maximum temperature (-0.32). A positive and significant correlation was observed with relative humidity (1.00), whereas, negative and significant correlation of disease intensity with minimum temperature. It indicates that as temperature in November goes down with increase in humidity play vital role and congenial for the disease development.

***1st December ($D_5$)***

The simple correlation co-efficient analysis of weather parameters and disease severity revealed a negative correlation of disease intensity with minimum temperature (-0.43) and maximum temperature (-0.98). A positive and non-significant correlation was observed with wind speed (0.62) whereas, a negative and non-significant correlation of disease intensity with relative humidity (-0.90). It shows that high relative humidity is not favourable but cooler the days coupled with wind disseminating the diseases very fast. Sharma (1999) conducted a field trial at Baval, Haryana to study the effect of sowing dates on powdery mildew (Erysiphe polygoni) of fenugreek (Trigonella foenum-graecum). The sowings were done on 5 dates between October 20 to November 30 at an interval of 10 days.

He reported that in early sowings (October 20 and October 30), the disease appeared in the last week of January (*i.e.,* 100 to 105 days after sowing), but it was unable to spread until the first week in March because of the low temperature and low relative humidity. In contrast, the late sown crops (November 20 and November 30), the crop was still at the flowering or pod formation stage when the environmental conditions were more congenial for disease spread. The powdery mildew disease intensity at the two early sowing dates (20th October and 30th October) was comparatively less than the late sowing dates (10th November, 20th November and 30th November). The maximum yield (16.6 q $ha^{-1}$) was obtained from the October 30th sown crop followed by October 20 crop (15.4 q $ha^{-1}$) and November 10 crop (14.5 q $ha^{-1}$). The results indicated that a suitable sowing time would be around October 30 to avoid losses from powdery mildew in fenugreek.

## References

A. O. A. C. 1984. Official method of analysis, Association of Official Agricultural Chemist, 11th Edn., Washington, D.C.

Datar, V. V. and Mayee, C. D. 1981. Assessment of loss in tomato yield due to early blight. *Indian Phytopathology*. 34 (2) : 191-195.

Sharma, S. 1999. Effect of sowing dates on the powdery mildew of fenugreek (Methi). *J. Mycology and Plant Patholo*gy. 29 (1) : 144-145.

Thakur, M. P., Sone, S. K., Khare, N. and Agrawal, K. C. 2004. Effect of sowing dates and varieties on severity and development of powdery mildew of mungbean. *J. Mycology and Plant Patholo*gy. 34 (1) : 83-85.

Wadje, A. G., Suryawanshi, A. P., Gawade, D. B., Kadam, T. S. and Pawar, A. K. 2008. Influence of sowing dates and varieties on incidence of powdery mildew of mungbean. *J. Plant Disease Science.* 3 (1) : 34-36.

Received : August 2017; Revised : October 2017; Accepted : November 2017.

*International J. Seed Spices 8(1), January 2018:74-79*

# Efficacy of soil solarization on growth and yield of cumin (*Cuminum cyminum* L.) under arid conditions

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## Abstract

A field experiment was conducted during 2014 - 2015 at ICAR-National Research Centre on Seed Spices, Ajmer, Rajasthan (India). The experiment was comprised of ten different treatments including, soil solarization alone; soil solarization combined with neem cake and bio-control agent (BCA) and their effect was observed on cumin growth and yield. Higher plant height, more number of primary & secondary branches, more number of umbels plant$^{-1}$, Higher number of seeds umbel$^{-1}$, number of seeds umbellate$^{-1}$, higher test weight (g) and average more straw yield were recorded in treatment (SS-30 day + BCA+ NC). Earliest 50% flowering (60 DAS) was found in two treatments (SS-30 day + BCA+ NC) and (SS-30 day + BCA) and in all other treatments the 50 % flowering was observed earlier than control. Highest number of umbellate umbel$^{-1}$, maximum seed & biological yield (q ha$^{-1}$) were recorded in treatment (SS-30 day + BCA + NC) followed by in treatment (SS-20 day + BCA+ NC). The maximum harvest index (%) was noticed in treatment (SS-20 day + BCA+ NC) followed by treatment (SS-10 day + BCA+ NC). The highest net profit approximately ` 76117.26 ha$^{-1}$ was obtained in (SS-30 day + BCA + NC) followed by ` 67301.26 ha$^{-1}$ in (SS-20 day + BCA + NC) while the minimum net return was recorded in control. The highest cost: benefit ratio (BCR) 1.94 was calculated in treatment (SS-30 day + BCA+ NC) and minimum (1.24) in control.

