit yield were recorded as 13.60 mm, 123.54 cm, 12.83 cm, 20.80, 216.68 gm and 10318.13 kg/ha respectively in silver black plastic mulch while it was found minimum in no mulch which was matched withMahadeen (2014), Laxmikanth*et al.,* 2018and. Patil and Tiwari (2018). Similar results were also obtained by Bhardwaj *et al.* 2018 ~~and Ashrafuzzaman*et al.*, 2011~~in chili and Shweta *et al.* 2018 in brinjal cultivation.The results indicate that the use of plastic mulch positively influences the growth and yield of okra which is in line with Thakur*et al* (2020).

Effect of structure on yield and yield attribute

The effect of structure onstem diameter, plant height, internode length, number of fruits/plant, weight of fruits/plant and fruit yield was found significant as shown Table 2. The effect of structure on stem diameter, plant height, Internode length, number of fruits/plant, weight of fruits/plant and fruit yield were recorded 11.91 mm, 114.46 cm, 12.00 cm, 28.02, 284.70 gm and 14253.72 kg/ha respectively which found significantly higher inside the net-cum-poly house without ridge vent as compare to other treatments. The lowestst*em* diameter, plant height, Internodes length, number of fruits/plant, weight of fruits/plant and fruit yield were recorded 5.89 mm, 47.6 cm, 5.58 cm, 3.79, 37.29 gm and 565.94 kg/ha respectively in open field condition.This might be due to plastic covering material create the greenhouse effect, opaque the cold wave and restrict to reduce the mean temperature during the night. Similarly, without ridge vent restrict hot air outside the structure that help to increase the mean temperature during the winter. The open field crop directly comes in contact with cold wave that reduces mean temperature at night which restricts to off season cultivation (Satasiya*et al.,* 2022b).

Table 2: Effect of structure and mulching on internode length, number of fruits/plant, weight of fruits/plant and fruit yield

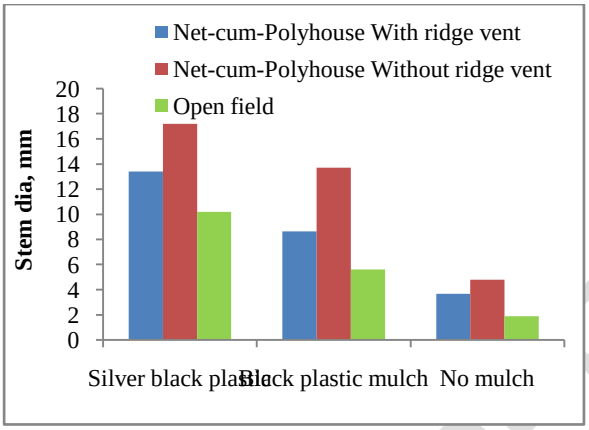
Treatment	Stem diameter at 90 DAS, mm	Plant height at 120 DAS, cm	Internode length, cm	No. of fruits/Plant	Weight of fruit per plant, gm	Fruit yield, kg/ha
Mulching treatment (M)						
Silver black plastic (M_1)	13.6	123.54	12.83	20.79	218.68	10318.13
Black plastic mulch (M_2)	9.32	88.63	8.75	17.04	170.38	7961.68
No mulch (M_3)	3.45	36.29	5.38	12.22	112.43	4445.42
S.Em.±	0.32	2.84	0.37	0.58	10.21	461.03
C.D. at 5%	0.9	8.06	1.05	1.63	62.11	2805.33
Structures (S)						
With ridge vent	8.58	86.35	9.38	18.25	179.5	7905.55
Without ridge vent	11.91	114.46	12	28.01	284.7	14253.72
Open field	5.89	47.65	5.58	3.79	37.29	565.94
S.Em.±	0.59	2.84	0.37	1.76	16.12	981.17
C.D. at 5%	3.61	8.06	1.05	10.69	98.11	5970.31
Interaction effect - M x S						
S.Em.±	0.78	6.96	0.91	1.41	10.4	622.26
C.D. at 5 %	2.2	19.75	2.58	4	29.47	1764.32
Y x M						
S.Em.±	0.45	4.02	0.53	0.81	6	359.26
C.D. at 5 %	NS	NS	NS	NS	36.52	2186.07
Y x S						
S.Em.±	0.45	4.02	0.53	0.81	6	359.26
C.D. at 5 %	1.76	NS	NS	3.2	23.57	1410.64
Y x M x S						
S.Em.±	0.78	6.96	0.91	1.41	10.4	622.26
C.D. at 5 %	NS	NS	NS	NS	NS	NS
CV %	17.66	16.82	20.25	16.9	12.44	16.43

