STANDARDIZATION OF SOWING DATES AND STAGE OF PINCHING FOR GROWTH, YIELD AND QUALITY OF FENUGREEK (*Trigonella foenum - graecum* L.) UNDER HILL ZONE OF KARNATAKA

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Affectionately Dedicated To

My forever loving parents

Mr. Javeed

&

Mrs. Zareena

My loving Sisters,

Brother-in-laws, Brother

and my Respected Teachers



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ABSTRACT

The study was conducted to standardize the optimum date of sowing and stage of pinching in fenugreek at College of Horticulture, Mudigere, UAHS, Shivamogga during 2014-15. The experiment consisted of five dates of sowing (1st October, 15th October, 1st November, 15th November and 1st December) and three levels of pinching (Pinching at 25 days after sowing (DAS), Pinching at 35 DAS and No pinching) which were assessed in all possible combinations for growth, yield and quality. Among the treatments sowing on 15th October and pinching at 35 DAS recorded maximum plant spread, number of branches per plant, dry matter production of leaves, stem, pods, seeds, total dry matter production, AGR, CGR, RGR, NAR, number of pods per plant, length of pod, fresh weight of pod, number of seeds per pod, weight of seeds per pod, seed yield, harvest index, 1000 seed weight, total chlorophyll content in leaves and protein content in seeds, whereas, maximum plant height was recorded in 1st November sown crop and in the non-pinched plants. Interaction effect of sowing dates and stage of pinching were found significant. The treatment D_3P_3 (Sowing on 1st November + No pinching) recorded significantly maximum plant height (48.24 cm), while D_2P_2 (Sowing on 15th October + Pinching at 35 DAS) registered significantly maximum number of branches per plant (12.06), plant spread (51.62 cm^2), total dry matter production (2.00 g/plant), number of pods per plant (13.80), number of seeds per pod (13.60), seed yield (3.44 g/plant and 1148.11 kg/ha), harvest index (29.16 %), total chlorophyll (3.25 g/mg), crude protein content in seeds (5.08 %) and benefit cost ratio (2.62:1) compared to other treatment combinations. The incidence of pest and diseases was found to be least in the 15th October sown crop.

June, 2015

Major advisor

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ಕರ್ನಾಟಕದ ಗುಡ್ಡಗಾಡು ವಲಯದಲ್ಲಿ ಮೆಂತ್ಯೆಯ(*ಟ್ರೈಗೋನೆಲ್ಲಾ ಫ್ಯೋನಮ್–ಗ್ರೇಕಮ್* ಎಲ್.) ಬೆಳವಣಿಗೆ, ಇಳುವರಿ ಮತ್ತು ಗುಣಮಟ್ಟದ ಮೇಲೆ ಬಿತ್ತನೆ ದಿನಾಂಕ ಮತ್ತು ಕುಡಿ ಚಿವುಟುವ ಹಂತವನ್ನು ನಿಗಧಿಪಡಿಸುವಿಕೆ

ಹೀನಾ ಕೌಸರ್ (ಎಂಎಚ್೨೬ಎಸಿ೦೨೪)

ಸಾರಾಂಶ

ಕರ್ನಾಟಕದ ಗುಡ್ಡಗಾಡು ವಲಯದಲ್ಲಿ ಮೆಂತ್ಯೆಯ (*ಟ್ರೈಗೋನೆಲ್ಲಾ ಫ್ಯೋನಮ್– ಗ್ರೇಕಮ್* ಎಲ್.) ಬೆಳವಣಿಗೆ, ಇಳುವರಿ ಮತ್ತು ಗುಣಮಟ್ಟದ ಮೇಲೆ ಬಿತ್ತನೆ ದಿನಾಂಕ ಮತ್ತು ಕುಡಿ ಚಿವುಟುವ ಹಂತದ ಪರಿಣಾಮದ ಬಗ್ಗೆ ಅಧ್ಯಯನವನ್ನು ೨೦೧೩–೨೦೧೪ ನೇ ಸಾಲಿನಲ್ಲಿ, ಕರ್ನಾಟಕದ ಚಿಕ್ಕಮಗಳೂರು ಜಿಲ್ಲೆಯ, ತೋಟಗಾರಿಕೆ ಮಹಾವಿದ್ಯಾಲಯ, ಮೂಡಿಗೆರೆಯಲ್ಲಿ ಹಮ್ಮಿಕೊಳ್ಳಲಾಗಿತ್ತು. ಈ ಅಧ್ಯಯನದಲ್ಲಿ ೫ ವಿವಿಧ ಬಿತ್ತನೆಯ ದಿನಗಳು (೧ನೇ ಅಕ್ಟೋಬರ್, ೧೫ನೇ ಅಕ್ಟೋಬರ್, ೧ನೇ ನವೆಂಬರ್, ೧೫ನೇ ನವೆಂಬರ್ ಮತ್ತು ೧ನೇ ಡಿಸಂಬರ್) ಮತ್ತು ಮೂರು ವಿವಿಧ ಹಂತದ ಕುಡಿ ಚಿವುಟುವಿಕೆಯನ್ನು (ಬಿತ್ತನೆಯಾದ ೨೫ ದಿನಗಳ ನಂತರ ಕುಡಿ ಚಿವುಟುವಿಕೆ, ಬಿತ್ತನೆಯಾದ ೩೫ ದಿನಗಳ ನಂತರ ಕುಡಿ ಚಿವುಟುವಿಕೆ ಮತ್ತು ಚಿವುಟದಿರುವಿಕೆ) ಎಲ್ಲಾ ಸಂಭಾವ್ಯ ಸಂಯೋಜನೆಗಳಿಂದ ಮೆಂತ್ಯೆಯ ಬೆಳವಣಿಗೆ, ಇಳುವರಿ ಮತ್ತು ಗುಣಮಟ್ಟದ ಮೇಲೆ ವಿಶ್ಲೇಷಿಸಲಾಗಿರುತ್ತದೆ. ೧೫ನೇ ಅಕ್ಟೋಬರ್ ರಂದು ಬಿತ್ತಿದ ಗಿಡಗಳಲ್ಲಿ ಹಾಗೂ ೩೫ ದಿನಗಳ ನಂತರದ ಕುಡಿ ಚಿವುಟಿರುವ ಗಿಡಗಳಲ್ಲಿ ಸಸ್ಯದ ಗರಿಷ್ಠ ಹರಡುವಿಕೆ, ಪ್ರತಿ ಗಿಡದ ರೆಂಬೆಗಳ ಸಂಖ್ಯೆ, ಎಲೆ, ಕಾಂಡ, ಕಾಯಿ, ಬೀಜದ ಒಣ ಪದಾರ್ಥ ಉತ್ಪನ್ನ, ಒಟ್ಟು ಒಣ ಪದಾರ್ಥದ ಉತ್ಪನ್ನ, ನಿರ್ದಿಷ್ಠ ಬೆಳವಣಿಗೆ ದರ, ಪೂರ್ಣ ಬೆಳವಣಿಗೆ ದರ, ಸಂಬಂಧಿತ ಬೆಳವಣಿಗೆ ದರ, ನಿವ್ವಳ ಸಮೀಕರಣ ದರ, ಪ್ರತಿ ಗಿಡದ ಕಾಯಿಗಳ ಸಂಖ್ಯೆ, ಕಾಯಿಯ ಉದ್ದ, ಕಾಯಿಯ ಹಸಿ ತೂಕ, ಪ್ರತಿ ಕಾಯಿಯಲ್ಲಿರುವ ಬೀಜಗಳ ಸಂಖ್ಯೆ, ಪ್ರತಿ ಕಾಯಿಯಲ್ಲಿರುವ ಬೀಜಗಳ ತೂಕ, ಬೀಜದ ಇಳುವರಿ, ಕೊಯ್ಲು ಸೂಚ್ಯಾಂಕ, ಸಾವಿರ ಬೀಜಗಳ ತೂಕ, ಎಲೆಯಲ್ಲಿರುವ ಪತ್ರ ಹರಿತ್ತು ಮತ್ತು ಬೀಜದಲ್ಲಿರುವ ಪ್ರೊಟೀನ್ ಅಂಶದ ಪ್ರಮಾಣವು ಕಂಡುಬಂದಿರುತ್ತದೆ. ಆದರೆ, ೧ನೇ ನವೆಂಬರ್ ರಂದು ಬಿತ್ತಿದ ಗಿಡಗಳಲ್ಲಿ ಹಾಗೂ ಕುಡಿ ಚಿವುಟದೆ ಇರುವ ಗಿಡಗಳಲ್ಲಿ ಅಧಿಕ ಗಿಡದ ಎತ್ತರವು ದಾಖಲಾಗಿರುತ್ತದೆ. ಬಿತ್ತನೆ ದಿನಗಳು ಮತ್ತು ಕುಡಿ ಚಿವುಟುವಿಕೆಯ ಸಂಯೋಜಿತ ಪರಿಣಾಮವು ಗಮನಾರ್ಹವಾಗಿರುತ್ತದೆ. ೧ನೇ ನವಂಬರ್ ರಂದು ಬಿತ್ತನೆ ಮಾಡಿ ಕುಡಿ ಚಿವುಟದಿರುವ ಗಿಡಗಳಲ್ಲಿ ಗಿಡದ ಗರಿಷ್ಠ ಎತ್ತರವು (೪೮.೨೪ ಸೆಂ.ಮೀ) ಕಂಡುಬಂದಿರುತ್ತದೆ. ಇತರ ಚಿಕಿತ್ಸಾ ಸಂಯೋಜನೆಗಳಿಗೆ ಹೋಲಿಸಿದರೆ, ಗರಿಷ್ಠ ರೆಂಬೆಗಳ ಸಂಖ್ಯೆ (೧೨.೦೬ ಪ್ರತಿ ಗಿಡಕ್ಕೆ), ಸಸ್ಯದ ಹರಡುವಿಕೆ (೫೧.೬೨ ಸೆಂ. ಮೀ^{2}), ಒಟ್ಟು ಒಣ ಪದಾರ್ಥ ಉತ್ಪನ್ನ (೨.೦೦ ಗ್ರಾಂ. ಪ್ರತಿ ಗಿಡಕ್ಕೆ), ಪ್ರತಿ ಗಿಡದ ಕಾಯಿಗಳ ಸಂಖ್ಯೆ (೧೩.೮೦), ಪ್ರತಿ ಕಾಯಿಗಳಲ್ಲಿರುವ ಬೀಜಗಳ ಸಂಖ್ಯೆ (೧೩.೬೦), ಬೀಜದ ಇಳುವರಿ (೩.೪೪ ಗ್ರಾಂ. ಪ್ರತಿ ಗಿಡಕ್ಕೆ ಮತ್ತು ೧೧೪೪.೧೧ ಕೆ.ಜಿ ಪ್ರತಿ ಹೆಕ್ಟೇರಿಗೆ), ಕೊಯ್ಲು ಸೂಚ್ಯಾಂಕ (ಶೇ. ೨೯.೧೬), ಎಲೆಯಲ್ಲಿರುವ ಪತ್ರ ಹರಿತ್ತು (೨.೩೫ ಗ್ರಾಂ ಪ್ರತಿ ಮಿ.ಗ್ರಾಂ ಗೆ) ಮತ್ತು ಬೀಜದಲ್ಲಿರುವ ಪ್ರೊಟೀನ್ ಅಂಶದ ಪ್ರಮಾಣ (ಶೇ. ೫.೦೮), ಲಾಭ ಮತ್ತು ಖರ್ಚಿನ ಅನುಪಾತ (೨.೬೨:೧) ವನ್ನು ೧೫ನೇ ಅಕ್ಟೋಬರ್ ರಂದು ಬಿತ್ತಿ ೩೫ ದಿನಗಳ ನಂತರದ ಕುಡಿ ಚಿವುಟಿರುವ ಗಿಡಗಳಲ್ಲಿ ದಾಖಲಿಸಲಾಗಿರುತ್ತದೆ. ಬೆಳೆಯನ್ನು ಬಾಧಿಸಿದ ಪ್ರಮುಖ ಕೀಟ ಹಾಗೂ ರೋಗಗಳನ್ನು ದಾಖಲಿಸಲಾಗಿ ೧೫ನೇ ಅಕ್ಟೋಬರ್ ರಂದು ಬಿತ್ತಿದ ಗಿಡಗಳಲ್ಲಿ ಕೀಟ ಮತ್ತು ರೋಗಗಳ ಬಾಧೆಯು ಕಡಿಮೆ ಇರುವುದು ಕಂಡುಬಂದಿದೆ.

ಜೂನ್ ೨೦೧೫

ಮುಖ್ಯ ಸಲಹೆಗಾರರು
(ಭೂಮಿಕಾ ಹೆಚ್.ಆರ್.)

ನೆಡುತೋಪು, ಸಾಂಬಾರ, ಔಷಧಿ ಮತ್ತು ಸುಗಂಧ ದ್ರವ್ಯ ಬೆಳೆಗಳ ವಿಭಾಗ
ತೋಟಗಾರಿಕೆ ಮಹಾವಿದ್ಯಾಲಯ, ಮೂಡಿಗೆರೆ

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INTRODUCTION

I. INTRODUCTION

India, the land of spices is the world's largest producer, consumer and exporter of spices. Spices are adding flavour, taste, aroma, colour and pungency to the food and are one of the major foreign exchange earners to the country. Out of the total 63 spices grown in India, 20 are classified as seed spices with 36 per cent share in area and 17 per cent share in production of total spices in India (Anwer *et al.*, 2011).

Fenugreek *(Trigonella foenum - graecum* L.), commonly called as 'Greek hay' and also called as 'methi' in Hindi and 'menthya' in Kannada, occupies a prime position among the seed spices grown in India. It is extensively grown in India, Morocco, Australia, Turkey, Bulgaria, Pakistan, Bangladesh, Egypt, China, France, Africa, Lebanon and Ethiopia. India occupies an important position among the fenugreek growing countries of the world but, the seed yield obtained under Indian condition is very low (1,093 kg/ha) as compared to Morocco (2,000 kg/ha), which is the major competitor in the world market. It is one of the important winter season leguminous crops cultivated mainly in Northern India, where Rajasthan (81.69%) is the major producer of fenugreek followed by Gujarat (16.61 %) and Uttar Pradesh (1.16%) (Anon., 2010).

Fenugreek, *Trigonella foenum - graecum* L. is an annual herb native to South-East Europe and West Asia. The name fenugreek comes from *foenum - graecum*, meaning Greek hay, as the plant was traditionally used to scent inferior hay. The name of the genus, *Trigonella*, is derived from the old Greek name, denoting 'three-angled', probably referring to the triangular shape of the flowers (Snehalatha and Payal, 2012).

There are as many as 260 species of fenugreek, of which a total of only 18 species of *Trigonella* are currently recognized. Most species, including *Trigonella foenum - graecum* L., are diploids with chromosome number 2n = 16 (Snehalatha and Payal, 2012). Other important species of the genus *Trigonella* is *Trigonella corniculata* commonly called as kasuri methi whose cultivation is mainly confined to North India and commercially grown in Rajasthan, Punjab, Madhya Pradesh and Maharashtra for its aromatic leaves used in various culinary preparations.

Fenugreek is an annual crop belonging to the family Fabaceae. The plant is erect or spreading, growing up to a height of 30-90 cm. The long slender stems bear pinnately trifoliate, toothed, grey-green obovate leaves, 20-25 mm long. The plant radiates a spicy odour which persists on the hands after touching. Flowers are 1-2, axillary, sessile, racemed, whitish or lemon yellow. Pod is 5.7 cm long with a persistent beak, hairy with 10-20 seeds. Seeds are small (5 mm long), hard, flattened, brownish yellow in colour and surrounded by a darker, horny, translucent endosperm, which separates the radicle from the cotyledons (Snehalatha and Payal, 2012). Though self-pollinated crop, fenugreek manifests a good variability for important qualitative and quantitative characters (Farooqi *et al*., 2003). The terminal parts of the roots bear nodules harbouring nitrogen fixing bacteria.

Fenugreek seeds are rich in protein (6.3%), fat (9.5%), carbohydrates (42.3%), vitamin A (1040 W) and have calorific value of 370 cal/100 g. Besides, it contains gum (22.06%), trigonellin (0.13-0.35%), diosgenin (1.0 g), gitogenin (0.l g) and a trace of triogenin per kg of dried seeds. The fixed oil content in the seed is about 7 per cent. The fatty acid of the seed consists largely of linoleic, oleic and linolenic acids. The oil has a disagreeable odour and bitter taste. Seeds contain volatile oil (0.02%) which is brown and slightly odorous. The leaves and stems are rich source of calcium, iron, carotene, ascorbic acid and protein. (Farooqi *et al*., 2003).

As a spice, fenugreek seeds add to the nutritive value and flavour of foods. Because of this character, it has gained considerable importance in vegetarian diet. Fenugreek was and remains, a food and a spice commonly eaten in many parts of the world. Fenugreek seed is commonly used in cooking as it has a strong flavour and aroma. The leaves and seeds are also widely consumed in Indo-Pak subcontinent as well as in other oriental countries as a spice in food preparations and as an ingredient in traditional medicine. In Egypt and Ethiopia, fenugreek is a popular ingredient of bread, known to the Arabs as 'hulba' (Shanmugavelu *et al*., 2002). In Greece, the seeds (boiled or raw) are eaten with honey. In India, fenugreek seeds are one of the important ingredient in curry powder, chutney powder, pickles, masala powder, *etc*. It is also used in the preparation of chapati, halva, *etc.* along with wheat flour and forms a nutritious and delicious food

(Farooqi *et al*., 2003). In England seeds are extracted for steroidal substance "diosgenin" a sex hormone and oral contraceptive in family planning (Vasudevan *et al*., 2008).

Apart from its culinary usage a wide range of medicinal uses were found for fenugreek from ancient times. The first recorded use of fenugreek is described in an ancient Egyptian papyrus dated to 1500 B.C. According to Lust (1986) fenugreek is one of the oldest known medicinal plants in the recorded history. Fenugreek leaves and seeds have been used extensively to prepare extracts and powders for medicinal uses (Basch *et al.,* 2003). Medicinally it was used for the treatment of wounds, abscesses, arthritis, bronchitis, ulcer and digestive problems. Traditional Chinese herbalists used it for kidney problems (Snehalatha and Payal, 2012). Fenugreek is also reported to have anti-diabetic, anti-fertility, anticancer, anti-microbial, anti-parasitic effects (Al-Habori and Raman, 2002). Reference to fenugreek has been made in Indian Ayurvedic and Traditional Chinese Medicines where it is recognized as a galactogogue or lactation stimulant in women after child birth as well as for its ability to treat wounds and sore muscles (Tiran, 2003).

Seed in powder or germinated form exhibits anti-diabetic properties (Hannan *et al.*, 2003), hypocholesterolaemic effect (Suboh *et al.*, 2004; Venkatesan *et al*., 2003) and anti-cancer effect (Devasena and Menon, 2003). Also used to prevent constipation and stimulate spleen and liver (Kole and Saha, 2013).

Fenugreek is a Rabi crop, it requires cool climate during vegetative growth and warm dry climate during maturity. It is tolerant to frost. Well drained loamy soil with 6.0 to 7.0 pH is ideal for better growth and development. Optimum sowing time in general is from second fortnight of October to first fortnight of November in North India, whereas in Southern part it is grown in kharif and rabi seasons (Nybe *et al*., 2007). Seed rate per hectare is 10-15 kg and the duration is 25-30 days for greens and 90-100 days for seeds. The yield of green is 7-8 tonnes per hectare and seed yield is 1.5-2 tonnes per hectare (Shanmugavelu *et al*., 2002).

The performance of the crop under hill zone for seeds is poor compared to that of plains. There is a need to standardize various agronomic techniques to improve seed yield in fenugreek. Among the various cultural practices, proper time of sowing is a prerequisite (Nandre *et al.*, 2011) and among several seed production approaches, apical bud pinching is one which is practiced to enhance flower bearing branches by curbing vegetative growth which ultimately reflects on the seed yield and quality of crop (Vasudevan *et al*., 2008). However, among various constraints in cultivation of this crop non availability of adequate quantity of good quality seeds is considered to be a major factor. Hence, there is a need to increase both seed yield and quality in fenugreek.