**Key words :** Bio-control agent, cumin, growth, neem cake, soil solarization, *Trichoderma*, yield.

## Introduction

Cumin (*Cuminum cyminum* L.) is an herbaceous annual plant belongs to Apiaceae family and grow up to a height of 15- 30cm as per environmental conditions. Cumin has been known as one of the most important medicinal plants in Iran (Moraghebi and Aghelpas and, 2008). Adaptation to different environmental condition is one of its characters. Due to low water and fertilization requirement and its high economic value makes it valuable in agriculture (Moraghebi and Etemadzadeh, 2006). The flavoring property of cumin is because of aromatic essential oil, which can be easily steam distilled *in vitro*. According to Singh, 1991 and the main constituent of cumin oil is 'cumin aldehyde', which shows pesticidal activity ('especially antifungal'). The similar anti-fungal substance in cumin oil was also reported, that inhibits the growth of *Fusarium oxysporum*, a fungus responsible for wilt disease in several crops (Agrawal and Gour, 1992). Cumin seeds have an aromatic fragrance due to an alcohol, cuminol. Cumin is produced in Iran, Lebanon, Cypress, Egypt, India, Syria, China, Indonesia, Mexico and Argentina (Karbacy, 2002).

The total spices in India production (2015-16) was 69.01 lac tonnes from the cultivated area of 34.57lac hectare of which cumin production was 5.03 lakh tonnes from 8.08 lakh hectare area (Anonymous, 2016). Globwise India is the largest producer (70% of world production), exporter and consumer of cumin seed across the globe (Shastry and Anandaraj, 2014). In India, cumin is cultivated mainly in Rajasthan, Gujarat and in some part of Madhya Pradesh as a *Rabi* crop. Rajasthan and Gujarat together contribute approximately 90 per cent of total cumin production of the country. Although the cumin production as well as productivity still remains low due to soil borne pests among them the severe weed competition is one of the important factors that is deeded to manage eco-friendly. The present tactics available are either less effective or ecologically not viable hence keeping this in mind the present investigation was carried out to enhance the production and productivity sustainably.

## Material and methods

The experiment was laid down at research farm of



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ICAR-National Research Centre on Seed Spices, Ajmer, Rajasthan, during '*Rabi*' season of 2014-2015. Geographically, the Centre lies on $74^0$ 35' 39" to $74^0$ 36' 01"E longitude, $26^0$ 22' 12" to $26^0$ 22' 31" N latitude and at an altitude of 460.17 m above mean sea level, at Ajmer, Rajasthan.India The region falls under agro climatic zone III of Rajasthan. The soil of research farm is sandy loam, poor in fertility and water holding capacity having pH 8 to 8.3, EC 0.07 to 0.12 and 0.15 to 0.23% organic carbon, available N 178.5 kg $ha^{-1}$ (low), $P_2O_5$ 12 kg $ha^{-1}$ (medium), $K_2O$ 85 kg $ha^{-1}$ (low), Ca 214.7 kg $ha^{-1}$ (high), Mg 258 kg $ha^{-1}$ (medium), S 27 kg $ha^{-1}$ (high). The experiment was comprised of ten treatments including soil solarization (SS) alone and soil solarization (SS) combined with neem cake and bio-control agent (*Trichoderma*) *viz* SS-10 day only, SS-20 day only, SS-30 day only, SS-10 day + BCA, SS-20 day + BCA, SS-30 day + BCA, SS-10 day + BCA + NC, SS-20 day + BCA + NC, SS-30 day + BCA + NC and Control. All the treatments were laid out in randomized block design (RBD) with three replications. Various growth and yield attributes observations were recorded, such as plant height (cm), number of primary and secondary branches, number of umbels $plant^{-1}$, number of umbellate $umbel^{-1}$, number of seed $umbel^{-1}$, number of seeds $umbellate^{-1}$, test weight (g), seed yield (q $ha^{-1}$), straw yield (q $ha^{-1}$) and biological yield (q $ha^{-1}$). Other than the attributes early 50% flowering (days), harvest index (%) was calculated and depend on this net return of treatments calculated to see the best treatments among them. White transparent plastic sheet of 100u was used during summer months (May-June) for soil solarization.