Interaction effect of mulch and structure:

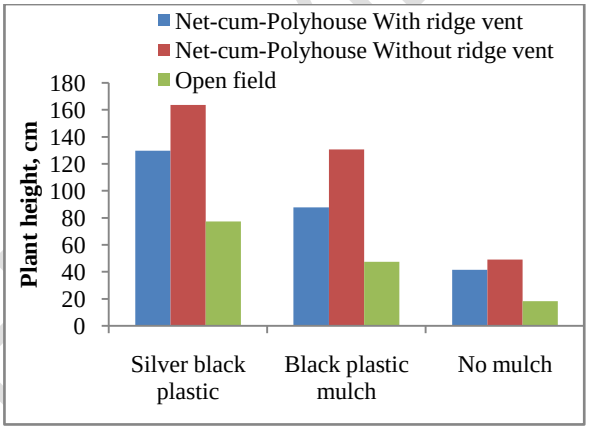
Interaction effect of mulch and structure on yield and yield attribute parameters were found significant (Table 2 and Fig. 3). The stem diameter, plant height, Internode length, number of fruits/plant, weight of fruits/plant and fruit yield were found 17.20 mm, 163.68 cm, 17.63 cm, 34.55, 367.31 gm and 19754.86 kg/ha respectively which is significantly highest

inside the net-cum-poly house without ridge vent with silver black plastic mulch. However it was found minimum in open field under no mulch condition. The similar results found for okra in shade net house by Kakade *et al.*, 2018.

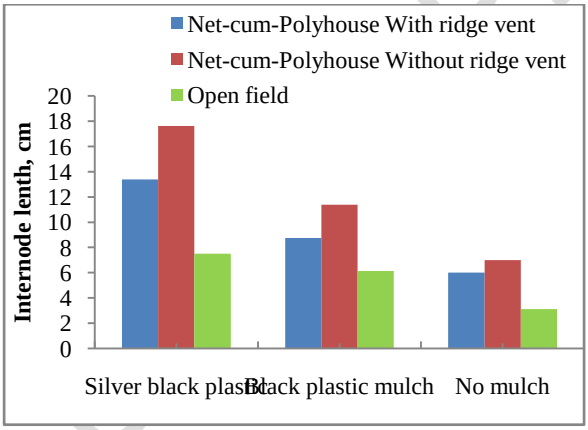
All the crop parameters and yield were found significant effect of silver black mulch and Net-cum-poly house without ridge vent structure. This might be due to climatic temperature inside the net-cum-poly house without ridge vent was recorded higher than open field. Micro climatic condition inside the silver black plastic mulch modified the micro climatic parameter which reported by the many scientists whichfavors the good crop growth.