As there is no much research on these aspects, in the region the present study was undertaken with the following objectives,

1. To study the effects of different sowing dates on growth, yield and quality of fenugreek.
2. To study the effects of stage of pinching on growth, yield and quality of fenugreek.
3. To work out the economics of fenugreek cultivation.

REVIEW OF LITERATURE

II. REVIEW OF LITERATURE

Interaction with agronomic, genetic and climatic factors must be scrutinized to introduce a new crop in a region. Time of sowing is known to influence the establishment of the crop growth and development of the seeds and also the environment experienced during seed development, both within and above the crop canopy (Castillo *et al*. 1994). Sowing date is a very important parameter in crop production. The optimum sowing date paves the way for better-use of time, light, temperature, precipitation and other factors (Moosavi, 2014). Slight variation in the temperature may cause complete crop failure or low yield and productivity. It is therefore essential to adjust the sowing time such a way to provide optimum soil and atmospheric temperature required for better growth and development of the crop.

Research information on effect of different dates of sowing and pinching intervals on growth, yield and quality of fenugreek is very limited. Hence information on closely related leguminous crops like cowpea, cluster bean, french bean, chick pea, mung bean, garden pea, soy bean, black gram etc., is reviewed along with fenugreek and presented in this chapter for better perception. The literature pertaining to important aspects of present study is presented below under the following headings:

2.1 Effect of sowing time

2.1.1 Effect of different dates of sowing on growth parameters

2.1.2 Effect of different dates of sowing on yield parameters

2.1.3 Effect of different dates of sowing on quality parameters

2.1.4 Effect of different dates of sowing on pest and disease incidence

2.1.5 Effect of different dates of sowing on economics

2.2 Effect of pinching intervals

2.2.1 Effect of pinching intervals on growth parameters

2.2.2 Effect of pinching intervals on yield parameters

2.1 Effect of sowing time:

The genetic constitution of plants determines their yielding ability but the extent to which the potential is really realized depends, greatly on the environment in which they grow. The date of sowing, governed mainly by the temperature is a crucial factor that can decide establishment, growth and performance of crops through changed morphological structure, physiological functioning and the time available for the crop to complete its life cycle.

Thus, environment has profound influence on growth and development of the plants. Modifications in environment by sowing dates gives a great opportunity of getting optimum temperature at the time of germination and at subsequent growth stages to maximize the production. Therefore, the time of sowing is very important as it is a non-monetary input and easily manageable component by the farmers (Khoja, 2004).

2.1.1 Effect of different dates of sowing on growth parameters:

2.1.1.1 Fenugreek (*Trigonella foenum – graecum* L.)

Maletic and Jevdjovic (2007) reported that the maximum plant height (36.91 cm) was observed under the sowing date of 22nd November and minimum plant height (24.83 cm) was observed under the sowing date of 1st Jan.

Heidari *et al.* (2009) observed that among three dates of sowing (3rd, 13th and 23rd March), the first sowing date recorded the maximum plant height (15.01 cm) and above ground biomass (62.55 g/m^2) followed by the other two dates of sowing.

Nandre *et al.* (2011) reported that the vegetative growth of fenugreek in terms of plant height and number of branches per plant were found to be the maximum with an early sowing (1st November).

Moghaddam *et al*. (2014) reported that sowing of fenugreek on 5th November resulted in maximum plant height of 86.01 cm than that sown on 5th December and 5th March (84.41 and 67.12 cm respectively).

2.1.1.2 Coriander (*Coriandrum sativum* L.)

Israel (1988) found that coriander sown on 15th October produced maximum plant height, dry matter and branches per plant and all these parameters decreased as sowing was delayed by 15 days and minimum with sowing on 15th November.

Baswana *et al.* (1989) found that coriander sown on 10th and 30th October produced equal or more plant height and primary branches per plant which were decreased as sowing date was delayed by every 20 days.

Bhati *et al.* (1989) observed that coriander sown on 3rd and 18th November gave more plant height as compared to 3rd December.

Bhati (1991) observed that plant height, primary and secondary branches per plant were highest in the coriander sown on 31st October that decreased when sown later on 10th and 20th November.

Sharma and Israel (1991) also reported more plant height and branches per plant from the crop sown on 31st October than 15th November sowing of coriander at New Delhi.

Pan *et al*. (2003) studied the effects of various planting dates (November 5th, November 20th and December 5th) on plant growth and reported that the highest plant height and number of branches per plant were recorded in November 5th sown crop.

Effects of different sowing dates (30th October, 20th October and 10th November) on growth of coriander was studied by Khoja (2004), who recorded significantly higher values for most of the growth parameters *viz.* number of branches per plant (23.3), dry matter per plant (21.8 g), leaf area per plant (8.3 cm^2), leaf area index (10.2), leaf area duration (22.4 days) and crop growth rate (12.5 g/m^2/day) for the crop sown on 30th October. Significantly maximum relative growth rate (3.75 g/g/day) was recorded in 20th November sown crop.

In a study Rassam *et al*. (2007) found that with the delay in sowing from March 30th to April 29th, plant height of coriander decreased significantly.

Ghobadi and Ghobadi (2010) reported that coriander sown on 19th June produced maximum plant height (81.2 cm) and number of branches per plant (4.6) than the 4th June and 20th May sown crop.

Moosavi *et al.* (2012) obtained highest plant height (42.67 cm) in 30th March sown crop and the lowest (27.77 cm) was in 29th April sowing. Further he reported that delay in sowing from March 30th to April 29th decreased the plant height, number of branches per plant and number of branches per main stem by 21.8 per cent, 60.8 per cent and 18.8 per cent respectively.

2.1.1.3 Fennel (*Foeniculum vulgare* L.)

Sowing of fennel on 15th September proved to be best by recording significantly maximum plant height (154.41 cm) and number of branches per plant (5.44) as compared to 7th October and 1st November sowing as reported by Tunio *et al.* (2005). Similar results were also reported by El-Khayat and Gouda (2005), Omidbaigi *et al.* (2006), Sudeep *et al.* (2006), Ayub *et al.* (2008) and Selim *et al*. (2013).

Effects of different sowing dates (14th September, 14th October and 14th November) on the yield of fennel was studied by Ayub *et al*. (2008). They recorded significantly higher values for growth parameters like plant height (147.01 cm), leaf area per plant (308.80 cm^2) and number of branches per plant (35.4) for the crop sown on 14th October than the other sowing dates.

Moosavi (2014) reported that fennel seeds sown on March 19th resulted in maximum number of branches per plant (4.80) than that sown on April 9th and April 20th (3.84 and 1.96 respectively).

2.1.1.4 Garden Pea (*Pisum sativum* L.)

Castillo *et al.* (1994) reported that sowing of garden pea during December resulted in significantly maximum seed germination (96 per cent), than that sown during November (90 per cent).

Significantly maximum values for various growth parameters *viz.* seed germination (92.73 per cent), plant height (58.35 cm) and number of branches per plant (2.69) were recorded in garden pea sown on 9th October as reported by Singh and Singh (2011).

2.1.1.5 Chick Pea (*Cicer arietinum* L.)

Total dry matter production of chick pea was maximum (27.42 g/m^2) in November 22nd sown crop compared to the one sown on 2nd December and 12th December (24.78 g/m^2 and 20.42 g/m^2 respectively) as reported by Kabir *et al.* (2009).

Mansur *et al*. (2010) reported that chickpea sown on 2nd fortnight of October recorded maximum number of branches per plant (35.34) than that sown on 1st fortnight of October and 1st fortnight of November (3.70 and 3.67 respectively).

2.1.1.6 Mung Bean (*Vigna radiata* L.)

Malik *et al.* (2006) revealed the maximum leaf area (1465.72 cm^2) and number of branches per plant (5.80) in mung bean for the crop sown during 3rd week of June than that sown on 1st week of July and 3rd week of July.

2.1.1.7 Cumin (*Cuminum cyminum* L.)

Moghaddam (2014) reported that cumin sown on 5th November resulted in maximum plant height (42.00 cm) than that sown on 5th December and 5th March (39.07 cm and 28.61 cm respectively). The result is in agreement with the findings of Ghorbani *et al*. (2009) on *Cuminum cyminum* L.

2.1.1.8 Anise (*Pimpinella anisum* L.)

Salmasi *et al.* (2003) studied the effect of three sowing dates (March-May) on *Pimpinella anisum* and concluded that delayed sowing reduced the plant height as compared to early sowing.

2.1.1.9 Dill (*Anethum graveolens* L.)

Early sowing (3rd April) resulted in significantly higher per cent germination (66 per cent) than delayed sowing (18th April-60 per cent and 4th May-5 per cent) in dill as reported by Salmasi *et al*. (2006).

2.1.1.10 Mustard (*Brasicca sp.*)

Bala *et al*. (2011) revealed that sowing of mustard on 8th November resulted in maximum number of branches per plant (4.70) than that sown on 1st November and 15th November (4.5 and 3.82 respectively). Similarly Singh *et al.* (2014) reported that sowing of mustard on 30th October resulted in maximum leaf area index (3.20 cm^2) and dry matter production (49.31 gram per plant) than that sown on 14th November and 29th November.

2.1.1.11 Soybean (*Glycine max* L.)

Mengxuan (2013) revealed that the crop sown on 15th June produced maximum plant height (63.5 cm), leaf area index (3.92) and number of branches per plant (65) than that sown on 22nd June which recorded minimum plant height (46.9 cm), leaf area index (3.04) and number of branches per plant (52). Photoperiod is one of the most important environmental factors that affect the soybean growth, because it regulates developmental processes of soybean.

2.1.1.12 Rice Bean (*Vigna umbellata* L.)

Khan *et al*. (2000) studied the effect of three dates of sowing (3rd, 10th and 17th August) on plant height and revealed that early sowing *i.e.*, on 3rd August recorded maximum plant height (136.11 cm) compared to other two dates of sowing.

2.1.1.13 Lentil (*Lens culinaris* M.)

Rahman *et al*. (2002) studied the effect of three different dates of sowing (1st December, 20th December and 10th January) on lentil and revealed that the first sowing date recorded maximum plant height (36.5 cm) and number of branches per plant (5.0) than the other two dates.

2.1.1.14 Okra (*Abelmoschus esculentus* L.M.)

Effects of two sowing dates (25th March and 9th May) on growth of okra was studied by Jabbar *et al.* (2007), who recorded significantly higher values for plant height (194.1 cm), number of branches per plant (12.25) and dry matter production (1.10 g/plant) for the crop sown on 25th April than the other sowing date.

2.1.2 Effect of different dates of sowing on yield parameters:

2.1.2.1 Fenugreek (*Trigonella foenum – graecum* L.)

Maletic and Jevdjovic (2007) reported that the highest yield of fenugreek seed (2917.50 kg/ha) was realized in the sowing period from April 10th and the lowest yield, of only 400 kg/ha was measured for seed sown at the end of May.

Heidari *et al.* (2009) observed that among three dates of sowing (3rd, 13th and 23rd March) in fenugreek the first sowing date recorded highest number of seeds per pod (7.280) and maximum seed yield (36.64 g/m^2) followed by the other two dates of sowing.

Moghaddam *et al*. (2014) reported that fenugreek sown on 5th November resulted in maximum number of pods per plant (34.51), number of seeds per pod (20.60), seed yield (1472 kg/ha) and harvest index (34.72 per cent) than that sown on 5th December and 5th March.

2.1.2.2 Coriander (*Coriandrum sativum* L.)

Israel (1988) reported that coriander sown on 15th October produced maximum umbels and umbellets per plant which decreased as sowing was delayed by 15 days and

minimum value was recorded with 15th November sowing. He also reported that seed weight per umbel and seed yield per hectare was highest with 30th October sowing followed by 15th October sowing. Similar results were observed by Baswana *et al.* (1989) that followed by 20th November sowing. Date of planting is the deciding factor of yielding ability (Gupta and Rai, 1989).

Bhati and Shaktawat (1990) reported that umbels per plant, umbellets per umbel, test weight and seed yield per plant were highest when coriander was sown on 3rd November but decreased as sowing was delayed by every 15 days and recorded minimum with 3rd December sowing.

Sharma and Israel (1991) observed that coriander sown on 31st October produced more umbels and umbellets per plant and seed yield than that sown on 15th November.

Chaudhari *et al.* (1995) at Rahuri, recorded maximum number of seeds per plant (217.67), seed yield per plant (2.57 g) and seed yield per hectare (9.83 q) by sowing the coriander on 1st November.

Toncer *et al.* (1998) stated that highest seed yield of coriander was obtained by sowing on 15th November at Diyarbakiir, Turkey.

Reddy and Rolston (1999) observed that seed yield of coriander declined 36 kg per hectare per day from first sowing on 17th September to the last sowing on 1st December. They also reported that seed weight and seed germination also declined as sowing dates were delayed from 17th September in New Zealand.

Effects of different sowing dates (30th October, 20th October and 10th November) on yield of coriander was studied by Khoja (2004), who recorded significantly higher values for number of umbels per plant (38.6) and number of umbellets per umbel (4.91) for the crop sown on 30th October than the other sowing dates.

Ghobadi and Ghobadi (2010) reported that coriander sown on 19th June produced maximum number of umbels per plant (24.8), number of seeds per umbel (10.3), seed

yield (1299.6 kg/ha) and 1000 seed weight (10.05 g) than the 4th June and 20th May sown crop and maximum harvest index (36.7 per cent) was recorded in the crop sown on 5th May.

Moosavi (2012) studied the effects of three dates of sowing in coriander (March 30th, April 14th and April 29th) and reported significantly maximum values for most of the yield parameters *viz.* number of umbels per plant (2.68), number of seeds per umbel (14.11), seed yield (444.03 kg/ha) and 1000 seed weight (8.6 g) in the crop sown on March 30th.

Significantly maximum values for various yield parameters like number of days for 50 per cent flowering (66 days), number of days for physiological maturity and seed yield (185 g/m^2) in coriander was obtained for the crop sown in April than the crop sown in June as reported by Guha *et al.* (2013).

2.1.2.3 Fennel (*Foeniculum vulgare* L.)

Bhati and Agarwal (1986) found that yield and yield attributes *viz*., umbels per plant and umbellets per plant of fennel were decreased as sowing was delayed by every 15 days from 1st to 30th October.

Kulhari and Bhati (1986) observed that the seed yield and umbels per plant of fennel decreased when sowing was done after 30th October.

Mohan *et al.* (2001) studied the effect of sowing dates on fennel at Hisar and found that the seed yield per plant and seed yield per hectare were recorded highest from 30th September sown crop followed by 15th October and lowest from 14th November sown crop.

Effects of different sowing dates (14th September, 14th October and 14th November) on the yield of fennel was studied by Ayub *et al*. (2008). They recorded significantly higher values for most of the parameters like number of umbels per plant (16.06), number of seeds per umbel (170.45), 1000 seed weight (4.38 g), seed yield per

hectare (233.45 kg) and biological yield per hectare (3747.27 kg) for the crop sown on 14th October than the other sowing dates.

Soleimani *et al*. (2010) reported 29.9 per cent decrease in fennel seed yield due to the delay in sowing date from March 25th to May 5th.

Selim *et al*. (2013) studied the effect of three sowing dates (15th September, 7th October and 1st November) on yield parameters of fennel. The crop sown on 7th October has proved best by recording significantly higher values for number of umbels per plant (25.37) and seed yield per plant (42.37 g) than the other two sowing dates.

Moosavi *et al.* (2014) reported that sowing of fennel on March 19th showed significantly maximum seed yield (1161.30 kg/ha) than the 30th April sown crop (97.93 kg/ha) and also highest biological yield was obtained in the crop sown on March 19th (4798.34 kg/ha) and the lowest one was obtained in the crop sown on April 30th (355.70 kg/ha).

2.1.2.4 Garden Pea (*Pisum sativum* L.)

In garden pea 1000 seed weight was maximum in the crop sown during November than that sown in December as reported by Castillo *et al.* (1994).

Singh and Singh (2011) reported maximum number of pods per plant (8.11), number of seeds per pod (6.78) and seed yield (12.51 q/ha) in the crop sown on 9th November than that sown on 9th October and 9th December (7.80 q/ha and 4.45 q/ha respectively) which may may be due to relatively cool temperature and sufficient time available for the growth and development to the seeds before low temperatures creep in, which could have promoted the growth of the plants. Similar results were also reported by Singh *et al*. (1996) and Nagarajana *et al*. (2002).

2.1.2.5 Chick pea (*Cicer arietinum* L.)

Kabir *et al.* (2009) reported that sowing of chickpea on 22nd November gave maximum number of pods per plant (30.18), number of seeds per pod (1.39), seed yield

per plant (4.68 g) and harvest index (0.49%) than that sown on 2nd December and 12th December but maximum seed yield of 855.50 kg/ha was obtained in the crop sown on 2nd December.

Mansur *et al*. (2010) revealed that sowing of chickpea on 2nd fortnight of October gave maximum number of pods per plant (55.69) than that sown on 1st fortnight of October and November (44.50 and 46.69 respectively).

2.1.2.6 Mung bean (*Vigna radiata* L.)

Malik *et al.* (2006) revealed that sowing of mung bean during 3rd week of July resulted in production of maximum number of pods per plant (34.58), 1000 seed weight (44.88 g) and number of grains per pod (11.17) than that sown on 3rd week of June and 1st week of July.

2.1.2.7 Cumin (*Cuminum cyminum* L.)

Sardooyi *et al.* (2011) revealed that sowing of cumin on 6th March gave maximum seed yield (787.86 kg/ha) and harvest index (0.5 per cent) than that sown on 4th February and 19th February.

Moghaddam *et al.* (2014) revealed that sowing of cumin on 5th December resulted in maximum number of umbels per plant (31.52) and seed yield (555 kg/ha) than the 5th December sown crop.

2.1.2.8 Black cumin (*Nigella sativa* L.)

Ahmed and Haque (1986) studied the effects of time of sowing (November 1st, November 20th, December 10th and December 30th) on the yield of black cumin (*Nigella sativa* L.) in Bangladesh, and found that early sowing (November 1st) was the best for higher seed yield in black cumin.

Sedigheh *et al.* (2009) reported that among three different sowing dates of black cumin (3rd, 13th and 23rd of March), the second sowing date resulted in higher seed yield (27.63 g/m^2) and number of seeds per umbel (7.475) than the first and third sowing date.

2.1.2.9 Dill (*Anethum graveolens* L.)

Salmasi *et al*. (2006) reported that among the three sowing dates *viz.* 3rd April, 18th April and 4th May, the first sowing resulted in maximum values for thousand seed weight (1.44 g) and significantly higher seed yield (540 kg/ha) than those sown on 4th May which yielded 430 kg seeds per hectare.

2.1.2.10 Mustard (*Brassica sp*.)

Bala *et al.* (2011) revealed that sowing of mustard on 8th November resulted in maximum seed yield (2.19 t/ha) but maximum harvest index (37.43%) was observed for the crop sown on 1st November than the crop sown on 8th November and 15th November (37.07 % and 32.79 % respectively).

Significantly maximum values for yield parameters like 1000 seed weight (4.71 g) and harvest index (24.89 %) in mustard was obtained for the crop sown on 29th November than the crop sown on 30th October and 14th November as reported by Singh *et al*. (2014).

2.1.2.11 Caraway (*Carum carvi* L.)

In a study on the effects of sowing date and plant density of caraway, Sadeghi *et al*. (2009) reported that the highest seed yield and biological yield were obtained in March 30th sown crop as compared to sowing on 14th and 29th of April.

2.1.2.12 Anise (*Pimpinella anisum* L.)

Askari *et al*. (2012) reported that seeds of *Pimpinella anisum* sown during November gave maximum seed yield of 218.9 kg/ha than that sown during December and April (210.6 kg/ha and 24.26 kg/ha respectively).