Data collected as mentioned in table-1and table 2 during the present investigation were subjected to statistical analysis by adopting appropriate methods of analysis of variance as described by Cochran and Cox (1967). Whereas, the variance ratios (F-values) were found significant at 5 per cent level of probability, the critical difference (CD) values were computed for making comparison among the treatment means. Summary table along with SEm ± and CD were prepared.

## Results and discussion

### *Growth*

Maximum average plant height (46.78 cm) was reported in the treatment (SS-30 day + BCA + NC) followed by (39.97 cm) in treatment (SS -30 day + BCA), while the minimum average plant height (31.15 cm) was reported in Control / no SS (table 1). Maximum number of primary branches $plant^{-1}$ (8.38) was reported at harvest in treatment SS-30 day + BCA+ NC followed by (7.70) in treatment SS -30 day + BCA, while the minimum (4.24) in control. Maximum number of secondary branches $plant^{-1}$ (21.97) were reported in treatment SS -30 day + BCA+ NC followed by (20.12) in treatment SS -30 day + BCA, while the minimum average number of secondary branches $plant^{-1}$ (9.62) was reported in control (Table 1).These results found were almost similar with those reported by Ashrafuzzaman *et al.,* (2011) in chilli and Rajablariani *et al.,* (2012) in tomato. The data presented in Table1 revealed that plant height was influenced significantly by soil solarization. The plant height was increased maximum in treatment SS-30 day + BCA + NC Followed by treatment SS -30 day + BCA at 40, 80 DAS and at harvest as compared to Control. This was probably due to better control of weeds throughout the crop growth period which might have resulted better availability of moisture and nutrients to the crop. The similar increase in growth parameters under soil solarization was also noticed by Katan and DeVay (1991), Shukla *et al.,* (2000) in aonla, Shirgure (2012) in certain field crops. The increase in plant height at various growth stages was also advocated the initial increase in plant height and plant dry matter was mainly due to enlargement of the cells. These results are in conformity with the finding reported by Mauromicale *et al.,*(2010) in tomato, Mahmood *et al.,*(2011) in cucumber and bitter-gourd, Ashrafuzzaman *et al.,*(2011) in chilli. Thus on one hand profuse branching might have led to formation of maximum number of flowers, and then developed into fertile fruits (umbels $plant^{-1}$). Almost similar findings were also reported by Mahadeen (2014) in okra and squash.

### *Yield attributes*

Results depicted in Table 2 showed that in the treatment SS -30 day + BCA + NC and treatment SS -30 day + BCA the earliest (minimum days) 50 % of flowering occurred after 60 days whereas in Control, 50 % flowering observed after 63 days and this was maximum duration among all the treatments. Soil solarization affects physiological and biochemical process in plants which probably responsible for 50% flowering early in plants. The similar results were also reported by several researches like Goukhand *et al.,* (2003) in okra, Mochiah *et al.,* (2012) in pepper.

The maximum number of umbels $plant^{-1}$ recorded (72.40) in treatment (SS -30 day + BCA + NC) followed by (65.10) in treatment (SS-30 days + BCA) and the minimum number of umbels $plant^{-1}$ was found in (Control). The maximum number of umbellates $umbel^{-1}$ (5.86) was recorded in treatment (SS -30 day + BCA + NC) followed by (5.72) in treatment (SS -20 days + BCA + NC) while the minimum