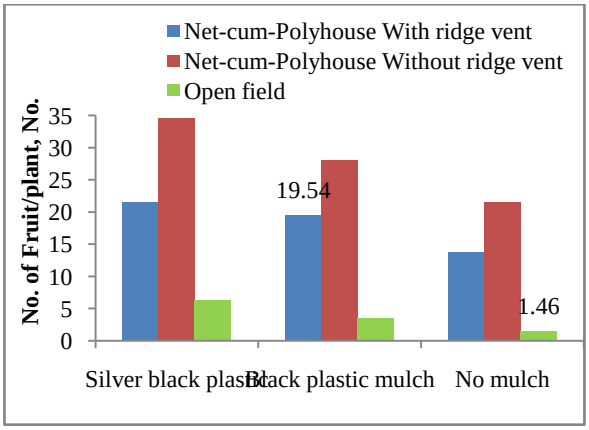
(a) Stem diameter



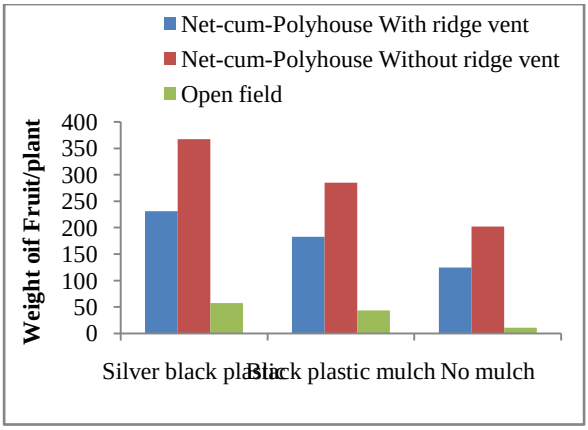
(b) Plant height



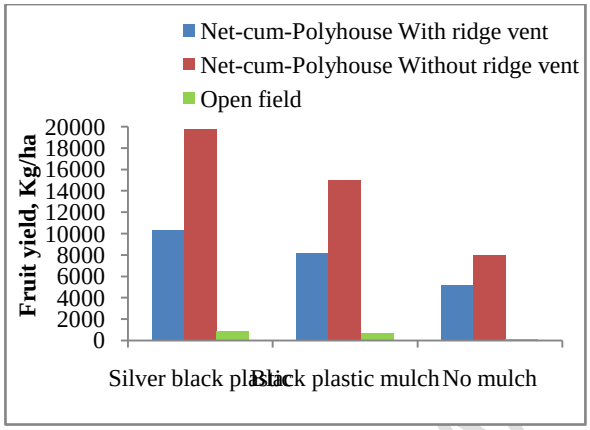
(c) Internode length



(d) Number of fruits/plant



(e) Weight of fruits/plant



(f) Fruit yield

Fig. 3: Interaction effect of structure and mulching on yield and yield attribute

(e) Water use efficiency

Monthly and total depth of water applied and water use efficiency under mulch and no mulch condition for open field and protected environment was calculated. Adoption of drip irrigation system with plastic mulching under protected environment is effective for water saving and increasing the crop yield to a great extent. Initial watering of 50 mm was applied for seed germination and establishment of the crop. Irrigation water delivered under mulch and no-mulch condition was 386.14 mm and 445.58 mm respectively for open field environment whereas it was 318.91 mm and 366.46 mm respectively for protected environment. Water saving under mulch conditionwas 13.34 % over no mulch conditionin open field environment. Water saving for protected environment was 28.43 % and 17.76 % under mulch and no-mulch condition respectively over no mulch condition in open field environment. Maximum water use efficiency (61.97 kg/ha-mm) was found under silver black plastic mulch inside the Net-cum-polyhouse without ridge vent while it was minimum (0.33 kg/ha-mm) in no mulch condition in open field environment.Similar results were alsoreported by Sajid*et al*(2015) in maize, Yaghi*et al* (2013) in cucumber,Razu*et al* (2018) in StrawberryandSatasiya*et al* (2022a) in summer groundnut.

CONCLUSIONS:

Silver black plastic mulch and modified greenhouse structure like net-cum-poly house provide the favorable micro climatic condition to improved crop parameter for off season okra cultivation. The Stem diameter at 90 DAS, Plant height at 120 DAS, Internodes length, number of fruits/plant, weight of fruits/plant and fruit yield were found were found 17.20 mm, 163.68 cm, 17.63 cm, 34.55, 367.31 gm and 19754.86 kg/ha respectively which is significantly highest inside the net-cum-poly house without ridge vent with silver black plastic mulch while it was recorded minimum in open field under no mulch condition.Irrigation water delivered under mulch and no-mulch condition was 386.14 mm and 445.58 mm respectively for open field environment whereas it was 318.91 mm and 366.46 mm respectively for protected environment. Water saving under mulch condition was 13.34 % over no mulch condition in open field environment. Water saving for protected environment was 28.43 % and 17.76 % under mulch and no-mulch condition respectively over no mulch condition in open field environment.Maximum water use efficiency (61.97 kg/ha-mm) was found under silver black plastic mulch inside the Net-cum-polyhouse without ridge vent while it was minimum (0.33 kg/ha-mm) in no mulch condition in open field environment.

REFERENCES

Allen, R. G., Pereira, L. S., Raes, D. and Smith, M. (1998) FAO Irrigation and drainage paper No. 56. Rome: Food and Agriculture Organization of the United Nations.

Anonymous (2020a) Medical news today. Available at https://www.medicalnewstoday.com/articles/311977#nutritional-content

Anonymous(2020b) Climate and Varieties. Available at http://agritech.tnau.ac.in/org_farm/orgfarm_bhendi_climate.html

Bhardwaj, R. L., Sundria, M. M., Kumhar, S. R., and Kumar, N. (2018) Effect of irrigation methods and mulching on growth and yield parameters of chilli (*Capsicumannum*L.) in arid condition. *Journal of Spices and Aromatic Crops*, 27(1):81-87.

Jayasurya, P., Chatterjee, S., Biswas, A., Viswanath, M., and Roy, A. (2021). Low cost protected structures for off-season vegetable production: a review. *The Pharma Innovation Journal*, 10(7), 778-783.

Kakade, S. R., Suchita V. Gupta, Bhagyashree N. Patil and Sanjivani C. Karne. (2018) Study of biometric parameters of okra in different shade net house. *International Journal of Current Microbiology and Applied Sciences*, 7(03)43-53. https://doi.org/10.20546/ijcmas.2018.703.005

Khurshid K, Iqbal M, Arif M. S. and Nawaz A.(2006). Effect oftillage and mulch on soil physical properties and growthof maize. *International Journal of Agriculture and Biology*, 8: 593–96.