2.1.2.13 Faba bean (*Phaseolus vulgaris* L.)

Ramírez *et al.* (2004) evaluated different sowing dates like May 12th, June 5th, April 29th and June 22nd. It was observed that sowing on June 5th showed best results by taking minimum of 42 days for first flowering followed by sowing on May 12th which

took 44 days for first flowering. They also observed a reduction in the growth cycle of beans in the second sowing date. It showed the most drastic reduction of the growth cycle having 112 days to maturity in the first sowing date and only 100 days to maturity in the second sowing date and also reported that June 5th sown crop gave maximum seed yield (4018 kg/ha) followed by May 12th sown crop (3503 kg/ha).

2.1.2.14 Soybean (*Glycine max* L.)

Barati *et al.* (2013) revealed that sowing of soybean on 5th May recorded maximum seed yield (1483.33 kg/ha) than that sown on 20th May and 22nd June (1483.33 kg/ha and 636.22 kg/ha respectively).

Mengxuan (2013) revealed that the crop sown on 15th June recorded significantly maximum number of pods per plant (67), number of seeds per pod (1500) and seed yield (2013 kg/ha) than that sown on 22nd June which recorded minimum number of pods per plant (55), number of seeds per pod (1356) and seed yield (1745 kg/ha). Increase in yield is attributed mainly because of photoperiod response which is one of the most important environmental factors that affect the growth as it regulates developmental processes of soybean.

Significantly maximum values for various yield parameters like number of pods per plant (20.62), number of seeds per pod (35.99) and pod length (4.50 cm) in soybean was obtained in the crop sown on 20th April but the crop sown on 10th May reached to physiological maturity early by taking minimum number of days (140.22 days) than that sown on 20th and 30th April (161.99 days and 155.77 days respectively) as reported by Sadeghi and Niyaki (2013).

2.1.2.15 Rice bean (*Vigna umbellata* L.)

Significantly maximum values for various yield parameters *viz*. number of pods per plant (130.8), 1000 seed weight (63.84 g) and seed yield (1492 kg/ha) were obtained for the crop sown on 30th August than the crop sown in 10th and 17th of August as reported by Khan *et al*. (2000).

2.1.2.16 Lentil (*Lens culinaris* M.)

Rahman *et al*. (2002) studied the effect of three different dates of sowing (1st December, 20th December and 10th January) on lentil and revealed that the first sowing date recorded maximum number of pods per plant (9.0) and seed yield (1050 kg/ha) than the other two sowings.

Azadi *et al*. (2013) reported that sowing of crop during winter months recorded significantly maximum readings for the parameters like number of seeds per pod (1184.4), seed yield (799.67 kg/ha) and harvest index (36.3 per cent) than that sown during spring.

2.1.3 Effect of different dates of sowing on quality parameters:

2.1.3.1 Coriander (*Coriandrum sativum* L.)

Khoja (2004) revealed that there was a significant increase in total chlorophyll content in coriander crop sown on 30th October than that sown on 20th October, 10th and 20th November.

2.1.3.2 Garden pea (*Pisum sativum* L.)

Siddique *et al*. (2002) reported that pea seeds sown on 24th June resulted in maximum protein content of 22.5 per cent than that sown on 1st March and 29th March (18.6 and 18.9 % respectively). Similar results were also recorded by Mengxuan (2013) who recorded maximum protein content of 36.72 per cent in soybean sown on 22nd June than that sown on 15th and 30th June (36.68 and 36.16 % respectively).

2.1.3.3 Soybean (*Glycine max* L.)

Sadeghi and Niyaki (2013) reported that sowing of soybean on 30th April resulted in maximum protein content of 36.25 per cent than that sown on 20th April and 10th May (35.92 and 33.17 % respectively).

2.1.3.4 Rice bean (*Vigna umbellata* L.)

Khan *et al*. (2000) studied the effect of three dates of sowing (3rd, 10th and 17th August) on protein content of rice beans and revealed that the first sowing recorded significantly maximum protein content (18.32 %) than the other two sowings which recorded 18.21 and 18.05 per cent of protein content respectively.

2.1.4 Effect of different dates of sowing on pest and disease incidence:

2.1.4.1 Fenugreek (*Trigonella foenum – graecum* L.)

Meena (1998) studied the impact of sowing dates on the occurrence of aphid (*Aphis pisum*) and seed yield of fenugreek. He concluded that crop sown on 30th October resulted in less aphid infestation and more yield as compared to the crop sown on 20th November which had maximum aphid infestation and less yield.

2.1.4.2 Coriander (*Coriandrum sativum*)

Jain and Yadava (1989) reported that sowing of coriander on 25th October resulted in low infestation of aphid (*Hyadaphis coriandari*). Sowing beyond 25th November led to increased aphid infestation and reduced yield. They further recommended that in areas of high aphid incidence, the crop should be sown from the last week of October to the first week of November. Similarly Meena *et al*. (2002) also conducted a trial at Jobner to see the effect of different sowing dates of coriander on the incidence of *Hyadaphis coriandari* and yield and found that crop sown on 30th October showed less aphid infestation and more yield while, crop sown on 20th November had maximum aphid infestation and less yield.

2.1.4.3 Fennel (*Foeniculum vulgare* L.)

Maximum powdery mildew disease index (36 %) was recorded in 15th December sown fennel crop than that sown on 15th October (27 %) and 15th November (35 %) as reported by Parashkar and Lodha (2012).

2.1.4.4 Mustard (*Brassica sp*.)

Ahuja (1990) observed that the incidence of mustard aphid (*Lypaphis erysimi* K.) commenced in late December or January in Rajasthan, gradually increased and reached peak towards the end of January to third week of February depending upon the prevailing weather conditions.

Kanwat and Kumawat (1995) recorded low aphid (*Lypaphis erysimi* K.) infestation and higher yield of mustard crop sown on 15th October in comparison to crop sown on 30th October.

Prasad and Lal (2001) conducted a field trial at IARI and reported that early sown crop (23rd October) of *Brassica sp*. had low intensity of aphid (*Lypaphis erysimi* K.). Whereas, late sown crop (23rd November) had high intensity of aphid.

Lasker *et al*. (2004) conducted a field trial in mid hill region of Darjeeling, West Bengal during 2001-02 and 2002-03 with 12 dates of sowing at weekly intervals, starting from the first week of October till the last week of December to study the incidence of mustard aphid (*Lypaphis erysimi* K.) and effect on seed yield and reported that the early sown crop attracted lower number of aphids.

Taker and Jat (2005) studied the effect of sowing dates on the incidence of mustard aphid (*Lypaphis erysimi* K.) on mustard cv. Bio-902 (Pusa Jai Kisan) and reported least incidence of aphid and highest yield in early sown crop (10th October) as compared to late sown crop (30th October).

2.1.5 Effect of different dates of sowing on economics:

2.1.5.1 Coriander (*Coriandrum sativum* L.)

As reported by Khoja *et al*. (2004) in coriander, the highest net return (26,838 Rupees/ha) and B:C ratio (2.72) was realised from the crop sown on 30th October followed by those sown on 20th October, 10th and 20th November.

2.1.5.2 Chickpea (*Cicer arietinum* L.)

Mansur *et al*. (2010) revealed that sowing of chickpea on 2nd fortnight of October reported significantly maximum cost of cultivation (11,193 Rupees/ha), gross returns (38963 Rupees/ha), net returns (27,769 Rupees/ha) and B:C (2.48) than that sown on 1st fortnight of October and 1st fortnight of November.

2.2 Effect of pinching intervals:

Among several seed production approaches, apical bud pinching is practiced to enhance flower bearing branches by curbing vegetative growth. (Vasudevan *et al.*, 2008). Cutting management or pinching practice greatly influences the growth and yield attributes in fenugreek (Baboo, 1997). Cutting of herbage at early stages of growth induces uniformity in growth, flowering and seed setting in fenugreek (Pandita and Randhawa, 1994).

2.2.1 Effect of pinching intervals on growth parameters:

2.2.1.1 Fenugreek (*Trigonella foenum – graecum* L.)

In a study on the effects of pinching intervals on growth of fenugreek**,** Vasudevan *et al.* (2008) reported significant reduction in plant height in the crop pinched at 35 days after sowing (33.57 cm) as compared to no pinching (42.58 cm) and also reported more number of branches (6.58) in the crop pinched at 35 days after sowing as compared to either pinching at 40 days after sowing (6.29) or with no pinching (6.10).

Krishnaveni *et al*. (2014) in fenugreek revealed that at the time of harvest the maximum plant height was recorded with no pinching (47.21 cm) as compared to pinching at 25 days after sowing (44.04 cm) and at 45 days after sowing (43.56 cm). Also revealed that maximum number of branches per plant (6.33) and maximum dry matter production (17.98 g per plant) was observed under the plants pinched at 25 days after sowing as compared to other pinching treatments.

2.2.1.2 Faba bean (*Phaseolus vulgaris* L.)

Olfati and Malakouti (2013) reported that pinching of faba bean three times when all lateral and sublateral branches had at least four leaves produced more number of shoots per plant (6.22) than no pinching (4.99).

2.2.1.3 Chickpea (*Cicer arietinum* L.)

Baloch and Zubair (2010) conducted an experiment on effect of nipping on growth of chickpea and revealed that pinching of plants decreased the plant height significantly (65.67 cm) as compared to the plants which were not pinched (67.53 cm).

2.2.1.4 Okra (*Abelmoschus esculentus* L. M.)

Sajjan (2002) revealed that pinching of okra recorded maximum number of branches per plant (2.20) and leaf area index (0.747) as compared to no pinching which recorded minimum number of branches per plant (0.70) and leaf area index (0.676).

As reported by Jabbar *et al*. (2007) in okra maximum number of branches per plant (12.80) and dry matter production (0.30 g) was observed in the plants that were pinched but maximum plant height was recorded in the plants that were not pinched (183.83 cm) as compared to the pinched plants (180.8 cm).

2.2.2 Effect of pinching intervals on yield parameters:

2.2.2.1 Fenugreek (*Trigonella foenum – graecum* L.)

Vasudevan *et al.* (2008) in fenugreek reported the beneficial influence with pinching at 30 DAS on number of pods per plant (36.23) compared to no pinching (32.15). But significantly maximum values for the other yield parameters *viz*. number of seeds per pod (17.44) and seed yield (26.23 g per plant and 21.86 q/ha) were observed for the plants pinched at 35 days after sowing . Also reported that fenugreek plants pinched at 35 days after sowing and 40 days after sowing took relatively more number of days to 50 per cent flowering (44.50 and 45.33 days respectively) as compared to no pinching which took 34.83 days to 50 per cent flowering because of more production of secondary branches.

Krishnaveni *et al.* (2014) in fenugreek revealed that the plants pinched at 25 days after sowing took maximum days for flower initiation (36.94) as compared to pinching at 45 days after sowing (35.09) and no pinching (34.64) and also recorded maximum number of pods per plant in the plants which were pinched at 25 days after sowing (22.57) as compared to pinching at 45 days after sowing (22.10) and no pinching (21.26).

2.2.2.2 Coriander (*Coriandrum sativum* L.)

Guha *et al.* (2013) in coriander reported that among different levels of cutting, the plants with two cut treatment took more time for 50 per cent flowering (75.33 days) as compared to one cut (69.20) and no cut (62.40) and also reported that plants with no cut treatment recorded early physiological maturity by taking minimum time (92.40) as compared to the plants with one cut and two cut treatments (109.93 and 114.7 respectively). He also revealed that the highest seed yield was reported in one cut treatment (190 g/m^2) as compared to the plants with no cut and two cut treatments (181.5 g/m^2 and 173.30 g/m^2 respectively).

2.2.2.3 Faba bean (*Phaseolus vulgaris* L.)

Olfati and Malakouti (2013) reported that pinching of faba bean three times when all lateral and sublateral branches had at least four leaves produced significantly maximum values for various parameters like number of pods per plant (6.34), pod yield (10.17 Mt/ha), seed yield (6.78 Mt/ha) and 1000 seed weight (390.86 g) as compared to no pinching. They attributed this increased yield to more number of branches per plant due to pinching.

2.2.2.4 Chickpea (*Cicer arietinum* L.)

Baloch and Zubair (2010) conducted an experiment on effect of nipping on yield of chickpea and revealed that pinching of plants recorded significantly maximum values for most of the yield parameters *viz*. number of pods per plant (82.60), number of grains per pod (1.44), 1000 grain weight (195.5 g) and grain yield (1625 kg/ha) as compared to the plants which were not pinched. Foliage nipping at early stages of crop could increase number of branches while restricting profuse vegetative growth thereby promoting crop

yield (Singh and Diwakar, 1995). Nipping at various stages tended to enhance number of branches and number of pods that in turn boost chickpea yield. Similar results were also noticed by Aziz (2000).

2.2.2.5 Okra (*Abelmoschus esculentus* L. M.)

Significantly maximum values for various yield parameters *viz*. number of pods per plant (5.53), number of seeds per pod (43.33) and seed yield (727.7 kg/ha) were obtained for the crop which was pinched 20 days after sowing as compared to the plants that were not pinched, which recorded minimum number of pods per plant (3.23), number of seeds per pod (41.35) and seed yield (655.8 kg/ha) as reported by Sajjan (2002) in okra.

Significantly maximum values for various yield parameters *viz*. number of pods per plant (14.25), number of seeds per pod (609) and seed yield (3.09 t/ha) were obtained for the pinched plants as reported by Jabbar *et al*. (2007) in okra.

MATERIAL AND METHODS

III. MATERIAL AND METHODS

A field experiment was conducted on "Standardization of sowing dates and stage of pinching for growth, yield and quality of fenugreek (*Trigonella foenum - graecum* L.) under hill zone of Karnataka" at the Department of Plantation, Spices, Medicinal and Aromatic Crops, College of Horticulture Mudigere, University of Agricultural and Horticultural Sciences, Shivamogga from October 2014 to March 2015. The details of the materials used and methods followed during the course of investigation are presented in this chapter.

3.1 Experimental location

The field experiment was carried out at the farm field of the department of Plantation, Spices, Medicinal and Aromatic Crops, College of Horticulture, Mudigere, during 2014-15. The College of Horticulture, Mudigere is situated in hill zone of Karnataka at 15^0 46′ N latitude, 76^0 4′ E longitude and at an altitude of 982 m above mean sea level. It receives an annual average rainfall of 2,400 mm which is well distributed in 104 rainy days during the period from May to October with three peaks during June, July and August. More than 35 to 40 per cent of total rainfall is received in the month of July alone. The mean maximum temperature is 30^0 C (April) and mean minimum temperature is 14^0 C (January) and the relative humidity ranges from 50 to 80 per cent.

3.2 Soil and climatic conditions of the experimental site

The soil of experimental site is red sandy loam texture and uniform fertility status, grouped under the class of Alfisols. Monthly weather data on total rainfall, maximum and minimum temperature and relative humidity recorded at the Agro-meteorological observatory, Zonal Agricultural and Horticultural Research Station, Mudigere that prevailed during the period of experiment are presented in Appendix-I. The physical and chemical properties of the soil are furnished in Appendix- II.

3.3 Experimental details

3.3.1 Design and layout of experiment

The experiment was laid out in open field with factorial randomized complete block design (FRCBD). There were three replications in the experiment. The plan of layout of the experiment is given in Figure.1.

The details are as follows:

Number of treatments : 15

Location : COH –Mudigere

Design : Factorial randomized complete block design (FRCBD)

Number of replications : 03

Spacing : 30 X 10 cm

Plot size : 2.5 m x 1.2 m

Variety : Belur Local

Factor I – Dates of sowing

D_1 – 1st October

D_2 – 15th October

D_3 – 1st November

D_4 – 15th November

D_5 – 1st December

Factor II- Stage of pinching

P_1- Pinching at 25 DAS

P_2 - Pinching at 35 DAS

P_3- No pinching

Treatment combinations

D_1P_1: Sowing on 1st October and pinching at 25 DAS

D_1P_2: Sowing on 1st October and pinching at 35 DAS

D_1P_3: Sowing on 1st October and no pinching

D_2P_1: Sowing on 15th October and pinching at 25 DAS

D_2P_2: Sowing on 15th October and pinching at 35 DAS

D_2P_3: Sowing on 15th October and no pinching

D_3P_1: Sowing on 1stNovember and pinching at 25 DAS

D_3P_2: Sowing on 1st November and pinching at 35 DAS

D_3P_3: Sowing on 1st November and no pinching

D_4P_1: Sowing on 15th November and pinching at 25 DAS

D_4P_2: Sowing on 15th November and pinching at 35 DAS

D_4P_3: Sowing on 15th November and no pinching

D_5P_1: Sowing on 1st December and pinching at 25 DAS

D_5P_2: Sowing on 1st December and pinching at 35 DAS

D_5P_3: Sowing on 1st December and no pinching

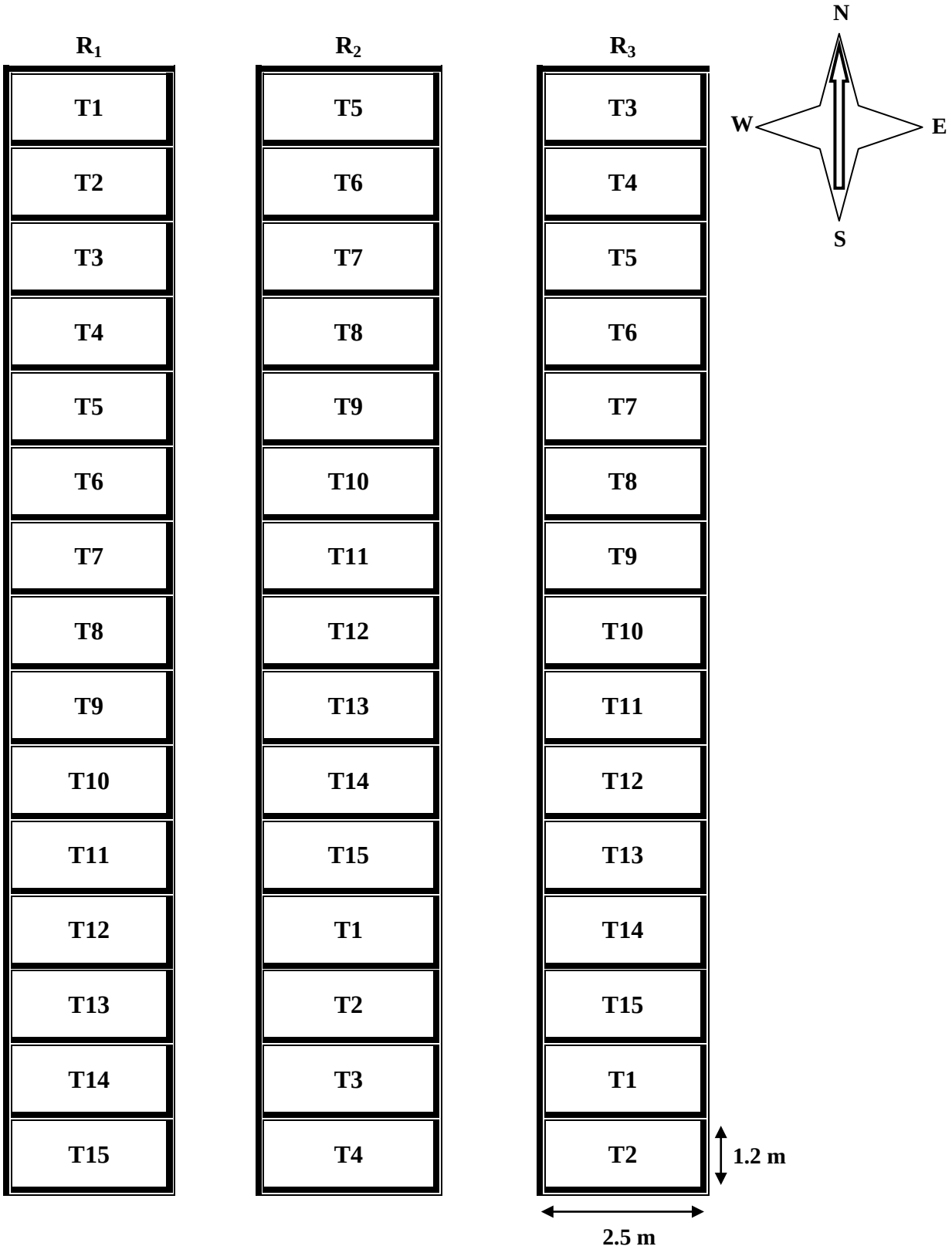


Fig. 1. Plan and layout of the experimental plot

3.4 Cultural practices

3.4.1 Preparation of the experimental plot

The experimental plot was ploughed twice by tractor drawn cultivator and levelled. The clods were crushed weeds were removed and brought to fine tilth. The land was divided into plots of required size (2.5 m x 1.2 m). Provision was made for bunds and irrigation channels.

