Biological Forum
an International Journal 17(3): 32-39(2025)
ISSN No. (Print): 0975-1130
ISSN No. (Online): 2249-3239

Effect of Arbuscular Mycorrhizal Fungi on Growth Parameters of Pea Plant in Mid Hill Region of Mandi District

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(Received: 20 December 2024; Revised: 24 January 2025; Accepted: 10 February 2025; Published online: 08 March 2025)
(Published by Research Trend)

ABSTRACT: Arbuscular mycorrhizal fungi associate symbiotically with the roots of nearly all land-dwelling plants, promoting growth and productivity, especially during periods of abiotic stress. VAM supports the uptake of minerals, water, and phosphorus, among other nutrients, which improves plant growth and aids in the defence against biotic and abiotic stresses. The current study aimed to find out how Arbuscular Mycorrhizal fungal spores affected the growth results of peas (*Pisum sativum* L.). The soils utilised in the pot experiment were gathered from the experimental fields at Abhilashi University. Sterile soil and sterile Farm Yard Manure (FYM) were mixed and put into the pots. Two pea seeds were inserted into each of the selected experimental pots. The four AM fungi that were utilised to inoculate experimental pots were *Acaulospora denticulata, Acaulospora nicolsonii, Glomus fasiculatum* and *Gigaspora margarita.* Root length, total number of leaves, plant height, and leaf length were all used to assess the effects of mycorrhizal fungi. The results show that fungus has a major impact on the peas plant in their height, leaf length, root length, total number of leaves and total number of roots. It was also concluded that mycorrhizal fungal showed symbiotic association with *Pisum sativum* L. plants. Based on these findings, AMF can significantly improve specific pea growth traits.

Keywords: Pea (*Pisum sativum* L.), Arbuscular Mycorrhizal fungi, inoculum, Mutualistic association, Growth parameters.

INTRODUCTION

The pea (*Pisum sativum* L.), most common leguminous, herbaceous annual crop plant, is a member of the Fabaceae family. "Faba" is derived from a Latin word that simply meaning "beans", is one of the earliest crops to be grown. It is widely farmed on six million hectares of land globally and is the third most significant pulse crop. The crop is grown all throughout the world, notably in India. This crop is commonly grown as a major human food supply and to help regulate soil fertility, particularly in arid areas. India ranks fifth in terms of pea production and fourth in terms of the land used for pea cultivation. Peas are mostly grown as a vegetable in the plains and hills of northern India. Its seeds are used as vegetable and a good source of zinc, vitamins and other antioxidants. Therefore plant have anti-inflammatory and immunological properties. Himachal Pradesh is the fifth-largest producer of peas, accounting for 5.79 percent of the country's total output. On 26000 hectares of land, the state produced 328.80 thousand tonnes of peas during the 2021–2022 growing season (Abedi and Esfandiari 2017; Millar *et al.*, 2019; Senapati *et al.*, 2019; Mondor, 2020; FAO, 2014).

Soil microorganisms known as arbuscular mycorrhizal fungi (AMF) coexist independently with the majority of terrestrial plants. Plant-associated mycorrhizal fungus form mutualistic symbiotic partnerships with delicate plant roots. Mycorrhizal fungi are believed to colonise about 90% of terrestrial plants. They are known to create resistance mechanisms throughout the plant, increasing its capacity to tolerate a variety of biotic and abiotic stimuli. Reducing chemical inputs is increasingly important to build a more sustainable agriculture economy. These fungi help improve the absorption of water, nitrogen, and immobile or fixed ions and are found in the rhizosphere of plants. The host plant provides carbon molecules to the fungus, which is advantageous to it (Gaur, 1998; Lin *et al.*, 1991; Sieverding, 1991; Stubblefield *et al.*, 1987; Kristek, 2005; Dipake *et al.*, 2022). It is more essential nutrients which improves their overall performance of the plant. Plant health and stress tolerance are enhanced by mycorrhizal fungi, which also increase resilience to disease and drought. Furthermore, the relationship