**Table 1.** Effect of, soil solarization on growth attributes in cumin

| S.no | Treatment | Plant height (cm) | Number of primary branch | Number of secondary branch |
|---|---|---|---|---|
| 1. | SS-10 day only | 33.85 | 6.37 | 10.26 |
| 2. | SS-20 day only | 34.16 | 6.76 | 15.03 |
| 3. | SS-30 day only | 38.65 | 7.64 | 19.99 |
| 4. | SS-10 day + BCA | 36.48 | 6.44 | 13.17 |
| 5. | SS-20 day + BCA | 38.33 | 7.16 | 16.61 |
| 6. | SS-30 day + BCA | 40.65 | 7.70 | 20.12 |
| 7. | SS-10 day + BCA + NC | 38.72 | 6.62 | 13.64 |
| 8. | SS-20 day + BCA + NC | 39.97 | 7.61 | 18.58 |
| 9. | SS-30 day + BCA + NC | 46.78 | 8.38 | 21.97 |
| 10. | Control | 31.15 | 4.24 | 9.62 |
| | S. Em± | 0.46 | 0.04 | 0.21 |
| | CD (P = 0.05) | 1.38 | 0.11 | 0.61 |
| | CV (%) | 6.35 | 6.27 | 6.73 |

Note: SS = Soil solarization
NC = Neem cake
BCA = Bio-control agent

number of umbellates per umbel were found in treatment Control. These results corroborate with those reported by Meena *et al.,* (2014) in fennel.

Results depicted in Table-2 explained that the maximum number of seed umbellate$^{-1}$ (7.06) was recorded in the treatment SS -30 day + BCA + NC followed by (6.87) in treatment SS -30 day + BCA, while the minimum number of seed per umbellate (6.20) was reported in treatment Control. The maximum number of seeds umbel$^{-1}$ (41.37) was recorded in the treatment SS-30 day + BCA + NC followed by (38.91) in treatment SS -30 day + BCA, while the minimum average number of seed umbel$^{-1}$ (31.00) were reported in treatment Control. The highest test weight (3.21 g) was recorded in treatment SS -30 day + BCA + NC followed by (3.20) in treatment SS -30 day + BCA, while the minimum test weight (2.65) was reported in Control.

Summarized results (Table 2) depicted that the maximum seed yield (10.2q ha$^{-1}$) was recorded in treatment SS -30 day + BCA + NC followed by (9.7q ha$^{-1}$) in treatment SS -20 day + BCA+ NC, while the minimum seed yield (2.1q ha$^{-1}$) was recorded in control. Result were almost similar with earlier researchers Soil solarization showed positive effect on plant growth, plant vigour, seed setting and seed quality. Three coloured plastic mulches such as black, red and yellow were effective and significantly increase the growth of cumin plants (Sharma, *et al.*, 2013; Ravinder *et al.,*1997) in tomato; Sekhon *et al.,*(2005) in Soybean (*Glycine max*) and Meena *et al.,*(2014) in fennel.

The maximum straw yield (21.58 q ha$^{-1}$) was recorded in treatment SS -30 day + BCA + NC followed by (15.26 q ha$^{-1}$) in treatment SS -30 day + BCA, the minimum straw yield (5.2 q ha$^{-1}$) was found in Control. The straw yield of cumin was significantly influenced by soil solarization the maximum straw yield was recorded in treatment SS-30 day + BCA + NC followed by in treatment SS -30 day + BCA as compared to Control. In all the treatments the straw yield was reported higher than control. These results were supported by earlier finding of Bakhtiar *et al.,* (2009) in maize. The highest biological yield (31.78 q ha$^{-1}$) was recorded in treatment SS-30 day + BCA + NC followed by (24.70 q ha$^{-1}$) in treatment SS -20 day + BCA + NC, while the lowest biological yield (7.30 q ha$^{-1}$) was reported in Control. The maximum harvest index plant$^{-1}$ (39.27 %) was recorded in treatment SS-20 day + BCA + NC followed by (35.99 %) in $T_7$ SS-10 day + BCA + NC. While the minimum harvest index (28.77 %) was reported in Control. Almost similar results were obtained earlier by Najafabadia *et al.,* (2012) in garlic.

The treatments resulted better growth parameters which ultimately exhibited higher yield attributes and yield. These results corroborate with report of Bakhtiar *et al.,* (2009) in maize. The presented data (Table 2) showed that harvest index was also significantly influenced by in soil solarization and the maximum harvest index was recorded in treatment (SS-20 day + BCA + NC) followed by treatment (SS-10 day + BCA+ NC) as compared to Control.