3.4.2 Sowing of seeds

The seeds were soaked overnight and they were treated with Captan 2g/kg seeds. Later they were shade dried for half an hour. The seeds were used with the seed rate of 12 – 15 kg/ha and 2-3 seeds were sown per hole. Seeds were sown at 15 days intervals starting from 1st October to 1st December, 2014 at a spacing of 30x10 cm. Furrows were properly covered with a thin layer of soil and the plots were irrigated lightly.

3.4.3 Thinning of seedlings

Thinning was done manually at 30 days after sowing to maintain recommended spacing so as to retain healthy vigorous seedling**.**

3.4.4 Manures and fertilizers

Farm yard manure @ 8 t/ha was applied to soil at the time of land preperation. Phosphorous, potassium and nitrogen was applied in the form of Single super phosphate, Murate of potash and urea at the rate of 25:25:50 NPK kg/ha respectively.

3.4.5 Time of application

The experimental plots were provided with the calculated quantity of fertilizers. Half dose of nitrogen and full dose of phosphorous and potassium was supplied as basal dose at the time of sowing. The remaining 50 per cent of nitrogen was given as top dressing at 30 days after sowing.

3.4.6 Pinching

The field experiment involved three pinching treatments viz., P_1-25 days after sowing (DAS), P_2-35 DAS and P_3–No pinching. The apical buds were removed by pinching manually without causing damage to the plant parts as per treatments.

3.5 After care

3.5.1 Weeding and irrigation

The plots were kept free from weeds by hand weeding at 15, 30, 45, 70 and 95 days after sowing. The plots were irrigated at an interval of 2-3 days in initial growth period. Later the irrigation interval increased to once in a week depending on the soil moisture conditions.

3.5.2 Plant protection

Incidence of powdery mildew (*Erysiphe polygoni*) and caterpillars (*Spodoptera sp.*) infestation was observed in some of the treatments. To control powdery mildew plants were sprayed with Wettable Sulphur @ 2g per litre of water. Chlorpyriphos @ 2ml per litre of water was sprayed to control the spodoptera infestation.

3.5.3 Harvesting

The plants took about 80 - 85 days from the date of sowing for harvesting. Harvesting of seeds was done when the lower leaves start shedding and pods become yellowish. Plants were uprooted and tied in bundles and allowed to dry for 4-6 days. Threshing was done in clean cemented floor. Seeds were separated by beating followed by winnowing. The weight of the seed was recorded and expressed in kg / ha.

3.6 Observations recorded

Observations on growth and yield parameters were recorded using five plants per plot selected randomly by avoiding the border plants. The observations on growth parameters were recorded at 30 and 60 days after sowing and at the time of harvest. The various observations recorded are mentioned here under.

3.6.1 Growth parameters

3.6.1.1 Germination percentage

It was calculated by using the formula which is given below.

$$\text{Germination (\%)} = \frac{\text{Number of seeds germinated}}{\text{Number of seeds sown}} \times 100$$

3.6.1.2 Plant height

Plant height was measured from the ground level to the growing tip of the main stem at 30 and 60 days after sowing (DAS) and at the time of harvest. Observations recorded on five plants from each plot and expressed in centimetre.

3.6.1.3 Number of branches per plant

Number of primary branches per plant was counted for each plant at 30 and 60 days after sowing and at the time of harvest. The mean values were expressed in numbers.

3.6.1.4 Plant spread

The plant spread was measured in both East-West and North-South directions using measuring scale and the distance were multiplied. The mean was expressed in square centimeters.

3.6.1.5 Leaf area (LA)

The fourth leaf from the tip of the branch was used for recording observation as it was considered as physiologically fully active. Observations were taken 30 and 60 days after sowing. Leaf area was measured by using leaf area meter and it was expressed in square centimeters.

3.6.1.6 Leaf Area Index (LAI)

Leaf area index was calculated at 30 and 60 days after sowing by using the formula suggested by Watson (1952).

$$LAI = \frac{\text{Leaf area}}{\text{Ground area covered by plant or spacing}}$$

3.6.1.7 Leaf Area Duration (LAD)

LAD signifies the duration of the functional activity of leaves which denotes the ability of the plant with reference to the photosynthetic duration of the crop plant. It was calculated by using the formula given below and expressed in days.

$$LAD = \frac{L_i + [\, L_{(i+1)} \,]}{2} \times (t_2 - t_1)$$

L_i = Leaf area index at time t_1

$L_{(i+1)}$ = Leaf area index at time t_2

$t_2 - t_1$ = Time interval in days

3.6.1.8 Dry matter production of leaves, stem, pods and seeds

Dry matter production (g/plant) in different plant parts was estimated by selecting five plants randomly from each plot by uprooting at 30 and 60 days after sowing and at harvest. The plant parts were cleaned by removing the adhering soil and other extraneous matter. They were shade dried for 2 days further, dried in hot air oven at 50^0 C till constant weight was achieved. The plant parts were finally weighed using an electronic weighing balance and the mean values were expressed as gram per plant.

3.6.1.9 Total dry mater production (TDMP)

The TDMP is the biomass accumulated by the whole plant over a period of interval of time and its distribution (allocation) to different parts of the plant such as stems, leaves, pods and seeds. The total dry matter production was calculated by adding dry weight of leaves, stem, pods and seeds. This data formed the basis for computing crop growth rate.

3.6.1.10 Absolute Growth Rate (AGR)

The AGR of plant was worked out by dividing the difference in total dry weight of the plant at two consecutive stages by the interval (days) between the two stages and expressed as grams per plant per days (Radford, 1967).

$$AGR = \frac{(W_2 - W_1)}{(t_2 - t_1)}$$

W_1= Dry weight of the plant at time t_1

W_2= Dry weight of the plant at time t_2

$t_2 - t_1$ = Time interval in days

3.6.1.11 Cumulative Growth Rate (CGR)

It is the rate of dry matter production per unit ground area per unit time. It was calculated by using the formula given by (Watson, 1952) and expressed as g per m^2 per day.

$$CGR = \frac{(W_2 - W_1)}{(t_2 - t_1)} \text{ X } \frac{1}{A}$$

W_1= Dry weight of the plant at time t_1

W_2= Dry weight of the plant at time t_2

$t_2 - t_1$ = Time interval in days

A = Land area

3.6.1.12 Relative Growth Rate (RGR)

It is the increase in dry weight of plant material per unit of material present per unit of time. The mean RGR of the crop was calculated by the following formula (Radford, 1967) and expressed as g/g/day.

$$RGR = \frac{\text{Loge } W_2 - \text{Loge } W_1}{t_2 - t_1}$$

W_1 = Total dry weight of plant at time t_1

W_2 = Total dry weight of plant at time t_2

$t_2 - t_1$ = Time interval in days

3.6.1.13 Net Assimilation Rate (NAR)

The NAR is the rate of dry weight increase per unit leaf area per unit time. It was calculated by following the formula of (Radford, 1967) and expressed as g per dm^2 per day.

$$NAR = \frac{(W_2 - W_1)}{(t_2 - t_1)} \; X \; \frac{(Log_e L_2 - Log_e L_1)}{(L_2 - L_1)}$$

L_1 and W_1 = Leaf area (cm^2) and total dry weight of the plant (g) respectively at time t_1

L_2 and W_2 = Leaf area (cm^2) and total dry weight of the plant (g) respectively at time t_2.

$t_2 - t_1$ = Time interval in days

3.6.2 Yield parameters

3.6.2 .1 Days taken for 50 per cent flowering

Days taken for 50 per cent of the plants in a bed to flower was counted and expressed in days.

3.6.2.2 Number of pods per plant

The number of pods per plant was counted at the time of harvest, the mean value was expressed in numbers.

3.6.2.3 Length of pod

Length of pod was calculated by measuring the pod length of 10 randomly selected pods from each replication using a measuring scale. The mean value was expressed in centimetres.

3.6.2.4 Weight of pod

Weight of pod was calculated by weighing of 10 randomly selected pods from each replication using a weighing balance. The mean value was expressed in grams.

3.6.2.5 Number of seeds per pod

Seeds from five pods each from five randomly selected plants in a plot were separated and counted and the mean was calculated as number of seeds per pod.

3.6.2.6 Weight of seeds per pod

Seeds from five pods each from five randomly selected plants in a plot were separated and weighed using a weighing balance and the mean was calculated and expressed in grams.

3.6.2.7 Seed yield per plant

Cleaned and dried seeds of the five labelled plants were weighed and expressed as weight of seeds per plant in grams.

3.6.2.8 Seed yield per hectare

The seed yield obtained per plant was converted into seed yield per hectare and expressed in kg per hectare.

3.6.2.9 Thousand seed weight

Weight of thousand dried seeds from each replication was recorded using an electronic weighing balance and the values were expressed in grams.

3.6.2.10 Number of days for harvest

Number of days was counted from sowing till 75 per cent of pods started drying in the plot and recorded as days for harvest.

3.6.2.11 Harvest Index (HI)

It is a measure of conversion efficiency of dry matter into economic product and expressed in per cent.

$$HI\ (\%) = \frac{\text{Economic yield}}{\text{Biological yield}} \times 100$$

3.6.3 Quality parameters

3.6.3.1 Chlorophyll content of leaf

Fully matured and healthy leaves from fifth node from the tip of the plant were used for analysis at 30 and 60 days after sowing.

Chlorophyll-a, chlorophyll-b and total chlorophyll content of leaf tissue were determined by using Dimethyl Sulfoxide (DMS) (Hiscox and Israelstam, 1979) as given below

Fresh and fully matured leaves from the plant were brought in polyethylene bags from the research field and were cut into pieces. Known weight of sample (100 mg) was incubated in 7.0 ml of DMSO at 65^0 C for 120 minutes. After the incubation, supernatant was collected by decanting and leaf tissue was discarded. Then the volume of the supernatant was made up to 10 ml using DMSO.

The absorbance of the extract was measured at 645 nm and 663 nm using DMSO reagent as blank solution for calibrating the spectrophotometer (Arnon, 1949).

The total chlorophyll, chlorophyll-a and chlorophyll-b contents were calculated by using the formulae given below.

$$\text{Total chlorophyll} = [20.2\ (A_{645}) + 8.02\ (A_{663})]\ \frac{V}{1000 \times W \times a}$$

$$\text{Chlorophyll-a} = [12.7\ (A_{663}) - 2.69\ (A_{645})]\ \frac{V}{1000 \times W \times a}$$

$$\text{Chlorophyll-b} = [22.9\ (A_{645}) - 4.68\ (A_{663})]\ \frac{V}{1000 \times W \times a}$$

Where,

A : Absorbance at specific wave lengths (645 nm and 663 nm)

V : Volume of the extract (10 ml)

W : Fresh weight of the sample (100 mg)

a : Path length of light in cuvette (1 cm)

3.6.3.2 Protein content

Crude protein content of the seeds was analysed. The nitrogen content was analysed by Micro Kjeldahl's method. The crude protein content was obtained by multiplying the nitrogen content of the seeds by 6.25 and expressed in per cent.

$$\text{Crude protein (\%)} = \text{Nitrogen content} \times 6.25$$

3.6.4 Economic analysis

3.6.4.1 Cost of cultivation

The prices of all inputs prevailing at the time of their use and the labour cost were used to work out the cost of cultivation and expressed in Rupees per ha.

3.6.4.2 Gross return

The gross income was worked out based on the prevailing market of the produce and expressed in Rupees per ha.

3.6.4.3 Net return

The net income per hectare was calculated on the basis of gross income and cost of cultivation per ha and expressed in Rupees per ha.

3.6.4.4 Benefit Cost Ratio

$$\text{Benefit Cost Ratio} = \frac{\text{Net return (Rupees/ha)}}{\text{Cost of cultivation (Rupees/ha)}}$$

3.6.5 Pest and disease scoring

3.6.5.1 Scoring of pests

The incidence of insect pest was assessed by visual observation during cropping period and scoring was calculated using following formula

$$\text{Percentage infestation} = \frac{\text{Number of plants infested}}{\text{Total number of plants per plot}} \times 100$$

3.6.5.2 Scoring of diseases

The per cent powdery mildew incidence was recorded as per cent leaf area infected which were rated from zero to four disease scale (Girisha,1989 and Girish,2011) as given below

Disease scoring scale for fenugreek powdery mildew disease as given by (Girisha, 1989 and Girish, 2011)

Sl. No.	Scale	Symptoms	Disease reaction
1.	0	No symptoms	Immune
2.	1	1 to 10 % leaf area infected	Resistant
3.	2	11 to 25 % leaf area infected	Moderately resistant
4.	3	26 to 50 % leaf area infected	Moderately susceptible
5.	4	51 to 75 % leaf area infected	Susceptible

The disease incidence percentage was calculated using following formula given by Phatak *et al*. (1996).

$$\text{Disease Incidence Percentage} = \frac{\text{Number of plants infected}}{\text{Total number of plants per plot}} \times 100$$

3.6.6 Statistical analysis

The data on various parameters recorded during the study period were subjected to computerised statistical analysis as per the procedure suggested by Sunderaraju *et al.* (1972) for factorial randomized complete block design.

3.6.6.1 Standard error of mean (S. Em ±)

It is the measure of the mean difference between sample estimate of mean (`x) and the population parameter (μ) *i.e*. it is the measure of controlled variation present in a sample and is denoted by S.Em.r

$$S.Em \pm = \sqrt{EMSS/r}$$

Where,

EMSS = Error mean sum of squares

r = Number of replications

3.6.6.2 Critical difference (CD)

Critical difference is used to compare the observed differences among different treatments. If the difference is greater than critical difference, it is considered as significant and vice versa.

$$CD = S\ Ed. \times t$$

Where,

S Ed. = Standard error of difference

t = table value at error degrees of freedom

EXPERIMENTAL RESULTS

IV. EXPERIMENTAL RESULTS

A field experiment was conducted at College of Horticulture, Mudigere during the *rabi* season in an open field condition on "Standardization of sowing dates and stage of pinching for growth, yield and quality of fenugreek (*Trigonella foenum - graecum* L.) under hill zone of Karnataka". The results obtained in the present investigation with respect to growth, yield and quality parameters are presented in this chapter.

4.1 Growth parameters

4.1.1 Germination percentage

As presented in table 1, germination percentage differed significantly among the different sowing dates. The maximum germination percentage was recorded in the crop sown on 1st December (99.37 %) which was statistically on par with D_2 – 15th October sowing (99.26 %) and D_4 – 15th November sowing (93.77 %) whereas, least was recorded in D_1 - 1st October sowing (40.06 %).

4.1.2 Plant height

The data on plant height at different stages of growth as influenced by different dates of sowing, stage of pinching and their interaction are presented in table 2.

Plant height varied significantly with different dates of sowing. Plant height at 30 DAS was significantly higher in 1st November sown crop (13.03 cm) followed by 15th October sown crop (11.10 cm) whereas, the least plant height was recorded in 1st October sown crop (7.56 cm). At 60 DAS also similar pattern with respect to plant height was observed. The maximum plant height of 32.96 cm was recorded in D_3 (1st November), followed by D_2 (15th October) which recorded 27.23 cm and least plant height of 16.67 cm was observed in D_1 (1st October). Same pattern with respect to plant height was observed even at the time of harvest. Wherein the 1st November sown crop recorded significantly higher values for plant height (42.31 cm) followed by 15th October sown crop (34.58 cm) and the least was in 1st October sown crop (23.91 cm).

Table 1. Effect of different dates of sowing on germination percentage of fenugreek

Treatments	Germination (%)
D_1 (Sowing on 1st October)	40.06
D_2 (Sowing on 15th October)	99.26
D_3 (Sowing on 1stNovember)	91.11
D_4(Sowing on 15th November)	93.77
D_5 (Sowing on 1st December)	99.37
Mean	84.72
SEm±	2.68
CD at 5 %	8.05



Plate 1: Emerging seedlings 7 days after sowing



Plate 2: General view of the experimental plot

Similarly the effect of pinching was also significant at all stages of plant growth with respect to plant height. At 30 DAS, significantly maximum plant height (10.20 cm) was recorded with no pinching and was found to be on par with pinching at 35 DAS (9.99 cm) and pinching at 25 DAS (9.43 cm). Similarly, maximum plant height (25.88 cm) at 60 DAS was recorded with no pinching followed by pinching at 35 DAS (24.23 cm), whereas the least plant height was with pinching at 25 DAS (23.15 cm). The maximum plant height (34.19 cm) was recorded in P_3 (No pinching) followed by P_2 (Pinching 35 DAS) which recorded 31.34 cm. The least plant height was recorded in P_1 (Pinching 25 DAS) which registered 29.54 cm at the time of harvest.

The interaction effect of dates of sowing and stage of pinching was significant on plant height. The treatment D_3P_3 (Sowing on 1st November and no pinching) recorded significantly maximum plant height (13.45 cm) at 30 DAS and it was on par with D_3P_2 (13.16 cm), D_3P_1 (12.48 cm), D_4P_1 (11.96 cm) whereas, the minimum plant height (6.58 cm) was recorded with the treatment combination D_1P_1 (Sowing on 1st October and pinching at 25 DAS).

The treatment combination D_3P_3 (Sowing on 1st November and no pinching) recorded significantly maximum plant height at 60 DAS and at the time of harvest (35.07 cm and 48.24 cm respectively), followed by D_3P_2 (32.26 cm and 40.30 cm respectively) whereas, the minimum plant height at 60 DAS and at the time of harvest (14.45 cm and 21.24 cm respectively) was recorded in the treatment combination D_1P_1 (Sowing on 1st October and pinching at 25 DAS).

4.1.3 Number of branches per plant

The data pertaining to number of branches per plant are presented in table 3. Production of branches varied significantly at all stages of plant growth with respect to different dates of sowing and stage of pinching.

The number of branches per plant at 30 DAS was maximum (6.34) in D_2 (15th October) followed by D_3 (1st November) *i.e*. 5.12 branches. However, minimum number of branches per plant (2.32) was recorded at D_1 (1st October). The number of branches

Table 2. Effect of dates of sowing and stage of pinching on plant height at different stages of crop growth in fenugreek

Treatments	Plant height (cm)		
	30 DAS	60 DAS	At harvest
Dates of sowing (D)			
D_1 : 1st October	7.56	16.67	23.91
D_2 : 15th October	11.10	27.23	34.58
D_3 : 1st November	13.03	32.96	42.31
D_4 : 15th November	8.01	20.96	27.61
D_5 : 1st December	9.68	24.29	30.03
SEm±	0.44	0.46	0.48
CD @ 5 %	1.31	1.39	1.45
Stage of pinching (P)			
P_1 : Pinching at 25 DAS	9.43	23.15	29.54
P_2 : Pinching at 35 DAS	9.99	24.23	31.34
P_3 : No pinching (Control)	10.20	25.88	34.19
SEm±	0.34	0.36	0.38
CD @ 5 %	1.03	1.08	1.13
Interaction effects (D x P)			
D_1P_1	6.58	14.45	21.24
D_1P_2	7.53	16.43	23.78
D_1P_3	8.56	19.15	26.71
D_2P_1	7.99	20.48	26.24
D_2P_2	8.32	20.89	28.05
D_2P_3	7.72	21.51	28.54
D_3P_1	12.48	31.54	38.38
D_3P_2	13.16	32.26	40.30
D_3P_3	13.45	35.07	48.24
D_4P_1	11.96	25.60	32.54
D_4P_2	10.50	27.24	34.46
D_4P_3	10.84	28.84	36.73
D_5P_1	8.16	23.70	29.26
D_5P_2	10.46	24.33	30.06
D_5P_3	10.42	24.86	30.75
SEm±	0.78	0.84	0.90
CD at 5 %	2.28	2.52	2.65

Note: DAS - Days After Sowing

per plant at 60 DAS also varied significantly among different sowing dates. The crop sown on 15th October (D_2) recorded maximum number of branches per plant (8.07) followed by 1st November sown crop (6.21), whereas, the number of branches per plant were minimum in 1st October sown crop (2.70).