between these fungi improved the success rate of transplanting and decreased the need for fertiliser and watering for plants. The rhizosphere of numerous plants, such as *Pisum sativum*, *Triticum aestivam, Zea mays,* and *Hordeum vulgare*, has been isolated and identified by other researchers in the past (Thangavelu and Raji 2016; Yaseen *et al.,* 2016; Millar *et al.,* 2019; Begum *et al.,* 2019; Johny *et al.,* 2021; Surayya *et al.,* 2021; Aishwarya *et al.,* 2022; Kaundal and Singh 2022). Soylu *et al.* (2023) revealed higher root length and a high mycorrhizal dependency (71.9%) with mycorrhiza inoculation. Manjula *et al.* (2022) found that arbuscular mycorrhizal fungi (AMF) namely *Glomus intraradices, G. aggregatum, G. clarum* and *Sclerocystis microcarpa* significantly improved pea growth. It was observed that these fungi have significant effects on plant height, root length and total number of roots, while no significant effects were observed on leaf length and the total number of leaves. But according to Hasan *et al.* (2024) studies AMF significantly increased tomato plant growth parameters, with the best effect on height, stem diameter, leaf number, dry weight, and root length. Many researchers studied the effects of AM fungi preceding crop on cereal crops, but the outcomes of previous crop in interaction with AMF inoculation and their practical potential as biofertilizers for sustainable agricultural output was scarcely investigated. Thus, the current study aims at investigate the impact of mycorrhizal fungi on some of the growth characteristics of peas (*Pisum sativum*) while keeping focus on these advantageous aspects of mycorrhizal connection with plants.

MATERIALS AND METHODS

Materials. The soil utilised in the pots was gathered from agricultural land in and around of Abhilashi University situated in mid hill region of Mandi district. The soil was autoclaved in the lab to sterilise it after its general properties (colour, texture, structure, etc.) were examined. The excess moisture was then removed by air drying. Additionally, sterile Farm Yard Manure (FYM) was put in a 3:1 ratio to air-dried soil. Pots with labels were then filled with this mixture. In each container, two seeds were sown two to three centimetres deep. Each experiment was conducted using a total of 9 pots for each fungal treatment and control. Isolation and inoculation of experimental fungi. The AM fungus were isolated by mixing 25 g samples of soil taken from the rhizospheric area of pea plant with 100 ml of water to create a homogenous suspension, then letting the debris float on top for five minutes. Different sized sieves like 240 µm, 120 µm, 100 µm, 63 µm, and 30 µm were used to filter the suspension. The last sieved suspension was decanted and run through Whatman filter paper. Under a stereomicroscope, the filter sheets were inspected to look for spores. In order to identify the spores, they were removed from the microscope using a needle and placed in to a glass slide (Gerdemann and Nicolson 1963). The spores of AM fungus were identified using the standard literature (Phillips and Hayman 1970). *Acaulospora denticulata, Acaulospora nicolsonii, Glomus fasiculatum* and *Gigaspora margarita* are the four AM fungi that were identified and chosen for this experiment (Manjula *et al*., 2022; Dipake *et al*., 2022; Hasan *et al.* (2024).

The selected fungi were added to the experimental pots throughout the sowing process and this process was repeated ten days later. Treatments included non-inoculated (untreated) and inoculated mycorrhizal fungal pots. *Acaulospora denticulata, Acaulospora nicolsonii, Glomus fasiculatum,* and *Gigaspora margarita* were the AM fungi that were kept in nine pots for each treatment and control. The plants were analysis of morphological properties at three different intervals—30, 60, and 90 days after inoculation.

Pea plants were analysed for growth parameters like plant height, leaf length, root length, total number of roots and leaves after providing tratment with AM fungi namely *Acaulospora denticulata, Acaulospora nicolsonii, Glomus fasiculatum,* and *Gigaspora margarita.* Centimetres were used to measure the plant height, leaf length and roots length. Visual analysis was used to count the number of leaves and roots.

The data collected following examinations of all morphological parameters were analysed using the student's t-test to compare with the control, and the means were computed for each treatment and control.

RESULTS

The results of the present investigation were displayed in terms of the abundance of the four AM fungus in different crops in mid hill region. When AM fungus were inoculated into pea plants, differences in morphological traits, such as plant height, leaf length, root length and the total number of roots and leaves were noted. Height of plant, leaf length, roots length, total number of leaves and total number of roots per plant were found to be highly significantly impacted by these fungi.

At the time of seeding and again ten days later, the experimental pots were added with the selected AM fungi. Treatments included the non-inoculated (untreated) pots and the pots with inoculated mycorrhizal fungi. Nine pots with AM fungus (*Acaulospora denticulata, Acaulospora nicolsonii, Glomus fasiculatum and Gigaspora margarita*) were kept for each treatment and control. Three time points—30 days post-inoculation (DPI), 60 DPI, and 90 DPI—were used to analyse the plants are presented in Plate 1-4.

Variations in morphological parameters of pea after inoculation with AMF

Effect of mycorrhiza fungi on various growth characteristics of pea. Effects of mycorrhiza fungi on various growth parameters characteristics of pea was noted on 30th, 60th and 90th day after showing. After analyses of results, it was revealed that these fungi have significant effects of plant height, root length, leaf length, total number of leaves and total number of roots.The detailed results on effects of AM fungi on

growth parameters of pea after 30th, 60th and 90th day of sowing are presented in Table (1-4).