**Table 2.** Effect of soil solarization (SS) on cumin yield and yield attributes.

| S.no | Treatments | Days taken to 50% flowering | No. of umbels plant$^{-1}$ | No. of umbellate umbel$^{-1}$ | No of seeds umbellate$^{-1}$ | No of seeds umbel$^{-1}$ | 1000 seed weight (g) | Seed yield q ha$^{-1}$ | Straw yield q ha$^{-1}$ | Biological yield q ha$^{-1}$ | Harvest index (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1. | SS-10 day only | 63.00 | 38.00 | 5.20 | 6.40 | 33.28 | 2.77 | 7.52 | 13.53 | 21.05 | 35.72 |
| 2. | SS-20 day only | 62.00 | 41.07 | 5.35 | 6.50 | 34.78 | 2.78 | 8.10 | 14.91 | 23.01 | 35.20 |
| 3. | SS-30 day only | 60.67 | 62.18 | 5.59 | 6.80 | 38.08 | 3.19 | 8.30 | 15.10 | 23.40 | 35.47 |
| 4. | SS-10 day + BCA | 61.33 | 39.93 | 5.23 | 6.43 | 33.63 | 2.82 | 7.55 | 13.60 | 21.15 | 35.70 |
| 5. | SS-20 day + BCA | 62.00 | 42.80 | 5.38 | 6.58 | 35.40 | 2.87 | 8.12 | 14.94 | 23.06 | 35.21 |
| 6. | SS-30 day + BCA | 60.00 | 65.10 | 5.60 | 6.87 | 38.91 | 3.20 | 8.23 | 15.26 | 23.49 | 35.04 |
| 7. | SS-10 day + BCA + NC | 60.67 | 40.20 | 5.27 | 6.47 | 34.06 | 2.96 | 7.68 | 13.66 | 21.34 | 35.99 |
| 8. | SS-20 day + BCA + NC | 61.67 | 45.93 | 5.72 | 6.60 | 35.64 | 2.83 | 9.70 | 15.00 | 24.70 | 39.27 |
| 9. | SS-30 day + BCA + NC | 60.00 | 72.40 | 5.86 | 7.06 | 41.37 | 3.21 | 10.2 | 21.58 | 31.78 | 32.10 |
| 10. | Control | 63.00 | 25.87 | 5.00 | 6.20 | 31.00 | 2.65 | 2.1 | 5.2 | 7.30 | 28.77 |
| | S. Em± | 2.59 | 2.26 | 0.25 | 0.20 | 1.31 | 0.13 | 0.27 | 0.68 | 0.84 | 1.46 |
| | CD (P = 0.05) | 7.69 | 6.72 | 0.74 | 0.58 | 3.88 | 0.38 | 0.80 | 2.03 | 2.49 | 4.33 |
| | CV (%) | 7.30 | 8.28 | 8.01 | 5.13 | 6.35 | 7.55 | 6.01 | 8.29 | 6.59 | 7.25 |

Note: SS = Soil Solarization
NC = Neem cake
BCA = Bio-control agent

## References


Abu-Goukh, A. A. and El-Balla, M. M. A. 2003. Use of plastic mulch for better performance and yield of okra during winter in Sudan. *J.Agricultural Sciences.* 11(2): 165-178.

Agrawal, S. and Gour, H. N. 1992. Anti-fungal substance in the essential oil of cumin. *Proceedings of National Seminar on exploration of indigenous raw materials for essential oil industry*, CIMAP, Lucknow. pp. 102-106.

Anonymous, 2016. Estimated by Spices Board: DASD, Calicut (Kerala). State Agriculture / Horticulture Department (Govt. of India).

Ashrafuzzaman, M., Halim, M. A., Ismail, M. R., Shahidullah, S. M. and Hossain, M. A. 2011. Effect of plastic mulch on growth and yield of chilli (*Capsicum annuum* L.). *Brazilian Archives of Biology and Technology*. 54(2): 321-330.

Bakhtiar, G., Marwat, K. B., Hassan, G., Khan, A., Hashim, S. and Khan, I. A. 2009. Impact of tillage, plant population and mulching on biological yield of maize. *Pakistan J.Botany.* 41 (5): 2243-2249.