Same trend with respect to number of branches was observed even at the time of harvest. Wherein the 15th October sown crop recorded significantly higher values (10.90) followed by 1st November sown crop (9.08) and the least was in 1st October sown crop (4.15).

The number of branches per plant differed significantly with respect to different stage of pinching at different plant growth stages. The number of branches per plant at 30 DAS was maximum (4.75) in P_2 (Pinching at 35 DAS) followed by P_3 (No pinching) which recorded 4.21 branches per plant. However, minimum branches per plant (3.95) were recorded at P_1 (Pinching at 35 DAS).

The plants pinched at 35 DAS recorded maximum number of branches per plant (5.78) at 60 DAS followed by the plants with no pinching (5.16), whereas, least number of branches (4.62) were recorded in the plants pinched at 25 DAS. Significantly higher number of branches per plant (8.45) were recorded in P_2 (Pinching at 35 DAS) followed by P_3 (No pinching) which recorded 7.64 branches per plant. However, pinching at 25 DAS resulted in least number of branches per plant (7.14) at the time of harvest.

Interaction effects of sowing dates and stage of pinching also registered significant influence on number of branches per plant at all stages of plant growth. The treatment combination D_2P_2 (Sowing on 15th October and pinching at 35 DAS) recorded significantly higher number of branches per plant (7.33) which was followed by D_2P_3 (5.96) and lowest was recorded in D_1P_1 (1.93) at 30 DAS. Similarly after 60 DAS, D_2P_2 recorded significantly maximum number of branches per plant (9.50) followed by D_2P_3 (7.73) and minimum was recorded in D_1P_1 (1.93). At the time of harvest also, significantly maximum number of branches per plant was recorded in the treatment combination D_2P_2 (12.06) followed by D_2P_3 (10.63) and minimum was in D_1P_1 (3.36).

Table 3. Effect of dates of sowing and stage of pinching on number of branches per plant at different stages of crop growth in fenugreek

Treatments	Number of branches per plant		
	30 DAS	60 DAS	At harvest
Dates of sowing (D)			
D_1 : 1st October	2.32	2.70	4.15
D_2 : 15th October	6.34	8.07	10.90
D_3 : 1st November	5.12	6.21	9.08
D_4 : 15th November	4.42	4.87	7.97
D_5 : 1st December	3.32	4.08	6.60
SEm±	0.13	0.15	0.19
CD at 5 %	0.41	0.45	0.58
Stage of pinching (P)			
P_1 : Pinching at 25 DAS	3.95	4.62	7.14
P_2 : Pinching at 35 DAS	4.75	5.78	8.45
P_3 : No pinching (Control)	4.21	5.16	7.64
SEm±	0.11	0.11	0.15
CD at 5 %	0.32	0.35	0.45
Interaction effects (D x P)			
D_1P_1	1.93	1.93	3.36
D_1P_2	2.70	3.30	4.96
D_1P_3	2.33	2.86	4.13
D_2P_1	5.73	7.00	10.00
D_2P_2	7.33	9.50	12.06
D_2P_3	5.96	7.73	10.63
D_3P_1	4.96	5.63	8.73
D_3P_2	5.33	6.63	9.66
D_3P_3	5.06	6.33	8.86
D_4P_1	4.10	4.63	7.60
D_4P_2	4.73	5.16	8.30
D_4P_3	4.43	4.83	8.03
D_5P_1	3.03	3.93	6.00
D_5P_2	3.66	4.30	7.26
D_5P_3	3.26	4.03	6.53
SEm±	0.23	0.26	0.37
CD at 5 %	0.71	0.79	1.01

Note: DAS - Days After Sowing

4.1.4 Plant spread

The data pertaining to plant spread (cm^2) due to different dates of sowing, stage of pinching and their interaction are presented in table 4.

At all the stages of plant growth (30, 60 and at the time of harvest), significant variation was observed for plant spread (cm^2) due to different dates of sowing. The maximum plant spread of 20.41 cm^2, 76.69 cm^2 and 45.26 cm^2 was recorded in D_2 (15^{th} October) at 30, 60 and at the time of harvest respectively, followed by D_3 (1^{st} November) by recording 15.71 cm^2, 50.87 cm^2 and 36.36 cm^2 at 30, 60 and at the time of harvest respectively, whereas minimum spread of 7.91 cm^2, 29.58 cm^2 and 22.81 cm^2 was recorded in D_1 (1^{st} October) at 30, 60 and at the time of harvest respectively.

Plant spread (cm^2) varied significantly at all the stages of plant growth due to pinching. At 30 DAS, the plants pinched at 35 DAS recorded significantly higher plant spread of 14.09 cm^2, followed by no pinching (12.87 cm^2) and it was found to be lowest in the plants pinched at 25 DAS (11.80 cm^2). Whereas, at 60 and at the time of harvest, P_2 (Pinching at 35 DAS) recorded significantly higher plant spread (cm^2) of 53.78 and 35.66 respectively, followed by P_3 (47.03 cm^2 and 32.48 cm^2 respectively). The least plant spread (cm^2) of 42.00 and 30.99 cm^2 was noted in P_1 (Pinching at 25 DAS).

As far as interaction effect of the two factors was concerned, it showed significant difference with respect to plant spread at all the crop growth stages. Among the different treatment combinations in the study, the treatment combination D_2P_2 (Sowing on 15^{th} October and pinching at 35 DAS) recorded significantly higher plant spread of 23.48 cm^2 at 30 DAS, and it was on par with D_2P_3 (20.42 cm^2). The least plant spread of 7.09 cm^2 was noticed in the treatment combination D_1P_1. Among the treatment combinations D_2P_2 recorded significantly higher plant spread of 96.33 cm^2 followed by D_2P_3 which recorded plant spread of 72.22 cm^2. The least plant spread of 25.59 cm^2 was noted in treatment combination D_1P_1 at 60 DAS. Similarly, at the time of harvest, the treatment combination D_2P_2 recorded significantly higher plant spread (51.62 cm^2) followed by D_2P_3 (43.04 cm^2). The least plant spread of 21.41 cm^2 was recorded in treatment combination D_1P_1.

Table 4. Effect of dates of sowing and stage of pinching on plant spread at different stages of crop growth in fenugreek

Treatments	Plant spread (cm^2)		
	30 DAS	60 DAS	At harvest
Dates of sowing (D)			
D_1 : 1st October	7.91	29.58	22.81
D_2 : 15th October	20.41	76.69	45.26
D_3 : 1st November	15.71	50.87	36.36
D_4 : 15th November	11.40	43.52	31.97
D_5 : 1st December	9.18	37.38	28.84
SEm±	0.73	1.39	1.10
CD at 5 %	2.17	4.13	3.27
Stage of pinching (P)			
P_1 : Pinching at 25 DAS	11.80	42.00	30.99
P_2 : Pinching at 35 DAS	14.09	53.78	35.66
P_3 : No pinching (Control)	12.87	47.03	32.48
SEm±	0.57	1.07	0.84
CD at 5 %	1.68	3.19	2.53
Interaction effects (D x P)			
D_1P_1	7.09	25.59	21.41
D_1P_2	8.51	32.16	24.65
D_1P_3	8.12	30.99	22.35
D_2P_1	17.32	61.51	41.11
D_2P_2	23.48	96.33	51.62
D_2P_3	20.42	72.22	43.04
D_3P_1	14.82	46.55	34.70
D_3P_2	16.97	55.71	38.38
D_3P_3	15.32	50.34	35.98
D_4P_1	10.83	40.96	31.01
D_4P_2	11.90	45.22	33.29
D_4P_3	11.47	44.35	31.61
D_5P_1	8.94	35.41	26.72
D_5P_2	9.60	39.47	30.38
D_5P_3	9.01	37.26	29.41
SEm±	1.26	2.41	1.91
CD at 5 %	3.76	7.14	5.66

Note: DAS - Days After Sowing

4.1.5 Leaf area

The data pertaining to leaf area is presented in table 5. Leaf area varied significantly at all stages of plant growth with respect to different dates of sowing and stage of pinching.

At 30 DAS, maximum leaf area (4.498 cm^2) was found in D_3 (1^{st} November), which was on par (4.235 cm^2) with D_4 (15^{th} November), while the least (3.353 cm^2) was recorded at D_1 (1^{st} October). Similarly at 60 DAS, maximum leaf area (4.557 cm^2) was noted in D_3 (1^{st} November), which was on par with D_4 (4.400 cm^2), D_5 (4.278 cm^2) and D_2 (4.276 cm^2), while least (3.989 cm^2) was recorded in D_1 (1^{st} October).

At 30 DAS, maximum leaf area (4.116 cm^2) was recorded in the plants pinched at 35 DAS followed the plants which were not pinched, while the least was in the plants pinched at 25 DAS (3.863 cm^2). Similarly at 60 DAS, plants pinched at 35 DAS recorded maximum leaf area (4.371 cm^2), which was on par with non-pinched plants (4.300 cm^2) and minimum leaf area was observed in pinching at 25 DAS (4.168 cm^2).

The interaction effect of dates of sowing and pinching was also significant with respect to leaf area. At 30 DAS, maximum leaf area (4.553 cm^2) was recorded in D_3P_2 (Sowing on 1^{st} November and no pinching), followed by D_3P_3 (4.406 cm^2) while, least (3.200 cm^2) was recorded in the treatment combination D_1P_1. The maximum leaf area at 60 DAS (5.056 cm^2) was recorded in D_3P_2 which was on par with all other treatment combinations except D_1P_1 which recorded the least leaf area of 3.700 cm^2.

4.1.6 Leaf Area Index (LAI)

The data on leaf area index as influenced by sowing on different dates, stage of pinching and their interaction is presented in table 5.

Leaf area index varied significantly with different dates of sowing. Leaf area index at 30 DAS was significantly high (0.019) in D_3 (1^{st} November) and it was statistically on par with D_4 - 15^{th} November (0.018) and D_5 – 1^{st} December (0.015). However, minimum leaf area index (0.011) was recorded at D_1 (1^{st} October). The leaf

area index at 60 DAS also varied significantly among different sowing dates. The crop sown on 1st November (D_3) recorded maximum leaf area index (0.019) and found to be statistically on par with D_4 - 15th November (0.018) and D_5 – 1st December (0.017), whereas, minimum leaf area index (0.011) was recorded in D_1 (1st October).

Significant difference was observed for leaf area index due to different pinching treatments at all the stages of crop growth. The maximum leaf area index (0.017) was registered under P_2 (Pinching at 35 DAS) which was on par with P_3 (No pinching) by recording 0.016 and least leaf area index of 0.011 was noticed in P_1 (Pinching 25 DAS). Similarly at 60 DAS, the maximum leaf area index of 0.017 was registered under P_2 (Pinching at 35 DAS) which was on par with P_3 (No pinching) by recording 0.016 and minimum leaf area index of 0.012 was noticed in P_1 (Pinching 25 DAS).

The interaction effect of date of sowing and pinching had shown significant difference with respect to leaf area index at 30 DAS and 60 DAS. Among the different treatment combinations, D_3P_2 (Sowing on 1st November and pinching at 35 DAS) recorded significantly higher leaf area index (0.019) over other treatment combinations and least (0.011) was noticed in treatment combination D_1P_1 at 30 DAS. At 60 DAS, among the different treatment combinations D_3P_2 recorded significantly higher leaf area index (0.019) over other treatment combinations, which was on par with the remaining treatment combinations except in D_1P_1 (0.012).

4.1.7 Leaf area duration (LAD)

The data pertaining to leaf area duration recorded at 30-60 DAS varied significantly with respect to sowing on different dates, stage of pinching and their interaction as presented in table 5.

Leaf area duration at 30-60 DAS was maximum (0.432 days) in D_3 (1st November), which was on par (0.420 days) with D_4 (15th November), while the least (0.376 days) was recorded in D_1 (1st October).

Leaf area duration at 30-60 DAS also varied significantly due to pinching. The maximum leaf area duration (0.416 days) was noticed in the plants pinched at 35 DAS which was on par with no pinch treatment (0.406 days), while the least was in P_1 (Pinching at 25 DAS) *i.e.* 0.396 days.

With respect to interaction effect on LAD, the treatment combination D_3P_2 recorded significantly maximum value at 30-60 DAS (0.446 days), followed by D_3P_3 (0.426 days) while, the least was recorded in D_1P_1 (0.370 days).

4.1.8 Dry matter production of leaves

The data pertaining to dry matter production of leaves as influenced by sowing dates, pinching and their interaction at different stages of plant growth is presented in table 6.

The dry matter production of leaves at 30 DAS was significantly maximum (0.113 g/plant) in D_2 (15^{th} October), followed by D_3 (1^{st} November) which registered 0.100 g/plant whereas, minimum (0.035 g/plant) was recorded in D_1 (1^{st} October). The crop sown on 15^{th} October (D_2) recorded maximum dry matter production of leaves (0.202 g/plant) followed by 1^{st} November sown crop (0.186 g/plant) at 60 DAS, whereas, minimum dry matter production of leaves (0.105 g/plant) was recorded in 1^{st} October sown crop.

The crop sown on 15^{th} October) recorded significantly maximum dry matter of leaves (0.132 g/plant) and it was statistically on par in 1^{st} November sown crop (0.122 g/plant). However, the crop sown on 1^{st} October registered minimum value (0.071 g/plant).

The dry matter production of leaves differed significantly with respect to different stage of pinching. The dry matter production of leaves at 30 DAS has found to be maximum (0.082 g/plant) in P_2 (Pinching at 35 DAS) which was statistically on par with P_3 (No pinching) which recorded 0.081 g/plant. However, minimum dry matter in leaves (0.077 g/plant) was recorded in P_1 (Pinching at 35 DAS). The dry matter production of

Table 5. Effect of dates of sowing and stage of pinching on leaf area, leaf area index and leaf area duration of fenugreek

Treatments	Leaf Area (cm^2)		Leaf Area Index		Leaf Area Duration (Days)
	30 DAS	60 DAS	30 DAS	60 DAS	30-60 DAS
Dates of sowing (D)					
D_1 : 1st October	3.353	3.989	0.011	0.013	0.376
D_2 : 15th October	3.726	4.276	0.012	0.016	0.390
D_3 : 1st November	4.498	4.557	0.019	0.019	0.432
D_4 : 15th November	4.235	4.400	0.018	0.018	0.420
D_5 : 1st December	4.040	4.278	0.015	0.017	0.404
SEm±	0.094	0.117	0.001	0.002	0.007
CD at 5 %	0.280	0.342	0.004	0.005	0.020
Stage of pinching (P)					
P_1 : Pinching at 25 DAS	3.863	4.168	0.011	0.012	0.396
P_2 : Pinching at 35 DAS	4.116	4.371	0.017	0.017	0.416
P_3 : No pinching (Control)	3.943	4.300	0.016	0.016	0.406
SEm±	0.074	0.091	0.001	0.002	0.005
CD at 5 %	0.220	0.263	0.004	0.005	0.015
Interaction effects (D x P)					
D_1P_1	3.200	3.700	0.011	0.012	0.370
D_1P_2	3.360	4.033	0.016	0.015	0.380
D_1P_3	3.500	4.233	0.013	0.016	0.380
D_2P_1	3.566	4.167	0.013	0.013	0.386
D_2P_2	3.700	4.133	0.012	0.016	0.390
D_2P_3	3.913	4.527	0.014	0.018	0.393
D_3P_1	4.333	4.400	0.013	0.014	0.423
D_3P_2	4.553	5.056	0.019	0.019	0.446
D_3P_3	4.406	4.527	0.018	0.018	0.426
D_4P_1	4.193	4.440	0.012	0.017	0.416
D_4P_2	4.226	4.427	0.017	0.016	0.420
D_4P_3	4.286	4.333	0.014	0.017	0.423
D_5P_1	4.013	4.133	0.013	0.013	0.396
D_5P_2	4.033	4.353	0.015	0.013	0.406
D_5P_3	4.073	4.347	0.016	0.013	0.410
SEm±	0.153	0.203	0.003	0.003	0.006
CD at 5 %	0.499	0.591	0.009	0.010	0.018

Note: DAS - Days After Sowing

leaves at 60 DAS also varied significantly. The plants pinched at 35 DAS recorded maximum dry matter production (0.174 g/plant) followed by no pinching (0.156 g/plant) whereas, minimum dry matter production (0.143 g/plant) was recorded in the plants pinched at 25 DAS. At the time of harvest, the treatment P_2 (Pinching at 35 DAS) recorded significantly higher dry matter production of leaves (0.110 g/plant) and it was statistically on par (0.108 g/plant) with P_3 (No pinching). However, pinching at 25 DAS recorded minimum dry matter production of leaves (0.102 g/plant).

Interaction effects of different sowing dates and stage of pinching also registered significant influence on dry matter production of leaves at different stages of plant growth. The treatment combination D_2P_2 (Sowing on 15th October and pinching 35 DAS) recorded significantly maximum dry matter production of leaves (0.136 g/plant) followed by D_2P_3 (0.116 g/plant) and lowest was recorded in D_1P_1 (0.026 g/plant) at 30 DAS. Similarly after 60 DAS, D_2P_2 recorded significantly maximum dry matter production of leaves (0.213 g/plant) which was on par with D_2P_3 (0.206 g/plant) and D_2P_1 (0.193 g/plant) and minimum was recorded in D_1P_1 (0.086 g/plant). At the time of harvest also, D_2P_2 recorded significantly maximum dry matter production of leaves (0.143 g/plant), which was on par with D_2P_3 (0.133 g/plant) and lowest was recorded in D_1P_1 (0.066 g/plant).

4.1.9 Dry matter production of stem

The data pertaining to dry matter production of stem as influenced by sowing on different dates, stage of pinching and their interaction at different stages of plant growth is presented in table 7**.**

At 30 DAS the dry matter production of stem was maximum (0.144 g/plant) in D_2 (15th October) followed by D_3 (1st November) which recorded 0.107 g/plant. However, minimum dry matter production of stem (0.038 g/plant) was recorded in D_1 (1st October). Similarly, the crop sown on 15th October also recorded significantly maximum dry matter production of stem at 60 and at the time of harvest (0.203 and0.901 g/plant respectively.) followed by D_3 (1st November) sown crop (0.172 and 0.434 g/plant respectively),

Table 6. Effect of dates of sowing and stage of pinching on dry matter production of leaves at different stages of crop growth in fenugreek

Treatments	Dry matter production of leaves (g/plant)		
	30 DAS	60 DAS	At harvest
Dates of sowing (D)			
D_1 : 1st October	0.035	0.105	0.071
D_2 : 15th October	0.113	0.202	0.132
D_3 : 1st November	0.100	0.186	0.122
D_4 : 15th November	0.086	0.133	0.093
D_5 : 1st December	0.063	0.162	0.102
SEm±	0.001	0.005	0.003
CD at 5 %	0.002	0.015	0.009
Stage of pinching (P)			
P_1 : Pinching at 25 DAS	0.077	0.143	0.102
P_2 : Pinching at 35 DAS	0.082	0.174	0.110
P_3 : No pinching (Control)	0.081	0.156	0.108
SEm±	0.001	0.002	0.001
CD at 5 %	0.003	0.007	0.005
Interaction effects (D x P)			
D_1P_1	0.026	0.086	0.066
D_1P_2	0.043	0.128	0.086
D_1P_3	0.033	0.114	0.072
D_2P_1	0.104	0.193	0.130
D_2P_2	0.136	0.213	0.143
D_2P_3	0.116	0.206	0.133
D_3P_1	0.093	0.176	0.118
D_3P_2	0.106	0.193	0.123
D_3P_3	0.100	0.179	0.123
D_4P_1	0.086	0.133	0.083
D_4P_2	0.096	0.143	0.093
D_4P_3	0.083	0.133	0.093
D_5P_1	0.056	0.156	0.104
D_5P_2	0.073	0.173	0.116
D_5P_3	0.070	0.162	0.109
SEm±	0.003	0.009	0.004
CD at 5 %	0.010	0.027	0.012

Note: DAS - Days After Sowing

whereas, minimum was recorded in D_1 (1st October) sown crop at 60 and at the time of harvest (0.098 and 0.182 g/plant respectively).