Plant height. In comparison to the control, the impact of AM fungus on plant height was noticeably greater. *Acaulospora nicolsonii* inoculated pea plants had the maximum plant height on the 30th day after planting (15.27 cm ±2.00 cm), followed by *Gigaspora margarita* (13.30 ±1.13 cm), *Acaulospora denticulata* (12.07 ±0.31 cm) and *Glomus fasiculatum* (11.27±0.25 cm). *Acaulospora denticulata* and *A.nicolsoni* showed highly significant effect on plant height. On the 60th day, plant heights were 53.00 ±3.16 cm, 48.00±8.00 cm, 44.72 ±5.39 cm, 44.07±5.68 cm for plants inoculated with *Acaulospora denticulata, Gigaspora margarita, Glomus fasiculatum* and *Acaulospora nicolsonii*, respectively. *Acaulospora denticulata* and *Gigaspora margarita* showed the significant effect on plant height. Similarly, pea plants inoculated with *Acaulospora nicolsonii* had the highest plant heights on the 90th day after planting (85.43 ±6.61 cm), followed by *Gigaspora margarita* (83.30±4.98 cm), *Acaulospora denticulata* (82.48 ±6.61 cm) and *Glomus fasiculatum* (75.96±7.50 cm). *Acaulospora denticulata* and *Gigaspora margarita* showed exellent effect on plant height when compared to non-inoculated plants. These findings demonstrated that AM fungus had a beneficial impact on pea plant height (Tables 1-4).

Leaf length. The findings indicated that, in comparison to the control, pea plants inoculated with AM fungus had a notable impact on leaf length. The pea plants inoculated with *Acaulospora nicolsonii* had the highest leaf length on the 30th day after sowing (4.33±2.08 cm), followed by *Gigaspora margarita* (3.46±0.15 cm), *Glomus fasiculatum* (3.45±1.34 cm), and *Acaulospora denticulata* (3.33±1.53 cm). The pea plants inoculated with *Acaulospora denticulata* had the longest leaves on the 60th day after planting (4.97±0.55 cm), followed by *Glomus fasiculatum* (4.60±0.62 cm), *Acaulospora nicolsonii* (4.27±0.91 cm) and *Gigaspora margarita* (4.27±0.40 cm). On 90th day after sowing, the leaf length was found to be highest in pea plants added with *Acaulospora denticulata* (6.10±0.20 cm), followed by *Glomus fasiculatum* (5.37±0.74 cm), *Gigaspora margarita* (5.23±0.81cm) and *Acaulospora nicolsonii* (5.17±0.31 cm). *Acaulospora denticulata* and *A. nicolsonii* shows significant impact on leaf length are presented in Tables 1-4.

Total number of leaves. According to the findings, inoculating pea plants with AM fungus significantly affects the overall number of leaves. *Acaulospora denticulata* (18±1.00 cm), *Gigaspora margarita* (20±2.00 cm), *Acaulospora nicolsonii* (21±2.08 cm), and were the next most numerous species on the 30th day after sowing, followed by *Glomus fasiculatum*-inoculated pea plants (22±1.53 cm). *Acaulospora denticulata and A. nicolsonii* shows highly significant and *Gigaspora margarita, Glomus fasiculatum* shows significant impact on total number of leaves when compared to non-inoculated plants. On 60th day after sowing, number of leaves was found be highest in pea plants treated with *Gigaspora margarita* (56±5.51cm) which was followed by *Glomus fasiculatum* (51±6.11cm), *Acaulospora nicolsonii* (49±2.00cm) and *Acaulospora denticulata* (41±4.73 cm). On 90th day after sowing, total number of leaves was found to be highest in pea plants inoculated with *Acaulospora denticulata* (125.33±4.16 cm), followed by *Acaulospora nicolsonii* (110.00±12.50 cm), *Gigaspora margarita* (83.33±5.51cm), and *Glomus fasiculatum* (81.67±17.79cm). *Acaulospora denticulata* and *Gigaspora margarita* shows highly significant impact on leaf length. *Acaulospora nicolsonii* and *Glomus fasiculatum* shows better effect on number of leaves at 30 days after sowing are presented in Tables 1-4.

Root length. The findings indicated that, in comparison to the control, pea plants treated with AM fungus had a notable impact on root length. On the 30th day following seeding, pea plants inoculated with *Acaulospora nicolsonii* had the longest roots (9.30±0.10 cm), followed by *Acaulospora denticulata* (9.10±0.10 cm), *Gigaspora margarita* (8.63±0.80 cm) and *Glomus fasiculatum* (7.76±0.23 cm). The pea plants inoculated with *A. denticulata* had the longest roots on the 60th day after sowing (11.87±0.15 cm), followed by *A. nicolsonii* (10.83±0.57 cm), *Gigaspora margarita* (10.80±1.06 cm) and *Glomus fasiculatum* (10.10±0.20 cm. The pea plants inoculated with *Acaulospora denticulata* had the longest roots on the 90th day after sowing (16.00±1.00 cm), followed by *A. nicolsonii* (14.66±0.90 cm), *Glomus fasiculatum* (13.34±1.08 cm) and *Gigaspora margarita* (12.01±1.27 cm). Every inoculated fungal species exhibits a notable impact on root length are presented in Tables 1-4.