Cochran, W. G. and Cox, G. M. 1967. Experimental Designs. 2nd Ed. Jon Wiley and Sons Inc. New York.

Karbacy, A. R. 2002. Economy of cumin Proceeding of Cumin: Technology, Production and Processing. Ferdosi University. Mashhad.

Katan, J. and DeVay, J. E. 1991. Soil solarization: historical perspectives, principles and uses in Plastic mulching (J. Katan and J.E. DeVay, Eds.). *CRC. Press, Boca Raton,* Florida (USA). pp. 23-37.

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 J. Agricultural and Biological Sciences.* 9(2): 202-207.

Mahmood, N., Anees, M., Ahmad, S. and Zakaullah, 2011. Effect of mulching on vegetables production in tunnel farming. *Mycopathologia.* 9(1): 21-24.

Mauromicale, G., Monaco, A. L. and Longo, A. M. G. 2010. Improved efficiency of plastic mulching for growth and yield of greenhouse tomatoes. *Agronomy for Sustainable Development*. 30: 753-761.

Meena, M., Yadav, L. R., Yadav, S. S., Sharma, O. P., Choudhary, G. L. and Choudhary, P. 2014. Response of fennel (*Foeniculum vulgare*) to irrigation and mulching. *J. Spices and Aromatic Crops*. 23(1): 106–109.

Mochiah, M. B., Baidoo, P. K. and Acheampong, G. 2012. Effects of mulching materials on agronomic characteristics, pests of pepper (*Capsicum annuum* L.) and their natural enemies' population. *Agriculture and Biology J. North America*. 3(6): 253-261.

Moraghebi, F., Aghelpasand, A. 2008. The effect of four fertilization treatments on morphology of Isfahan, Khorasan and Erman varieties of *Cuminum cyminum*. *Scientific and Research J. Secience.* 70(1).

Moraghebi, .F, and Etemadzadeh, A. 2006. Principles of plantation of medicinal plants. Share- e- Rey Azad Islamic University.

Najafabadia, M. B. M., Peyvasta, G. H., Asila, M. H., Olfatia, J. A. and Rabiee, M. 2012. Mulching effects on the yield and quality of garlic as second crop in rice fields. *International J. Plant Production.*6(3): 279-290.

Rajablariani, H. R., Hassankhan, F. and Rafezi, R. 2012. Effect of colored plastic mulches on yield of tomato and weed biomass. *International J. Environmental Science and Development.* 3(6): 590-593.

Ravinder, K., Srivastava, B. K. and Kumer, R. 1997. Effect of different mulch materials on the soil temperature and moisture in winter tomato. *Crop Research.* 14: 137-141.

Sekhon, N. K., Hira, G. S., Sidhu, A. S., and Thind, S. S. 2005. Response of soybean (*Glycine max* Mer.) to wheat straw mulching in different cropping seasons. *Soil Use Management*. 21: 422–426.

Sharma, N. C., Sharma, S. D. and Spehia, R. S. 2013. Effect of plastic mulch colour on growth, fruiting and fruit quality of strawberry under polyhouse cultivation. *International J. Bio-resource and Stress Management*. 4(2): 314-316.

Shastry, E. V. D. and Anandaraj, M. 2014. Soils, plant growth and crop production-Cumin, Fennel and Fenugreek, *www.eolss.net/sample-chapters/c10/e1-05a-50-00.pdf* .pp 1-10.

Shirgure, P. S. 2012. Sustainable acid lime fruit production and soil moisture conservation with different mulches. *Agricultural Engineering Today*. 36(3): 21-26.

Shukla, A. K., Pathak, R. K., Tiwari, R. P., and Nath, V. 2000. Influence of irrigation and mulching on plant growth and leaf nutrient status of aonla (*Emblica officinalis* Gaertn.) under sodic soils. *J. Applied Horticulture*. 2(1): 37-38.

Singh, M. and Upadhaya, R. 1991. Fungi toxic activity of cumin aldehyde, the main constituent of the *Cuminum cyminum* oil. *FitoTerapia*. 62: 87.

Received : July 2017; Revised : November 2017; Accepted : December 2017.