Pinching also found to be significantly influencing the dry matter production of stem at all the plant growth stages under the study. At 30 DAS, maximum dry matter production of stem (0.095 g/plant) was recorded in P_2 (Pinching at 35 DAS) which was statistically on par (0.083 g/plant) with P_3 (No pinching). While the least (0.078 g/plant) was under P_1 (Pinching at 25 DAS).

Similarly at 60 DAS, P_2 (Pinching 35 DAS) reported significantly maximum dry matter production of stem (0.153 g/plant), which was on par with P_3 (No pinching) and P_1 (Pinching at 25 DAS) which recorded 0.148 g/plant and 0.143 g/plant respectively. While, at the time of harvest, maximum dry matter production of stem (0.508 g/plant) was recorded in P_2 (Pinching at 35 DAS) followed by (0.394 g/plant) P_3 (No pinching) and minimum (0.333 g/plant) under P_1 (Pinching at 25 DAS).

The interaction effect of sowing on different dates and stage of pinching had shown significant difference with respect to dry matter production of stem at different stages of plant growth. Among the different treatment combinations, D_2P_2 (Sowing on 15th October and pinching at 35 DAS) recorded significantly maximum dry matter production of stem (0.176 g/plant) at 30 DAS, which was on par with D_2P_3 (0.146 g/plant). The least was noticed in D_1P_1 (0.026 g/plant).

Similar trend was observed at 60 and at the time of harvest wherein, D_2P_2 registered maximum dry matter production of stem (0.206 g/plant and 1.196 g/plant respectively) while, the least was noticed in D_1P_1 (0.083 and 0.170 g/plant respectively).

4.1.10 Dry matter production of pods

The data on dry matter production of pods as influenced by sowing on different dates, stage of pinching and their interaction is presented in table 8.

Table 7. Effect of dates of sowing and stage of pinching on dry matter production of stem at different stages of crop growth in fenugreek

Treatments	Dry matter production of stem (g/plant)		
	30 DAS	60 DAS	At harvest
Dates of sowing (D)			
D_1 : 1st October	0.038	0.098	0.182
D_2 : 15th October	0.144	0.203	0.901
D_3 : 1st November	0.107	0.172	0.434
D_4 : 15th November	0.054	0.127	0.257
D_5 : 1st December	0.078	0.143	0.281
SEm±	0.011	0.006	0.034
CD at 5 %	0.026	0.019	0.130
Stage of pinching (P)			
P_1 : Pinching at 25 DAS	0.078	0.143	0.333
P_2 : Pinching at 35 DAS	0.095	0.153	0.508
P_3 : No pinching (Control)	0.083	0.148	0.394
SEm±	0.007	0.005	0.033
CD at 5 %	0.020	0.017	0.100
Interaction effects (D x P)			
D_1P_1	0.026	0.083	0.170
D_1P_2	0.043	0.098	0.193
D_1P_3	0.042	0.083	0.183
D_2P_1	0.126	0.192	0.585
D_2P_2	0.176	0.206	1.196
D_2P_3	0.146	0.203	0.916
D_3P_1	0.093	0.168	0.380
D_3P_2	0.116	0.183	0.506
D_3P_3	0.103	0.173	0.413
D_4P_1	0.052	0.118	0.223
D_4P_2	0.062	0.136	0.296
D_4P_3	0.053	0.126	0.253
D_5P_1	0.066	0.143	0.306
D_5P_2	0.086	0.158	0.330
D_5P_3	0.073	0.146	0.206
SEm±	0.015	0.007	0.081
CD at 5 %	0.045	0.021	0.234

Note: DAS - Days After Sowing

The maximum dry matter production of pods was noticed for the crop sown on 15th October (0.305 g/plant), followed by 1st November sown crop (0.291 g/plant), while minimum was noticed in 1st October sown crop (0.222 g/plant).

Dry matter production of pods also got significantly influenced by pinching. Pinching at 35 DAS recorded significantly maximum dry matter production of pods (0.281 g/plant), followed by P_3 - No pinching (0.264 g/plant). Whereas minimum (0.262 g/plant) was noticed in P_1 -Pinching at 25 DAS.

As far as interaction was concerned, significantly maximum dry matter production of pods (0.326 g/plant) was reported in D_2P_2 (Sowing on 15th October and pinching at 35 DAS) followed by D_2P_3 (0.303 g/plant) and minimum (0.213 g/plant) was noticed in D_1P_1 treatment combination.

4.1.11 Dry matter production of seeds

The data pertaining to dry matter production of seeds as influenced by sowing on different dates, stage of pinching and their interaction is presented in table 8.

The maximum dry matter production of seeds was noticed in 15th October sown crop (0.247 g/plant), followed by the crop sown on 1st November (0.227 g/plant), while 1st October sown crop recorded minimum (0.191 g/plant) dry matter production of seeds.

Similarly, dry matter production of seeds was also significantly influenced by pinching treatments. Maximum dry matter production of seeds was noticed in P_2 - Pinching at 35 DAS (0.220 g/plant), followed by P_3 - No pinching (0.211 g/plant). While, minimum (0.207 g/plant) was noticed in P_1 -Pinching at 25 DAS.

With respect to interaction, D_2P_2 (Sowing on 15th October and pinching 35 DAS) recorded maximum dry matter production of seeds (0.266 g/plant), followed by D_2P_3 (0.243 g/plant), whereas minimum (0.186 g/plant) was registered under D_1P_1 treatment combination.

Table 8. Effect of dates of sowing and stage of pinching on dry matter production of pods and seeds of fenugreek

Treatments	Dry matter production (g/plant)	
	Pods	Seeds
Dates of sowing (D)		
D_1 : 1st October	0.222	0.191
D_2 : 15th October	0.305	0.247
D_3 : 1st November	0.291	0.227
D_4 : 15th November	0.252	0.207
D_5 : 1st December	0.277	0.217
SEm±	0.001	0.002
CD at 5 %	0.003	0.007
Stage of pinching (P)		
P_1 : Pinching at 25 DAS	0.262	0.207
P_2 : Pinching at 35 DAS	0.281	0.220
P_3 : No pinching (Control)	0.264	0.211
SEm±	0.002	0.002
CD at 5 %	0.006	0.007
Interaction effects (D x P)		
D_1P_1	0.213	0.186
D_1P_2	0.230	0.193
D_1P_3	0.226	0.193
D_2P_1	0.296	0.233
D_2P_2	0.326	0.266
D_2P_3	0.303	0.243
D_3P_1	0.283	0.226
D_3P_2	0.303	0.236
D_3P_3	0.286	0.230
D_4P_1	0.243	0.206
D_4P_2	0.263	0.206
D_4P_3	0.256	0.206
D_5P_1	0.273	0.203
D_5P_2	0.283	0.220
D_5P_3	0.276	0.218
SEm±	0.005	0.004
CD at 5 %	0.016	0.011

Note: DAS - Days After Sowing

4.1.12 Total dry matter production

The data presented on total dry matter production as influenced by different dates of sowing and stage of pinching at 30, 60 and at the time of harvest showed significant differences among the different treatments (Table 9).

The total dry matter production at 30 DAS was recorded significantly maximum in D_2 *i.e.* 15th October sowing (0.251 g/plant), followed by D_3 *i.e.* 1st November sowing (0.198 g/plant), while, minimum was recorded in D_1 *i.e.* 1st October (0.086 g/plant). At 60 DAS, total dry matter production varied significantly due to the influence of different sowing dates. D_2 (15th October) recorded significantly maximum total dry matter production of 0.414 g, followed by D_3 (0.353 g) and minimum of 0.192 g was registered in D_1 (1st October). Similarly at the time of harvest, maximum total dry matter production of 1.636 g was registered under D_2 (15th October), followed by D_3 (1.197 g), whereas least was noticed in D_1 (0.492 g).

Pinching had significant difference on the total dry matter production as evident from the data in table9. At 30 DAS, maximum total dry matter production (0.182 g) was recorded in P_2 - Pinching 35 DAS followed by P_3 - No pinching (0.154 g), while the least (0.142 g) was in P_1 (Pinching at 25 DAS) while, the maximum total dry matter production (0.326 g) was recorded in P_2 - Pinching 35 DAS followed by P_3 - No pinching (0.303 g), while the least (0.288 g) was in P_1 (Pinching at 25 DAS) at 60 DAS. At the time of harvest the maximum total dry matter production (1.122 g) was recorded in P_2 – Pinching at 35 DAS followed by P_3 - No pinching (0.981 g), while the least (0.886 g) was in P_1 (Pinching at 25 DAS)

As far as interaction was concerned, significantly maximum total dry matter production was observed in D_2P_2 (Sowing on 15th October and pinching at 35 DAS) at 30 DAS (0.306 g/plant), 60 DAS (0.453 g/plant) and at the time of harvest (2.00 g/plant) and minimum was noticed in the treatment combination D_1P_1 at 30 DAS (0.073 g/plant), 60 DAS (0.173 g/plant) and at the time of harvest (0.470 g/plant).

Table 9. Effect of dates of sowing and stage of pinching on total dry matter production at different stages of crop growth in fenugreek

Treatments	Total dry matter production (g/plant)		
	30 DAS	60 DAS	At harvest
Dates of sowing (D)			
D_1 : 1st October	0.086	0.192	0.492
D_2 : 15th October	0.251	0.414	1.636
D_3 : 1st November	0.198	0.353	1.197
D_4 : 15th November	0.121	0.250	0.702
D_5 : 1st December	0.147	0.320	0.943
SEm±	0.010	0.011	0.043
CD at 5 %	0.029	0.031	0.130
Stage of pinching (P)			
P_1 : Pinching at 25 DAS	0.142	0.288	0.886
P_2 : Pinching at 35 DAS	0.182	0.326	1.122
P_3 : No pinching (Control)	0.154	0.303	0.981
SEm±	0.004	0.005	0.040
CD at 5 %	0.012	0.015	0.106
Interaction effects (D x P)			
D_1P_1	0.073	0.173	0.470
D_1P_2	0.096	0.213	0.529
D_1P_3	0.086	0.190	0.486
D_2P_1	0.226	0.383	1.380
D_2P_2	0.306	0.453	2.000
D_2P_3	0.240	0.406	1.530
D_3P_1	0.196	0.350	1.086
D_3P_2	0.213	0.356	1.293
D_3P_3	0.182	0.353	1.213
D_4P_1	0.113	0.226	0.593
D_4P_2	0.126	0.266	0.786
D_4P_3	0.126	0.256	0.724
D_5P_1	0.133	0.306	0.893
D_5P_2	0.162	0.333	0.990
D_5P_3	0.140	0.320	0.946
SEm±	0.015	0.015	0.081
CD at 5 %	0.041	0.045	0.239

Note: DAS - Days After Sowing

4.1.13 AGR (Absolute Growth Rate)

The data pertaining to absolute growth rate is presented in table 10. Absolute Growth Rate was recorded at 30-60 DAS and 60 DAS till harvest. AGR varied significantly at all stages of plant growth with respect to different dates of sowing, stage of pinching and their interaction.

At 30-60 DAS, maximum AGR (0.145 g per day) was found in D_2 (15^{th} October), followed by D_3 (1^{st} November) by recording 0.094 g per day, while, minimum (0.038 g per day) was recorded in D_1 (1^{st} October). Similarly at 60 DAS till harvest, maximum Absolute Growth Rate of 0.546 g per day was found in D_2, followed by D_3 (0.377 g per day). While, minimum of 0.200 g per day was recorded in D_1.

Absolute growth rate at 30-60 DAS also varied significantly due to pinching. Significantly maximum AGR (0.086 g per day) was noticed under pinching at 35 DAS which was on par with no pinching (0.082 g per day) and pinching at 25 DAS (0.073 g per day), whereas, at later stage also (60 DAS till harvest) pinching at 35 DAS recorded maximum AGR (0.460 g per day) followed by no pinching (0.323 g per day). While the least was registered in the plants pinched at 25 DAS (0.291 g per day).

The interaction effect was also significant on AGR in fenugreek at different growth stages. Maximum absolute growth rate was registered under D_2P_2 (0.170 g per day) followed by D_2P_3 (0.146 g per day), while minimum was noticed in D_1P_1 (0.030 g per day) treatment combination at 30-60 DAS, whereas at 60 DAS till harvest, maximum AGR was recorded in D_2P_2 (0.847 g per day), followed by D_2P_3 (0.397 g per day), whereas minimum was recorded in D_1P_1 (0.197 g per day) treatment combination.

4.1.14 CGR (Cumulative Growth Rate)

Cumulative growth rate recorded at different growth stages (at 30-60 DAS and 60 DAS till harvest) is presented in table 10. CGR varied significantly with respect to different dates of sowing, stage of pinching and their interaction.

At 30-60 DAS, maximum CGR (0.050 g per m^2 per day) was found in D_2, followed by D_3 (0.027 g per m^2 per day) while, minimum (0.021 g per m^2 per day) was recorded at D_1 (1^{st} October). Similarly at 60 DAS till harvest, maximum CGR (0.186 g per m^2 per day) was found in D_2 (15^{th} October), followed by D_3 (1^{st} November) by recording 0.126 g per m^2 per day while, minimum of 0.068 g per m^2 per day was recorded at D_1 (1^{st} October).

With respect to pinching treatments, significantly maximum CGR (0.032 g per m^2 per day) was noticed under P_2 (Pinching at 35 DAS) which was on par with no pinching (0.030 g per m^2 per day). While, at later stage (60 DAS till harvest), pinching at 35 DAS recorded maximum Cumulative growth rate (0.157 g per m^2 per day) followed by no pinching (0.109 g per m^2 per day). While the least was registered in the plants pinched at 25 DAS (0.098 g per m^2 per day).

The interaction effect was also significant on CGR in fenugreek at different growth stages. Maximum CGR was registered under D_2P_2 (0.060 g per m^2 per day), which was on par with D_2P_3 (0.050 g per m^2 per day) and D_2P_1 (0.040 g per m^2 per day) whereas minimum was noticed in D_1P_1 (0.016 g per m^2 per day) treatment combination at 30-60 DAS. However at 60 DAS till harvest, maximum cumulative growth rate was recorded in D_2P_2 (0.288 g per m^2 per day), followed by D_2P_3 (0.138 g per m^2 per day) whereas, minimum was recorded in D_1P_1 (0.066 g per m^2 per day) treatment combination.

4.1.15 RGR (Relative Growth Rate)

The data pertaining to relative growth rate recorded at 30-60 DAS and 60 DAS till harvest is presented in table 11. RGR varied significantly with respect to different dates of sowing and pinching.

At 30-60 DAS, maximum RGR (0.027 g per g per day) was found in D_2 (15^{th} October), followed by D_3 (0.015 g per g per day) while, the least (0.004 g per g per day) was recorded in D_1 (1^{st} October). Similarly at 60 DAS till harvest, maximum Relative Growth Rate of 0.024 g per g per day was found in D_2 (15^{th} October) which was on par

Table 10. Effect of dates of sowing and stage of pinching on Absolute Growth Rate (AGR) and Cumulative Growth Rate (CGR) of fenugreek

Treatments	AGR (g/plant/day)		CGR (g/m^2/day)	
	30-60 DAS	60 DAS till harvest	30-60 DAS	60 DAS till harvest
Dates of sowing (D)				
D_1 : 1st October	0.038	0.200	0.021	0.068
D_2 : 15th October	0.145	0.546	0.050	0.186
D_3 : 1st November	0.094	0.377	0.027	0.126
D_4 : 15th November	0.072	0.350	0.022	0.120
D_5 : 1st December	0.058	0.318	0.025	0.107
SEm±	0.007	0.034	0.006	0.011
CD at 5 %	0.019	0.098	0.018	0.033
Stage of pinching (P)				
P_1 : Pinching at 25 DAS	0.073	0.291	0.026	0.098
P_2 : Pinching at 35 DAS	0.086	0.460	0.032	0.157
P_3 : No pinching (Control)	0.082	0.323	0.030	0.109
SEm±	0.004	0.026	0.002	0.009
CD at 5 %	0.013	0.076	0.002	0.025
Interaction effects (D x P)				
D_1P_1	0.030	0.197	0.016	0.066
D_1P_2	0.046	0.220	0.026	0.075
D_1P_3	0.040	0.183	0.016	0.062
D_2P_1	0.120	0.393	0.040	0.131
D_2P_2	0.170	0.847	0.060	0.288
D_2P_3	0.146	0.397	0.050	0.138
D_3P_1	0.053	0.260	0.013	0.086
D_3P_2	0.055	0.507	0.016	0.171
D_3P_3	0.053	0.363	0.053	0.122
D_4P_1	0.066	0.317	0.026	0.108
D_4P_2	0.076	0.377	0.026	0.130
D_4P_3	0.073	0.357	0.023	0.121
D_5P_1	0.086	0.290	0.023	0.098
D_5P_2	0.100	0.350	0.033	0.121
D_5P_3	0.096	0.313	0.029	0.102
SEm±	0.008	0.058	0.008	0.020
CD at 5 %	0.025	0.169	0.022	0.057

Note: DAS - Days After Sowing

with (1st November) by recording 0.023 g per g per day while, the least value of 0.015 g per g per day was recorded in D_1 (1st October).

Relative growth rate at 30-60 DAS also varied significantly due to pinching. Significantly maximum relative growth rate was noticed under pinching at 35 DAS (0.018 g per g per day) followed by no pinch treatment and pinching at 25 DAS (0.014 g per g per day and 0.014 g per g per day respectively).Whereas, at later stage also (60 DAS till harvest) pinching at 35 DAS recorded maximum relative growth rate (0.026 g per g per day) followed by no pinching (0.016 g per g per day). While least was registered in the plants pinched at 25 DAS (0.010 g per g per day).

Interaction with respect to the relative growth rate showed significant difference at all the stages of plant growth. Maximum was registered under D_2P_2 (0.026 g per g per day) followed by D_2P_3 and D_2P_1 (0.023 g per g per day and 0.023 g per g per day respectively) at 30-60 DAS whereas, at 60 DAS till harvest, maximum relative growth rate was recorded in D_2P_2 (0.026 g per g per day), followed by D_2P_3 (0.025 g per g per day) while, minimum was recorded in D_1P_1 (0.013 g per g per day) treatment combination.

4.1.16 NAR (Net Assimilation Rate)

Net assimilation rate recorded (30-60 DAS and 60 DAS till harvest) is presented in table 11. NAR varied significantly at all stages of plant growth with respect to different dates of sowing and stage of pinching.

At 30-60 DAS, maximum net assimilation rate of was found in D_2 - 15th October (0.040 g per dm^2 per day) and minimum was noticed in D_1 – 1st October (0.028 g per dm^2 per day). Similarly at 60 DAS till harvest, maximum net assimilation rate of 0.023 g per dm^2 per day was found in D_2 (15th October), which was on par with D_3 (0.019 g per dm^2 per day) while, minimum of 0.014 g per day was recorded at D_1 (1st October).