Total Number of roots. The root lengths of the inoculated and control pea plants varied after the AM fungus inoculation. Positive results are seen in pea plants from all four fungus. The pea plants inoculated with *Acaulospora denticulata* had the highest number of roots on the 30th day after sowing (15.53±0.50 cm), followed by *Gigaspora margarita* (13±1.00 cm), *Glomus fasiculatum* (12±1.73 cm), and *Acaulospora nicolsonii* (12±1.00 cm). On 60th day, total number of roots was found be highest in pea plants which was inoculated with *Gigaspora margarita* (48±8.00 cm), which was followed by *Acaulospora denticulata* (44±4.16 cm), *Glomus fasiculatum* (39±4.16 cm) and *Acaulospora nicolsonii* (29±3.61 cm). On 90th day after sowing, total number of leaves was found to be highest in pea plants inoculated with *Gigaspora margarita* (78±1.00 cm), followed by *Glomus fasiculatum* (70±3.79 cm), *Acaulospora denticulata* (62±3.51cm) and *Acaulospora nicolsonii* (57±5.03 cm). All the AM fungi shows highly significant and exellent impact on total number of roots when compared to non-inoculated plants are presented in Tables 1-4.

DISCUSSION

In the present study, the growth of *Pisum sativum* L. inoculated with AM mycorrhizal fungi was analyzed. It indicated that the inoculated plants significantly impacted pea growth metrics and had more plant height, root length, leaf length, and the total number of

roots on pea plants compared to the non-inoculated plants. AM fungi namely *Acaulospora denticulata* significantly impacted plant height, root length, leaf length, and the total number of roots on pea plants. *Acaulospora nicolsonii* significantly impacted plant height, root length, leaf length, and the total number of roots on pea plants. *Glomus fasiculatum* significantly impacted the length of roots, total number of leaves, and the number of roots in pea plants, but had no discernible effect on leaf length. Because significant changes were observed at 90 days in *Acaulospora denticulata* and *A. niolsonii* treatments, whereas no significant changes were recorded at 30 and 60 days after sowing. Two arbuscular mycorrhizal fungi namely *Acaulospora denticulata* and *A. nicolsonii* were the most efficient and optimal among the four Arbuscular mycorrhizal fungi for every parameter. Although there were no discernible effects on leaf length, *Glomus* and *Gigaspora* genera significantly impacted plant height, root length, total number of roots, and total number of leaves in pea plants are presented in Tables 1-4. After that, it was concluded that if the plants are inoculated with mycorrhizal fungi, they showed more growth compared to the non-inoculated ones. It is shown that the mycorrhizal fungal showed a symbiotic association with *Pisum sativum* L. plants.

Pea plants in pot cultures that were inoculated with *Acaulospora denticulata* and *Acaulospora nicolsonii* significantly impacted plant height, root length, leaf length, and the total number of roots on pea plants. These results are in accordance with the previous study carried out by Singh *et al.* (2004), where they reported that on the impact of the mycorrhizal species *Glomus aggregatum* on leaf length. Similarly, *Glomus intraradices* exhibit a noteworthy impact on plant height (Olivera *et al.*, 2004). Although, total number of leaves in pea plant was inoculated with AM fungi were affected by *Glomus clarum.* However, Prasann (2019), reported effects of AM fungi on leaves nodes or new shoot but the average is equal. Soylu *et al*. (2023) examined the impact of mycorrhiza inoculation on pepper plant growth and dependency. Results showed higher root length and a high mycorrhizal dependency (71.9%) with mycorrhiza inoculation, indicating increased plant growth and development.

In the present studies *Glomus fasiculatum* significantly impacted the length of roots, total number of leaves, and the number of roots in pea plants, but had no discernible effect on leaf length. Manjula *et al.* (2022). The findings showed that there is no discernible change in the overall number of leaves when pea plants are inoculated with AM fungus. Nonetheless, a positive difference in leaf count was noted between the plants treated with AM fungus and the control group. According to Grant (2012); Abdelaal *et al.* (2020), the changes in physiological and biochemical characteristics may be the cause of the differences in growth parameters between inoculated and control plants. In a related study, Surayya *et al.* (2021) examined the effects of various AMF inoculum (*G. mossae*, *G. etunicatum*, and *Acaulospora kentinensis)* on the colonisation roots of cowpea and improvement of soil. According to Wu & Xia's (2004) study, inoculating plants with arbuscular mycorrhizal fungus may enhance plant growth, including plant height, stem diameter, leaf area, shoot dry weight, root dry weight, and plant dry weight. The introduction of *Glomus* sp. into Lolium perenne led to a notable increase in root vigour, chlorophyll content, and photosynthetic carbon absorption capacity (Zhang *et al.*, 2018). This could be the reason for the notable rise in plant height and root length. In a similar vein, Soylu *et al.* (2023); Hasan *et al*. (2024) examined the most recent information on AMF and how it affects host plants at different phases of growth.