Laxmikanth, Mallikarjun, RubeenaTarranum and Kavitha (2018) Effect of colour plastic mulching and different levels of drip irrigation on plant growth parameters of okra (*Abelmoschuses*culentus) Crop. Abstract *Journal of Pharmacognosy and Phytochemistry*. SPI: 3184-3188.

Mahadeen, A. Y. (2014)Effect of polyethylene black plastic mulch on growth and yield of two summer vegetable crops under rain-fed conditions under semi-arid region conditions. *American Journal of Agricultural and Biological Sciences*, 9(2): 202-207.

Meenakshi, A. E. R. C., and Chattopadhyay, S. K. S. (2017). Economic analysis of cost and return of off season vegetables with focus on polyhouse effect. *Methodology*, 17-22.

Patil, A., and Tiwari, K. N. (2018). Evapotranspiration and crop coefficient of okra under subsurface drip with and without plastic mulch. *Current Science*, 115(12), 2249-2258.

Patil, S.S., Kelkar, T.S. and Bhalerao, S.A. (2013) Mulching: A soil and water conservation practice. *Research Journal of Agriculture and Forestry Sciences*. 1(3): 26-29.

Prajapati G. V. and R. Subbaiah (2018). Combined response of irrigation system regimes and mulching on productivity of Bt. Cotton. *Journal of Agrometeorology.* Special Issue "NASA 2014" Part-II. 20:47-51.

Prajapati G. V. and R. Subbaiah (2019). Crop coefficients of Bt. cotton under variable moisture regimes and mulching. *Journal of Agrometeorology. 21 (2):166-170.*

Prosdocimi, M., Tarolli, P., andCerdà, A. (2016). Mulching practices for reducing soil water erosion: A review. *Earth-Science Reviews*, *161*, 191-203.

Razu Ahmed, AlamgirSiddiky, Abu Saleh Md. Yousuf Ali, Khandakar Faisal Ibn Mura and Pijush Kanti Sarkar. (2018)Effect of irrigation and mulch on the yield and water use of strawberry. *International Journal of Agronomy*, 1-10.https://doi.org/10.1155/2018/2903706

Sajid Hussain, Mazhar Iqbal, Muhammad Iqbal, Omar Aziz, Ghulam murtaza, Shazia Iqbal, ShahidMehmood, Tassadduq Rasool (2015)Effect of different irrigation practices and plastic mulch on water use efficiency, growth and yield of spring maize.*Basic Research Journal*, 4(11):1-8.

Satasiya, R. M., Antala D. K., Gupta R. A., Akabari, P. D. and Chauhan P. M. (2014) Development of a poly-cum-shade net house for capsicum cultivation for saurashtraregion of gujaratstate. *Agricultural Engineering Today*, 38(3):28-33.

Satasiya, R. M., Sojitra, M. A., Kothiya, A. V., and Chauhan, P. M. (2022a). Performance of summer groundnut under different types of plastic mulch. *Agricultural Research Journa*l, 59(3): 418-422.

Satasiya, R.M., Sojitra, M. A., Kothiya, A.V., and Chuhan, P.M., (2022b).Effect of protected environment on off-season seedlingraising of papaya. *Environment and Ecology*, 40(2B),650−655.

Shilpa, Sharma, P. and Bijalwan, P. (2022) Effect of mulching on crop production under rainfed condition: A Review. *Agricultural Reviews*, 43(2): 199-204.

Shweta, D., Mal, L. Singh, S. Gharde, P. Kaur and Datta, S. 2018. Effect of mulching in brinjal (*Solanum melongena*L.): A Review. *International Journal of Current Microbiology and Applied Sciences,* 7(6). 504-509. https://doi.org/10.20546/ijcmas.2018.706.056

Thakur, S., Cahuhan, R. P., and Singh, O. P. (2020). Effect of different mulching materials on growth and yield of okra (*Abelmoschusesculentus*L.). *Journal of the Institute of Agriculture and Animal Science,* 197-205.

Yaghi, T., Arslan, A. and Naoum, F. (2013). Cucumber (*Cucumissativus*, L.) water use efficiency (WUE) under plastic mulch and drip irrigation. *Agricultural water management*, 128: 149-157.

Zhang, W., Dong, A., Liu, F., Niu, W. and Siddique, K.H., (2022). Effect of film mulching on crop yield and water use efficiency in drip irrigation systems: A meta-analysis. *Soil and Tillage Research*, 221:105-392.

Fig 4:Protected Structures in Semi-Arid Region

Fig 5: Plant production