Significantly maximum net assimilation rate (0.038 g per dm^2 per day) was noticed under P_2 (Pinching at 35 DAS) at 30-60 DAS which was on par with P_1 (Pinching

at 25 DAS) and P_3 (No pinching) which recorded 0.036 g per dm^2 per day. Whereas, at later stage also (60 DAS till harvest) pinching at 35 DAS recorded maximum net assimilation rate (0.021 g per dm^2 per day) which was statistically on par with no pinching (0.017 g per dm^2 per day) while, the least was registered in the plants pinched at 25 DAS (0.014 g per dm^2 per day).

As far as interaction was concerned, the net assimilation rate showed significant difference at all the stages of plant growth. Maximum was registered under D_2P_2 (0.045 g per dm^2 per day) which was on par with all the remaining treatments except D_1P_1 which recorded minimum Net Assimilation Rate (0.024 g per dm^2 per day) whereas, at 60 DAS till harvest, maximum net assimilation rate was recorded in D_2P_2 (0.028 g per dm^2 per day), which was on par with D_2P_3 (0.024 g per dm^2 per day) and D_4P_1 (0.021 g per dm^2 per day) while, minimum was recorded in D_1P_1 (0.010 g per dm^2 per day) treatment combination.

4.2 Yield parameters

4.2.1 Number of days taken for first flowering

The perusal of data presented in table 12 indicated that the number of days taken for first flowering varied significantly with different dates of sowing and pinching.

Among the different sowing dates, D_2 (15^{th} October) took minimum days (38.48 days) for first flowering, followed by D_3 (1^{st} November) which took 40.68 days. Whereas, D_1 (1^{st} October) took more number of days of 44.40 for first flowering.

On the contrary pinched plants took relatively more days to first flowering compared to no pinching. Among the pinching treatments, P_3 (No pinching) recorded relatively minimum days to first flowering *i.e.* 38.72 days, followed by P_2 (Pinching at 35 DAS) *i.e.* 41.64 days whereas, P_1 (Pinching at 25 DAS) registered maximum days of 43.60 for first flowering.

As far as interaction was concerned, D_2P_3 recorded (Sowing on 15^{th} October and no pinching) significantly minimum days for first flowering (36.00 days), followed by

Table 11. Effect of dates of sowing and stage of pinching on Relative Growth Rate (RGR) and Net Assimilation Rate (NAR) of fenugreek

Treatments	RGR (g/g/day)		NAR (g/dm^2/day)	
	30-60 DAS	60 DAS till harvest	30-60 DAS	60 DAS till harvest
Dates of sowing (D)				
D_1 : 1st October	0.004	0.015	0.028	0.014
D_2 : 15th October	0.027	0.024	0.040	0.023
D_3 : 1st November	0.015	0.023	0.038	0.019
D_4 : 15th November	0.009	0.018	0.035	0.016
D_5 : 1st December	0.005	0.018	0.034	0.014
SEm±	0.002	0.001	0.003	0.002
CD at 5 %	0.006	0.002	0.009	0.006
Stage of pinching (P)				
P_1 : Pinching at 25 DAS	0.014	0.010	0.036	0.014
P_2 : Pinching at 35 DAS	0.018	0.026	0.038	0.021
P_3 : No pinching (Control)	0.014	0.016	0.036	0.017
SEm±	0.001	0.004	0.002	0.016
CD at 5 %	0.002	0.009	0.007	0.004
Interaction effects (D x P)				
D_1P_1	0.003	0.013	0.024	0.010
D_1P_2	0.005	0.016	0.028	0.023
D_1P_3	0.006	0.014	0.034	0.017
D_2P_1	0.023	0.023	0.034	0.013
D_2P_2	0.026	0.026	0.045	0.028
D_2P_3	0.023	0.025	0.039	0.024
D_3P_1	0.006	0.016	0.034	0.015
D_3P_2	0.007	0.024	0.036	0.018
D_3P_3	0.006	0.020	0.035	0.013
D_4P_1	0.006	0.013	0.032	0.021
D_4P_2	0.016	0.016	0.032	0.013
D_4P_3	0.006	0.016	0.037	0.015
D_5P_1	0.016	0.016	0.042	0.018
D_5P_2	0.013	0.020	0.043	0.014
D_5P_3	0.016	0.018	0.043	0.010
SEm±	0.003	0.002	0.005	0.003
CD at 5 %	0.008	0.002	0.017	0.011

Note: DAS - Days After Sowing

D_3P_3 (37.33 days) while, the treatment combination D_1P_1 (Sowing on 1st October and pinching at 25 DAS) took maximum days for first flowering (46.40 days).

4.2.2 Number of days taken for 50 per cent flowering

The data presented on days to 50 per cent flowering as influenced by different sowing dates and pinching showed significant differences among the different treatments (Table 12).

The minimum days taken for 50 per cent of flowering (46.57 days) was recorded in D_2 (15th October), followed by D_3 (1st November) *i.e*. 49.93 days. While, D_1 (1st October) took relatively maximum days for 50 per cent of flowering (54.82 days).

Days taken for 50 per cent of flowering also varied significantly due to pinching. P_3 9No pinching) recorded minimum days for 50 per cent of flowering (47.54 days), followed by P_2 (Pinching at 35 DAS) which took 51.08 days. Whereas, P_1 (Pinching at 25 DAS) took more number of days for 50 per cent flowering (54.19 days).

With respect to interaction, significant variation was observed with respect to days taken for 50 per cent flowering. The D_2P_3 recorded least number of days for 50 per cent flowering (43.66 days), followed by the treatment combination D_3P_3 (47.86 days). However, the maximum numbers of days were recorded in D_1P_1 (58.63 days).

4.2.3 Days taken for harvesting

The data presented on days taken for harvesting as influenced by different sowing dates and pinching showed significant differences among the different treatments (Table 13).

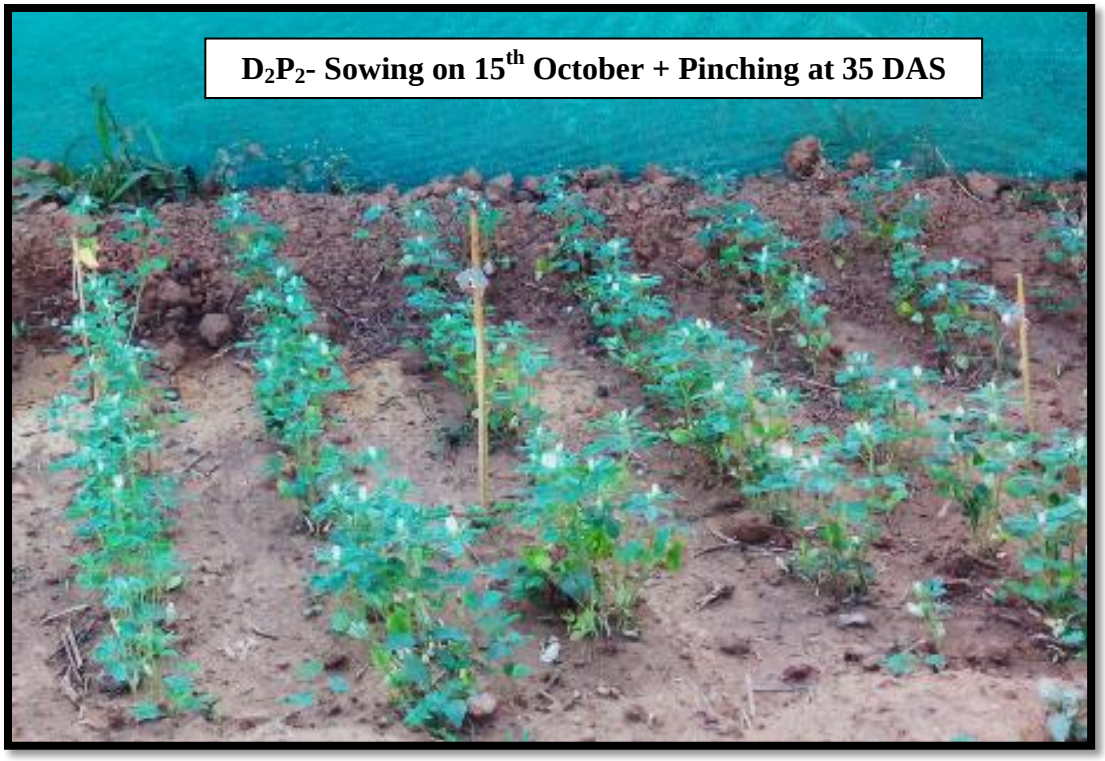
The minimum days taken for harvesting (82.44 days) was recorded at D_2 (15th October), followed by D_3 (1st November) *i.e.* 85.88 days. While, D_1 (1st October) took relatively more number of days for harvesting (90.00 days).

Days taken for harvesting also varied significantly due to pinching. P_3 - No pinching, recorded less number of days for harvesting (86.22 days), followed by P_2 -

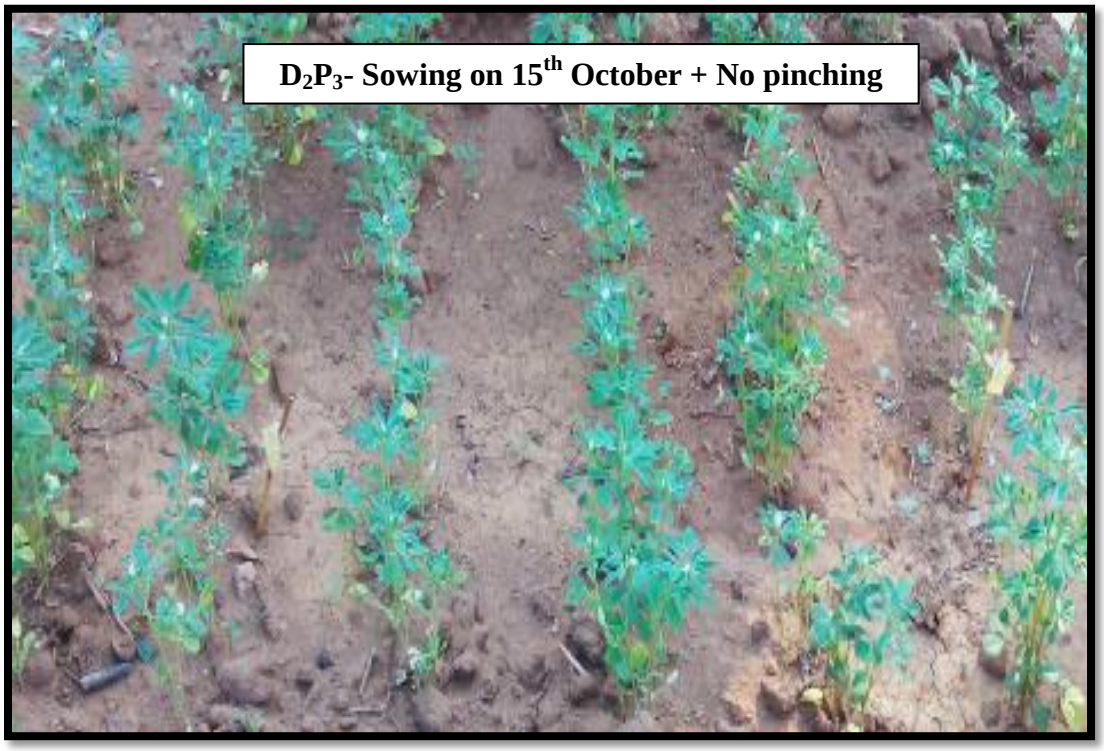
Table 12. Effect of dates of sowing and stage of pinching on flowering in fenugreek

Treatments	Days taken for	
	1st flowering	50 % flowering
Dates of sowing (D)		
D_1 : 1st October	44.40	54.82
D_2 : 15th October	38.48	46.57
D_3 : 1st November	40.68	49.93
D_4 : 15th November	40.80	51.60
D_5 : 1st December	42.23	51.75
SEm±	0.13	0.60
CD at 5 %	0.37	1.77
Stage of pinching (P)		
P_1 : Pinching at 25 DAS	43.60	54.19
P_2 : Pinching at 35 DAS	41.64	51.08
P_3 : No pinching (Control)	38.72	47.54
SEm±	0.10	0.51
CD at 5 %	0.28	1.37
Interaction effects (D x P)		
D_1P_1	46.40	58.63
D_1P_2	45.00	55.53
D_1P_3	41.80	50.30
D_2P_1	40.86	49.86
D_2P_2	38.60	46.20
D_2P_3	36.00	43.66
D_3P_1	43.80	52.13
D_3P_2	41.26	49.80
D_3P_3	37.33	47.86
D_4P_1	43.00	55.13
D_4P_2	40.40	51.53
D_4P_3	38.66	48.13
D_5P_1	43.96	55.20
D_5P_2	42.93	52.33
D_5P_3	39.80	47.73
SEm±	0.22	1.03
CD at 5 %	0.64	3.07

Note: DAS - Days After Sowing



(a)



(b)

Plate 3 (a & b): Fenugreek plants at flowering stage

Pinching at 35 DAS (87.52 days). Whereas, P_1 (Pinching at 25 DAS) delayed the harvesting (88.74 days).

With respect to interaction, significant variation was observed for the parameter. D_2P_3 was early to mature by recording 80.66 days followed by D_3P_3 (84.46 days). However, the treatment D_1P_1 took maximum number of days (91.00 days) to harvest.

4.2.4 Number of pods per plant

The data pertaining to number of pods per plant are presented in table 14. Number of pods per plant varied significantly with respect to sowing on different dates, stage of pinching and their interaction.

The number of pods per plant differed significantly among the different sowing dates. Significantly more number of pods per plant were observed in D_2 - 15th October sowing (12.40), followed by D_3 - 1st November sowing (10.44) while, least number of pods per plant were found in D_1 - 1st October (5.40).

The number of pods per plant differed significantly due to pinching. Number of pods per plant was found to be maximum *i.e.* 9.29 at P_2 (Pinching at 35 DAS), followed by P_3 (No pinching) *i.e.* 8.66 whereas, minimum was recorded in P_1 (Pinching at 25 DAS) *i.e.* 7.85.

The interaction effect on number of pods per plant was also significant. Maximum number of pods per plant (13.80) was observed in D_2P_2 (Sowing on 15th October and pinching at 35 DAS), followed by D_2P_3 (12.33) and the minimum number of pods per plant were noticed in D_1P_1treatment combination (5.10).

4.2.5 Pod length

The data pertaining to length of pod is presented in table 14. Length of pod varied significantly with respect to different sowings, pinching and their interaction.

Table 13. Effect of dates of sowing and stage of pinching on number of days taken for harvesting in fenugreek

Treatments	Days taken for harvesting
Dates of sowing (D)	
D_1 : 1st October	90.00
D_2 : 15th October	82.44
D_3 : 1st November	85.88
D_4 : 15th November	89.51
D_5 : 1st December	89.64
SEm±	0.11
CD at 5 %	0.30
Stage of pinching (P)	
P_1 : Pinching at 25 DAS	88.74
P_2 : Pinching at 35 DAS	87.52
P_3 : No pinching (Control)	86.22
SEm±	0.07
CD at 5 %	0.23
Interaction effects (D x P)	
D_1P_1	91.00
D_1P_2	90.26
D_1P_3	88.73
D_2P_1	84.60
D_2P_2	82.06
D_2P_3	80.66
D_3P_1	87.20
D_3P_2	86.00
D_3P_3	84.46
D_4P_1	90.33
D_4P_2	89.60
D_4P_3	88.60
D_5P_1	90.60
D_5P_2	89.66
D_5P_3	88.66
SEm±	0.18
CD at 5 %	0.53

Note: DAS - Days After Sowing

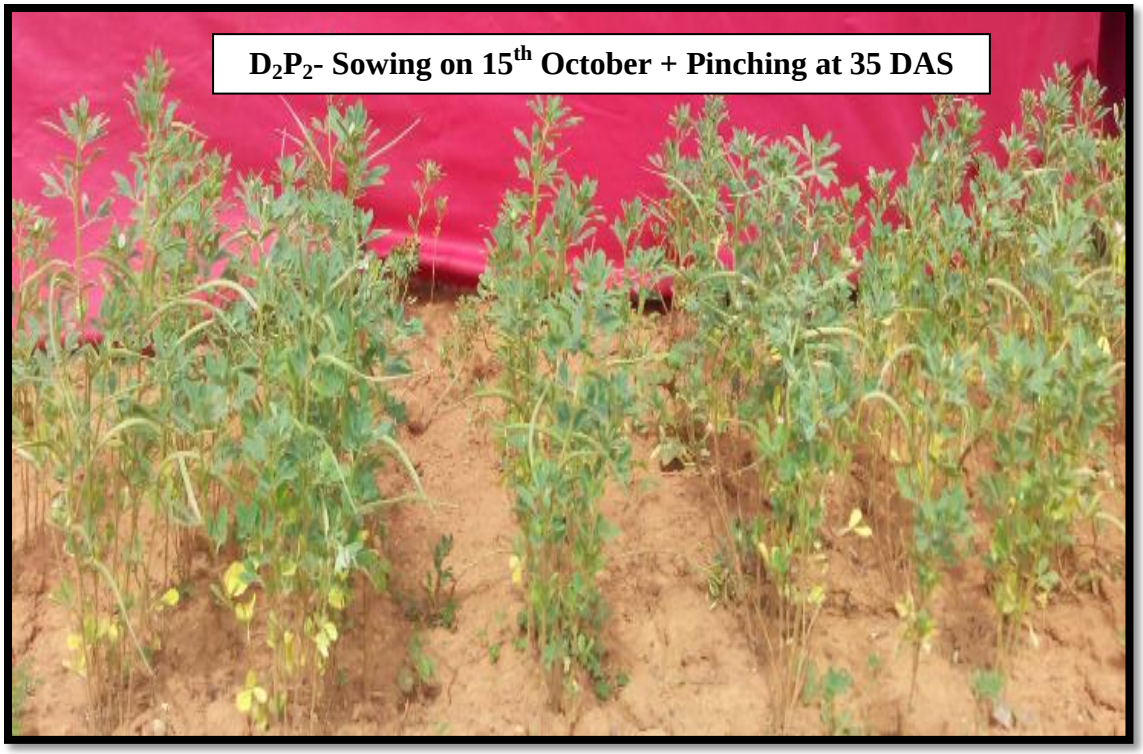


Plate 4: Plants at maturity in best treatment combination

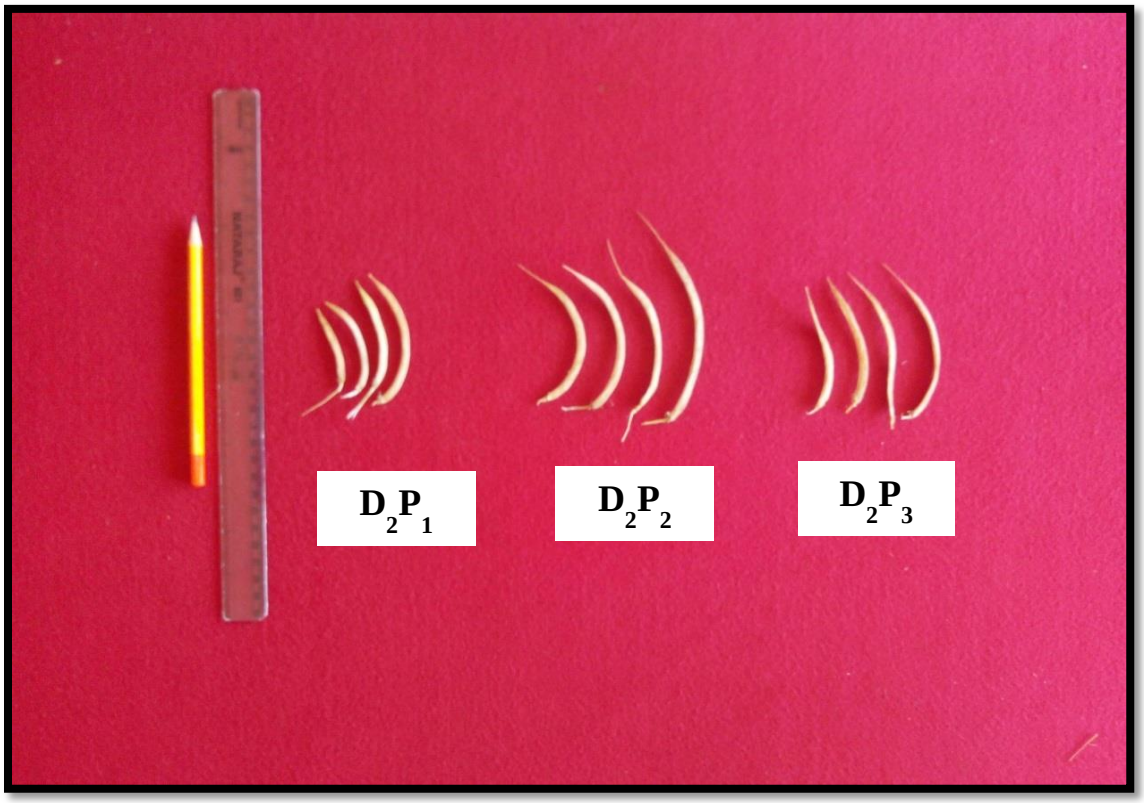


Plate 5: Variation in fenugreek pods size

Pod length was highest in 15th October sowing (10.13 cm), followed by 1st November sown crop (9.63 cm) whereas, least pod length (7.31 cm) was recorded in 1st October sown crop.