The outcomes of the present study revealed that in recent years, arbuscular mycorrhiza has been proved as a better form of bio-fertilizer and potential alternative to chemical fertilizer. Individual species or consortia of AM fungi have been used to test their effect on variety of crops. In many experiments AM inocula have shown excellent results in terms of growth enhancement, increase in productivity and improving drought and disease resistance of the host plants. It established the framework for the possible future use of VAM fungus as biofertilizers in reclamation wastelands. In addition, it helps in the formation of future inoculums and can be applied as fertiliser to improve seedling growth and survival under challenging circumstances.

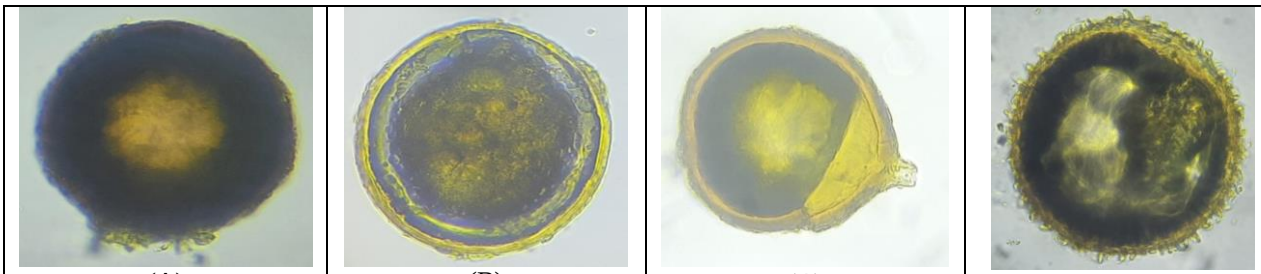

Plate 1. Species of VAM fungi used for inoculation with Pea plant experimentation, (A) *Acaulospora denticulata,* (B) *Acaulospora nicolsonii,* (C) *Glomus fasiculatum,* (D) *Gigaspora margarita.*

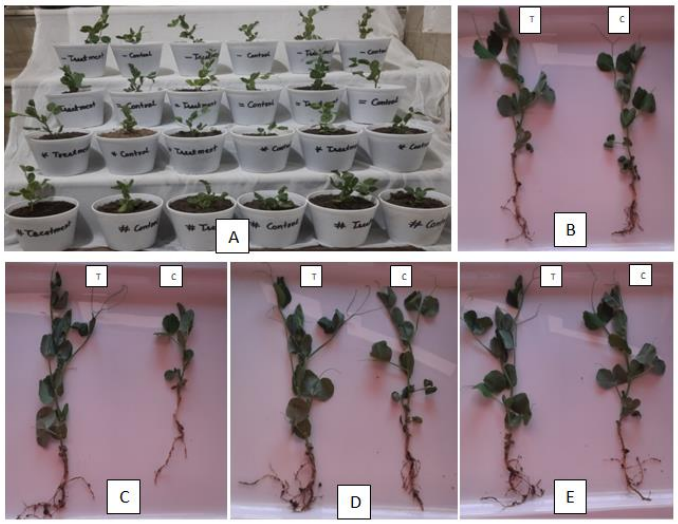

Plate 2. Effect of AM fungi inoculation on morphological attributes of pea (A) Experiment on 30th day after AM inoculation, (B) *Acaulospora denticulata*, (C) *Acaulospora nicolsonii*, (D) *Glomus fasiculatum*, (E) *Gigaspora margarita.*

Plate 3. Effect of AM fungi inoculation on morphological attributes of pea (A) Experiment on 60th day after AM inoculation, (B) *Acaulospora denticulata*, (C) *Acaulospora nicolsonii*, (D) *Glomus fasiculatum*, (E) *Gigaspora margarita.*

Plate 4. Effect of AM fungi inoculation on morphological attributes of pea (A) Experiment on 90th day after AM inoculation, (B) *Acaulospora denticulata*, (C) *Acaulospora nicolsonii*, (D) *Glomus fasiculatum*, (E) *Gigaspora margarita.*

Table 1: Effect of *Acaulospora denticulata* on different characteristics of pea plant.

Parameters	*Acaulospora denticulata*					
	Treatment			Control		
	30 Days	60 Days	90 Days	30 Days	60 Days	90 Days
Plant height (cm)	12.07±0.31**	53.00±2.00**	82.48±3.64**	10.23±0.67	36.22±6.26	58.33±9.71
Leaf length (cm)	3.33±1.53	4.97±0.55	6.10±0.20**	3.17±0.76	3.93±0.06	4.40±0.61
Total no. of leaves	18±1.00***	41±4.73	125.33±4.16**	13±1.53	38±2.52	91±11.53
Root length (cm)	9.10±0.10**	11.87±0.15**	16.00±1.00**	7.30±0.61	7.30±0.61	11.77±1.03
Total no. of roots	15±0.50***	44±4.16**	62±3.51***	10±1.53	30±1.73	43±2.65

PH: Plant height (in cm); RL: Root length (in cm); LL: Leaf length (in cm); TL: Total Number of leaves; TR: Total number of roots.
Mean ± standard deviation; **Significant($p \leq 0.05$),*** Highly significant ($p \geq 0.01$)

Table 2: Effect of *Acaulospora nicolsonii* on different characteristics of pea plant.

Parameters	*Acaulospora nicolsonii*					
	Treatment			Control		
	30 Days	60 Days	90 Days	30 Days	60 Days	90 Days
Plant height (cm)	15.27±0.15***	44.07±5.68	85.43±6.61	10.63±0.45	35.45±5.09	72.41±4.67
Leaf length (cm)	4.33±2.08	4.27±0.91	5.17±0.31**	3.20±0.70	3.90±1.14	4.10±0.87
Total no. of leaves	21±2.08***	49±2.00	110.00±12.50	13±2.00	49±4.51	93±5.29
Root length (cm)	9.30±0.36***	10.83±0.57***	14.66±0.90**	8.40±0.56	8.73±0.32	11.67±0.75
Total no. of roots	12±1.00	29±3.61**	57±5.03**	11±1.53	28±1.53	41±11.37

PH: Plant height (in cm); RL: Root length (in cm); LL: Leaf length (in cm), TL: Total Number of leaves; TR: Total number of roots.
Mean ± standard deviation; **Significant ($p \leq 0.05$),*** Highly significant ($p \geq 0.01$)

Table 3: Effect of *Glomus fasiculatum* on different characteristics of pea plant.

Parameters	*Glomus fasiculatum*					
	Treatment			Control		
	30 Days	60 Days	90 Days	30 Days	60 Days	90 Days
Plant height (cm)	11.27±0.25	44.72±5.39	75.96±7.50	10.77±0.76	35.29±5.57	70.00±1.13
Leaf length (cm)	3.45±1.34	4.60±0.62	5.37±0.74	2.87±0.91	3.53±0.85	4.63±0.46
Total no. of leaves	22±1.53**	51±6.11	81.67±17.79	14±2.00	43±5.29	75±8.50
Root length (cm)	7.76±0.23***	10.10±0.20**	13.34±1.08**	7.43±0.86	8.87±0.67	11.17±0.46
Total no. of roots	12±1.73	39±4.16**	70±3.79**	11±1.00	30±1.00	47±13.00

PH: Plant height (in cm); RL: Root length (in cm); LL: Leaf length (in cm), TL: Total Number of leaves; TR: Total number of roots.
Mean ± standard deviation; **Significant($p \leq 0.05$),*** Highly significant ($p \geq 0.01$)

Table 4: Effect of *Gigaspora margarita* on different characteristics of pea plant.

Parameters	*Gigaspora margarita*					
	Treatment			Control		
	30 Days	60 Days	90 Days	30 Days	60 Days	90 Days
Plant height (cm)	13.30±1.13	48.00±8.00**	83.30±4.98**	11.73±0.78	35.26±9.03	76.02±3.85
Leaf length (cm)	3.46±0.15	4.27±0.40	5.23±0.81	3.30±0.60	3.63±0.49	5.17±0.31
Total no. of leaves	20±2.00**	56±5.51**	83.33±5.51**	12±2.08	36±5.86	71±4.04
Root length (cm)	8.63±0.80	10.80±5.51**	12.01±1.27**	8.41±0.95	9.90±0.44	10.27±1.27
Total no. of roots	13±1.00	48±8.00**	78±1.00**	12±0.58	22±2.65	61±5.03

PH: Plant height (in cm); RL: Root length (in cm);LL: Leaf length (in cm), TL: Total Number of leaves; TR: Total number of roots.
Mean ± standard deviation; **Significant($p \leq 0.05$),*** Highly significant ($p \geq 0.01$)

CONCLUSIONS

This study demonstrated that all inoculation treatments significantly enhanced the various growth parameters like plant height, leaf length, roots length, total number of leaves and total number of roots per plant. In comparison to non-inoculated plants, the study discovered that inoculated plants had greater plant height, root length, leaf length, and total number of roots. The four Arbuscular mycorrhizal fungi *Acaulospora denticulata, Acaulospora nicolsonii, Glomus fasiculatum*, and *Gigaspora margarita* —had a major effect on plant growth metrics. For all parameters, *Acaulospora denticulata* and *A. nicolsonii* were the most effective and ideal. The genera *Glomus* and *Gigaspora* also had a substantial effect on plant height, total number of roots, total number of leaves, and root length. According to the findings, plants that were inoculated with mycorrhizal fungi exhibited more growth than those that were not. A symbiotic relationship between the mycorrhizal fungus and *Pisum sativum* L. plants has been demonstrated.

FUTURE SCOPE

According to the current study's findings, arbuscular mycorrhiza has emerged as a superior biofertilizer and possible substitute for chemical fertiliser in recent years. It has a promising future scopes in plants, with potential applications in sustainable agriculture, ecological restoration, and environmental conservation. Mycorrhizal inoculation enhances the plant growth, biomass, yield and also increases plant resistance to various stresses, such as salt stress. It can develop effective mycorrhizal inoculation strategies, including the selection of suitable fungal species, inoculation timing, and application rates. It helps in exploring the potential of mycorrhizal inoculation in different crop species, including cereals, legumes, and horticulture crops. It established the base for the potential application of VAM fungi as biofertilizers in reclamation wastelands in the future. Furthermore, it aids in the development of subsequent inoculums and can be used as fertiliser to enhance seedling survival and growth in harsh conditions.

Acknowledgements. Authors are thankful to Career Point University, Hamirpur for providing the platform to conduct the research. And author would also like to thanks DEST & CC (Department of science and technology and Climate change) Shimla for their grant to proceed the research work and Abhilashi university for providing field and laboratory facilities.

REFERENCES

Abdelaal, K. A. A., Attia, K. A., Alamery, S. E. and El-Afry, M. M. (2020). Exogenous Application of Proline and Salicylic Acid can Mitigate the Injurious Impacts of Drought stress on Barley, Plants Associated with Physiological and Histological Characters. *Sustainability*, *12*, 1736.

Abedi, B. and Esfandiari, B. (2017). Effect of Mycorrhizal Fungi on Morpho-physiologic and Nutritive Characteristics of Flying Dragon under Salinity Stress. *International Journal of Theoretical & Applied Sciences*, *9*(2), 288- 293.

Aishwarya, Manjula, Payal, Kaundal, S., Kumar, R., Singh, R., Avasthi, S. and K. Gautam, A. K. (2022). Arbuscular Mycorrhizal Fungal Diversity and Root Colonization in *Pisum sativum. Biological Forum – An International Journal*, *14*(1), 1626-1632.

Begum, N., Qin, C., Ahanger, M. A., Raza, S., Khan, M. I., Ashraf, M., Ahmed, N. and Zhang, L. (2019). Role of arbuscular mycorrhizal fungi in plant growth regulation: implications in abiotic stress tolerance. *Frontiers in Plant Science*, *10*, 1068.

Dipake, S., Ekta, D., Bagde and Tini, P. (2022). Studies on Morphological Characteristics of Arbuscular Mycorrhiza Associated with Forest spp. *Biological Forum – An International Journal, 14*(1), 313-316.

FAO (2014). Statistical Year Book Asia and the Pacific Food and Agriculture Accessed from: http://www.fao.org/3/a-i3590e.pdf.Accessed on 13 April 2022.

Gaur, A., Adholeya, A. and Mukerji, K. G. (1998). A comparison of AM fungi inoculants using Capsicum and Polianthes in marginal soil amended with organic matter. *Mycorrhiza*, *7*, 307–312.

Gerdemann, J. W. and Nicolson, T. H. (1963). Spores of mycorrhizal *Endogone* species extracted from soil by wet sieving and decanting. *Transactions of the British Mycological Society, 46*, 235–244.

Grant, O. M. (2012). Understanding and exploiting the impact of drought stress on plant physiology. In Abiotic Stress Responses in Plants; *Springer*: New York, NY, USA, 89 –104pp.

Hasan, R., Tia, S., Dede, S. and Mohamad, N. (2024). The arbuscular mycorrhizal fungi inoculation affects plant growth and flavonoid content in tomato plant (*Lycopersicum esculentum* Mill.) *Journal of Applied Biology & Biotechnology*, *10*(20), 1-7.

Johny, L., Cahill, D. M. and Adholeya, A. (2021). AMF enhance secondary metabolite production in Ashwagandha, Licorice, and Marigold in a fungi-host specific manner. *Rhizosphere*, *17*, 100314.

Kristek, S. (2005). The influence of mycorrhizal fungi (*Glomus* spp.) on field pea and maize plant survival and growth in drought caused stress condition. *Plant soil and environment*, *51*, 385-389.

Lin, X., George, E. and Marschner, H. (1991). Extensions of the Phosphorus depletion zone in VA- mycorrhizal white clover in a Carlcareous soil. *Plant Soil*, *136*, 41–48.

Manjula, Aishwarya, Payal, Avasthi, S., Verma, R. K. and Gautam, A. K. (2022). Effects of arbuscular mycorrhizal fungi on growth parameters of *Pisum sativum. Asian Journal of Mycology*, *5*(2), 1–10.

Millar, K. A., Gallagher, E., Burke, R., McCarthy, S. and Barry- Ryan, C. (2019). Proximate composition and anti- nutritional factors of fava- beans (*Vicia faba*), green-pea and yellow-pea (*Pisum sativum*) flour. *Journal of Food composition and Analysis*, *82*, 103–233.

Mondor, M. (2020). Pea. In Pulses (Eds. Manickavasagan A, Thirunathan P). *Springer, Cham*, 245- 273.

Prasann (2019). Comparision between the growth rates of mycorrhizae, uninfected roots and a mycorrhizal fungus. *New Phytologist*, *91*, 453-466.

Phillips, J. M. and Hayman, D. S. (1970). Improved procedures for clearing roots and staining parasitic and vesicular-arbuscular mycorrhizal fungi for rapid assessment of infection. *Transactions of the British Mycological Society*, *55*, 158 – 161.

Senapati, A. K., Varshney, A. K. and Sharma, K. V. (2019. Dehydration of green peas: A review. *International Journal of Chemical Studies*, *7*, 1088–1091.

Kaundal, S. and Singh, R. (2022). Diversity of VAM and rhizospheric fungi in wheat (*Triticum aestivum*) grown in mid-hill conditions of Himachal Pradesh. *The Pharma Innovation Journal*, *11*(3), 591-594.

Sieverding, E. (1991). Vesicular-arbuscular mycorrhiza management in tropical agrosystem. Techical Cooperation, Federal Republic of Germany Eschborn. *International Standard Book Number* (ISBN), 3-88085-462.

Singh, T. K., Pyare, R., Dwivedi, D. P. and Singh, S. K. (2004). Response of varieties and dates of sowing on growth and yield of chickpea. *Plant Archives, 4*, 471–474.

Soylu, E., Işik, M. and Ortaş, I. (2023). The effect of mycorrhiza inoculation on pepper plant growth and mycorrhizal dependency. *International Journal of Agricultural and Applied Sciences*, *4*(1),127-131.

Stubblefield, S. P., Taylor, T. N. and Trappe, J. M. (1987). Vesicular-arbuscular mycorrhizae from the Triassic of Antarctica. *American Journal of Botany*, *74*, 1904 – 1911.

Surayya, A. M., Safianu, R., Halima, M. R. and Bala, Z. M. (2021). Influence of Mycorrhizal Inocula on Cowpea Root Colonization and Soil Improvement in Kano, Nigeria. *Plant Pathology & Quarantine*, *11*, 165–172.

Thangavelu, M. and Raji, M. (2016). Arbuscular Mycorrhizal and Dark Septate Endophyte Fungal Associations in *Asparagus*. *Turkish Journal of Botany*, *40*, 662–675.

Wu, Q. S. and Xia, R. X. (2004). Effects of arbuscular mycorrhizal fungi on plant growth and osmotic adjustment matter content of trifoliate orange seedling under water stress. *Journal of Plant Physiology and Molecular Biology*, *30*, 583–588.

Yaseen, T., Yaseen, K., Fazli, R., Sher, W., Izhar, A., Husan, A. B. and Saima, S. G. (2016). Arbuscular Mycorrhizal Fungi Spores Diversity and AMF Infection in Medicinal Plants of district Charsadda Khyber Pakhtunkhwa. *Pure and Applied Biology*, *5*, 1176–1182.

Zhang, H., Xu, N., Li, X., Long, J., Sui, X., Wu, Y., Li, J., Wang, J., Zhong, H. and Sun, G. Y. (2018). Arbuscular mycorrhizal fungi (*Glomus mosseae*) improves growth, photosynthesis and protects photosystem ii in leaves of *Lolium perenne* L. in cadmium contaminated soil. *Frontiers in Plant Science*, *9*, 1156.

How to cite this article: Shivani, Hem Chander, Manu Vineet Sharma and Ritika Singh (2025). Effect of Arbuscular Mycorrhizal Fungi on Growth Parameters of Pea Plant in Mid Hill Region of Mandi District. *Biological Forum*, *17*(3): 32-39.