The length of pod differed significantly due to pinching. Pinching at 35 DAS recorded maximum pod length (9.25 cm), followed by no pinching (9.00 cm) and minimum was in the plants pinched at 25 DAS (8.79 cm).

With respect to interaction, there was significant difference among the treatments. The treatment combination D_2P_2 recorded maximum pod length (10.34 cm), which was on par with D_2P_3 (10.16 cm), while minimum pod length (6.90 cm) was noticed in D_1P_1treatment combination.

4.2.6 Fresh weight of pod

The data with respect to the effect of different dates of sowing and stage of pinching on fresh weight of pod is presented in table 14. The pod weight found to be significantly influenced by the treatments imposed.

The pod weight was found to be maximum (0.305 g) in D_2 (15th October), followed by D_3 (1st November*) i.e.* (0.291 g) while, minimum pod weight (0.234 g) was recorded at D_1 (1st October).

The weight of pod with respect to different pinching treatments also differed. The pod weight per plant was found to be maximum in P_2 (Pinching at 35 DAS) *i.e.* 0.28 g, which was followed by P_3 (No pinching) *i.e.* 0.27 g whereas, minimum pod weight of 0.26 g was recorded in P_1 (Pinching at 25 DAS).

The treatment combination D_2P_2 (Sowing on 15th October and pinching 35 DAS) recorded significantly maximum pod weight (0.31 g), which was statistically on par with D_2P_3 (0.30 g). While, the minimum (0.22 g) pod weight was noticed in D_1P_1.

Table 14. Effect of dates of sowing and stage of pinching on various pod characters in fenugreek

Treatments	No. of pods per plant	Pod length (cm)	Fresh weight of pod (g)
Dates of sowing (D)			
D_1 : 1st October	5.40	7.31	0.23
D_2 : 15th October	12.40	10.13	0.30
D_3 : 1st November	10.44	9.63	0.29
D_4 : 15th November	8.15	9.31	0.28
D_5 : 1st December	6.61	8.71	0.26
SEm±	0.210	0.081	0.002
CD at 5 %	0.531	0.233	0.005
Stage of pinching (P)			
P_1 : Pinching at 25 DAS	7.85	8.79	0.26
P_2 : Pinching at 35 DAS	9.29	9.25	0.28
P_3 : No pinching (Control)	8.66	9.00	0.27
SEm±	0.140	0.062	0.002
CD at 5 %	0.414	0.183	0.004
Interaction effects (D x P)			
D_1P_1	5.10	6.90	0.22
D_1P_2	5.86	7.87	0.25
D_1P_3	5.23	7.16	0.23
D_2P_1	11.06	9.88	0.29
D_2P_2	13.80	10.34	0.31
D_2P_3	12.33	10.16	0.30
D_3P_1	9.73	9.56	0.28
D_3P_2	10.93	9.70	0.29
D_3P_3	10.66	9.64	0.29
D_4P_1	7.16	9.15	0.27
D_4P_2	8.90	9.47	0.28
D_4P_3	8.40	9.32	0.27
D_5P_1	6.20	8.49	0.25
D_5P_2	6.96	8.90	0.27
D_5P_3	6.66	8.74	0.26
SEm±	0.312	0.140	0.005
CD at 5 %	0.919	0.406	0.016

Note: DAS - Days After Sowing

4.2.7 Number of seeds per pod

The data in table 15 indicated that sowing on different dates and stage of pinching had significant effect on number of seeds per pod.

Among different sowing dates, sowing on 15th October recorded significantly maximum number of seeds per pod (13.04), followed by the crop sown on 1st November (11.88), whereas, minimum number of seeds per pod (10.00) were noticed in 1st October sowing.

The number of seeds per pod differed significantly due to pinching. Number of seeds per pod was found to be maximum at P_2 - Pinching at 35 DAS (11.61) which was statistically on par with P_3 - No pinching (11.33). Whereas, the minimum number of seeds per pod (11.10) was recorded in P_1 - Pinching at 25 DAS.

The interaction effect between different sowing dates and stage of pinching differed significantly on number of seeds per pod. Maximum number of seeds per pod (13.60) was observed in D_2P_2 treatment combination, which was on par with D_2P_3 (13.00) and the minimum (9.83) number of seeds per pod was recorded in treatment D_1P_1.

4.2.8 Weight of seeds per pod

The data with respect to the effect of different dates of sowing and stage of pinching on weight of seeds per pod is presented in table 15. The seed weight was found to be significantly influenced by the treatments imposed.

Sowing on 15th October reported maximum weight of seeds per pod (0.24 g), followed by 1st November sown crop (0.22 g), while minimum was registered under the crop sown on 1st October (0.18 g).

Similarly, the seed weight per pod was found to be maximum at P_2 (Pinching at 35 DAS) *i.e.* 0.22 g, which was followed by P_3 (No pinching) *i.e.* 0.21 g, whereas minimum seed weight of 0.20 g was recorded in P_1 (Pinching at 25 DAS).

Statistically significant difference was noticed among the interaction with respect to seed weight per pod. Among the treatment combinations, D_2P_2 recorded maximum pod weight (0.25 g), which was statistically on par with D_2P_3 (0.24 g). While, treatment combination D_1P_1 registered the minimum pod weight (0.18 g).

4.2.9 Thousand seed weight

The data pertaining to thousand seed weight is presented in table 15. Test weight of seeds varied significantly with respect to different sowing dates and pinching treatments.

Thousand seed weight was maximum in D_2 (20.58 g), followed by D_3 (1^{st} November) sown crop (19.56 g) whereas, the minimum (14.60) was recorded in D_1 (1^{st} October) sowing.

Thousand seed weight differed significantly due to pinching. Pinching at 35 DAS recorded maximum test weight (18.94 g), followed by no pinching (18.17 g) and minimum in the plants pinched at 25 DAS (17.67 g).

With respect to interaction, there was significant difference among the different treatment combinations. The treatment combination D_2P_2 recorded maximum thousand seed weight (21.09 g), which was on par with D_2P_3 (20.43 g) while, minimum (12.79 g) was noticed in D_1P_1.

4.2.10 Seed yield per plant

The data presented on seed yield per plant as influenced by sowing on different dates and stage of pinching is presented in table 16 which showed significant differences among the treatments.

Seed yield per plant was significantly higher (3.04 g) in 15^{th} October sown crop, followed by 15^{th} October sown crop (2.34 g) while, minimum seed yield per plant (g) was recorded in 1^{st} October sown crop (1.04 g).

Table 15. Effect of dates of sowing and stage of pinching on number of seeds per pod, weight of seeds per pod and thousand seed weight of fenugreek

Treatments	No. of seeds/pod	Weight of seeds/pod (g/pod)	1000 seed weight (g)
Dates of sowing (D)			
D_1 : 1st October	10.00	0.18	14.60
D_2 : 15th October	13.04	0.24	20.58
D_3 : 1st November	11.88	0.22	19.56
D_4 : 15th November	11.25	0.21	17.76
D_5 : 1st December	10.56	0.19	18.80
SEm±	0.131	0.001	0.286
CD at 5 %	0.374	0.002	0.838
Stage of pinching (P)			
P_1 : Pinching at 25 DAS	11.10	0.20	17.67
P_2 : Pinching at 35 DAS	11.61	0.22	18.94
P_3 : No pinching (Control)	11.33	0.21	18.17
SEm±	0.120	0.001	0.226
CD at 5 %	0.296	0.003	0.655
Interaction effects (D x P)			
D_1P_1	9.83	0.18	12.79
D_1P_2	10.16	0.19	16.64
D_1P_3	10.00	0.19	14.37
D_2P_1	12.53	0.22	20.20
D_2P_2	13.60	0.25	21.09
D_2P_3	13.00	0.24	20.43
D_3P_1	11.60	0.22	19.36
D_3P_2	12.13	0.22	19.77
D_3P_3	11.93	0.22	19.56
D_4P_1	11.13	0.20	17.50
D_4P_2	11.43	0.21	18.15
D_4P_3	11.20	0.21	17.64
D_5P_1	10.43	0.19	18.50
D_5P_2	10.73	0.20	19.03
D_5P_3	10.53	0.19	18.87
SEm±	0.221	0.005	0.503
CD at 5 %	0.651	0.012	1.456

Note: DAS - Days After Sowing

The seed yield per plant differed significantly with respect to stage of pinching. Maximum (2.07 g) seed yield per plant was found in P_2 (Pinching at 35 DAS) and it was followed by P_3 (1.91 g). Whereas, minimum seed yield per plant (1.68 g) was recorded in P_1 (Pinching at 25 DAS).

With respect to interaction, there was significant difference among the different treatments. The treatment combination D_2P_2 recorded maximum seed yield per plant (3.44 g), followed by D_2P_3 (3.16 g), while minimum (0.93 g) was noticed in D_1P_1.

4.2.11 Seed yield per hectare

The data with respect to the effect of different dates of sowing and stage of pinching on seed yield per hectare is presented in table 16. The seed yield was found to be significantly influenced by the treatments imposed.

The data indicated that among different dates of sowing, sowing on 15th October reported maximum seed yield per hectare (1015.09 kg), followed by 1st November sown crop (779.40 kg), while minimum was registered under the crop sown on 1st October (347.11 kg).

The seed yield per hectare differed significantly due to pinching. Number of seed yield per hectare was found to be maximum in P_2 (Pinching at 35 DAS) *i.e.* 694.79 kg, followed by P_3 (No pinching) *i.e.* 642.39 kg, whereas, minimum was recorded in P_1 (Pinching at 25 DAS) *i.e.* 563.30 kg.

The data indicated that interaction of sowing on different dates and stage of pinching had significant effect on seed yield per hectare. However, maximum seed yield per hectare (1148.11 kg) was observed in D_2P_2 treatment combination, followed by D_2P_3 (1051.21 kg) and the minimum was noticed in D_1P_1treatment combination (312.21 kg).

4.2.12 Harvest Index (HI)

The data on the harvest index as influenced by different dates of sowing, stage of pinching and their interaction is presented in table 17.

Table 16. Effect of dates of sowing and stage of pinching on seed yield of fenugreek.

Treatments	Seed yield (g / plant)	Seed yield (kg / ha)
Dates of sowing (D)		
D_1 : 1st October	1.04	347.11
D_2 : 15th October	3.04	1015.09
D_3 : 1st November	2.34	779.40
D_4 : 15th November	1.71	576.15
D_5 : 1st December	1.30	449.74
SEm±	0.04	14.54
CD at 5 %	0.13	43.01
Pinching interval		
P_1 : Pinching at 25 DAS	1.68	563.30
P_2 : Pinching at 35 DAS	2.07	694.79
P_3 : No pinching (Control)	1.91	642.39
SEm±	0.04	12.11
CD at 5 %	0.09	33.32
Interaction effects (D x P)		
D_1P_1	0.93	312.21
D_1P_2	1.14	382.75
D_1P_3	1.03	346.36
D_2P_1	2.54	845.94
D_2P_2	3.44	1148.11
D_2P_3	3.16	1051.21
D_3P_1	2.16	716.34
D_3P_2	2.51	837.00
D_3P_3	2.35	784.85
D_4P_1	1.52	526.96
D_4P_2	1.88	622.11
D_4P_3	1.75	579.38
D_5P_1	1.24	513.18
D_5P_2	1.37	564.98
D_5P_3	1.28	541.16
SEm±	0.08	25.35
CD at 5 %	0.21	74.49

Note: DAS - Days After Sowing



(a)



(b)



(c)

Plate 6: (a) Fresh herb (b) Dried herb (c) Seeds of fenugreek

Harvest index differed significantly among the different sowings. The highest harvest index was recorded in the crop sown on 15th October (27.43 %) followed by 1st November sowing (24.87 %) and the least was recorded in the crop sown on 1st October (16.06 %).

Similarly, harvest index was also differed significantly among the different pinching treatments. The highest harvest index of 23.90 per cent was recorded in P_2 (Pinching at 35 DAS), followed P_3 (22.66 %). However, the least (21.26 %) was recorded in P_1 (Pinching at 25 DAS).

With respect to interaction effect, the maximum harvest index (29.16 %) was recorded in D_2P_2 (Sowing on 15th October and pinching 35 DAS), followed by D_2P_3 (27.26 %) whereas, minimum harvest index (12.52 %) was recorded in D_1P_1 (Sowing on 1st October and pinching at 25 DAS).

4.3 QUALITY PARAMETERS

4.3.1 Chlorophyll content in leaves

The data pertaining to chlorophyll 'a', chlorophyll 'b' and total chlorophyll content in leaves is presented in table 18. The chlorophyll content in leaves was found to be significantly influenced by different dates of sowing and stage of pinching.

The chlorophyll 'a' content at 30 DAS was maximum in 15th October sown crop *i.e.* 2.41 mg/g followed by D_3. The least was noticed in D_1. Similarly at 60 DAS also chlorophyll 'a' and 'b' content were maximum in 15th October sown crop (2.49 mg/g and 1.34 mg/g respectively) followed by 1st November sown crop (2.29 and 0.83 mg/g respectively).

Similarly, total chlorophyll was significantly maximum in 15th October sown crop at 30 and 60 DAS (3.14 mg/g and 3.15 mg/g respectively). The least was in 1st October sown crop (1.70 mg/g fresh weight and 2.62 mg/g respectively).

Table 17. Effect of dates of sowing and stage of pinching on harvest index of fenugreek

Treatments	Harvest Index (%)
Dates of sowing (D)	
D_1 : 1st October	16.06
D_2 : 15th October	27.43
D_3 : 1st November	24.87
D_4 : 15th November	23.42
D_5 : 1st December	21.26
SEm±	0.24
CD at 5 %	0.72
Stage of pinching (P)	
P_1 : Pinching at 25 DAS	21.26
P_2 : Pinching at 35 DAS	23.90
P_3 : No pinching (Control)	22.66
SEm±	0.21
CD at 5 %	0.55
Interaction effects (D x P)	
D_1P_1	12.52
D_1P_2	19.18
D_1P_3	16.49
D_2P_1	25.86
D_2P_2	29.16
D_2P_3	27.26
D_3P_1	24.52
D_3P_2	25.29
D_3P_3	24.80
D_4P_1	22.98
D_4P_2	23.78
D_4P_3	23.50
D_5P_1	20.41
D_5P_2	22.10
D_5P_3	21.29
SEm±	0.43
CD at 5 %	1.24

Note: DAS - Days After Sowing

Pinching at 35 DAS recorded significantly higher chlorophyll 'a' and 'b' content at 60 DAS (2.18 mg/g and 0.92 mg/g respectively). The total chlorophyll was also significantly high in plants pinched at 35 DAS (2.98 mg/g).

The treatment combination D_2P_2 recorded higher total chlorophyll content of 3.28 mg/g and 3.25 mg/g at 30 and 60 DAS.

4.3.2 Crude protein content in seed

The data recorded on crude protein content in seeds is presented in table 19. The protein content was found to be significantly influenced by different dates of sowing and stage of pinching.

Protein content was significantly maximum in 15th October sown crop (4.79 %) followed by 1st November sown crop (3.78 %). The least was in 1st October sown crop (2.79 %).

Pinching at 35 DAS also recorded significantly maximum protein in seeds (3.71 %) whereas, minimum in P_1. With respect to interaction, D_2P_2 (Sowing on 15th October and pinching at 35 DAS) recorded significantly maximum protein (5.08 %) whereas, minimum was registered in D_1P_1 (2.69 %).

4.4 Scoring of pest and diseases

There was a great impact of different dates of sowing date on the incidence of pest and diseases as depicted in table 20.

Maximum pest infestation of *Spodoptera sp.* was noticed in the crop sown during 1st November (12.05 %). Whereas, there was no pest infestation in the crop sown during other dates.

Similarly, maximum powdery mildew incidence (11.93 %) was recorded in 1st December sown crop, whereas there was no incidence of the disease in the crop sown on 1st October, 15th October and 1st November.

Table 18. Effect of dates of sowing and stage of pinching on chlorophyll content of fenugreek leaves

Treatments	Chlorophyll a and b (mg/g)				Total Chlorophyll (mg/g)	
	30 DAS		60 DAS		30 DAS	60 DAS
	Chl-a	Chl- b	Chl- a	Chl- b		
Dates of sowing (D)						
D_1 : 1st October	0.77	0.42	1.58	0.52	1.70	2.62
D_2 : 15th October	2.41	1.79	2.49	1.34	3.14	3.15
D_3 : 1st November	2.18	0.83	2.29	0.83	2.94	3.05
D_4 : 15th November	1.92	0.76	2.14	0.75	2.74	2.96
D_5 : 1st December	1.39	0.71	1.96	0.69	2.55	2.80
SEm±	0.08	0.09	0.10	0.07	0.10	0.03
CD at 1 %	0.23	0.27	0.29	0.22	0.27	0.08
Stage of pinching (P)						
P_1 : Pinching at 25 DAS	1.62	0.76	1.96	0.76	2.46	2.86
P_2 : Pinching at 35 DAS	1.85	1.03	2.18	0.92	2.77	2.98
P_3 : No pinching (Control)	1.74	0.92	2.13	0.79	2.61	2.90
SEm±	0.06	0.07	0.08	0.06	0.07	0.02
CD at 1 %	0.17	0.20	0.23	0.18	0.21	0.06
Interaction effects (D x P)						
D_1P_1	0.68	0.21	1.07	0.55	1.29	2.54
D_1P_2	0.86	0.57	1.86	0.52	2.12	2.69
D_1P_3	0.79	0.49	1.80	0.48	1.68	2.63
D_2P_1	2.30	1.39	2.48	1.06	3.06	3.09
D_2P_2	2.59	2.17	2.49	1.76	3.28	3.25
D_2P_3	2.34	1.81	2.49	1.21	3.07	3.11
D_3P_1	2.08	0.77	2.27	0.82	2.84	3.02
D_3P_2	2.27	0.89	2.31	0.86	3.00	3.08
D_3P_3	2.19	0.84	2.29	0.83	2.98	3.04
D_4P_1	1.74	0.74	2.05	0.72	2.67	2.93
D_4P_2	2.04	0.79	2.23	0.78	2.78	3.00
D_4P_3	1.97	0.76	2.14	0.75	2.77	2.96
D_5P_1	1.29	0.68	1.94	0.65	2.44	2.73
D_5P_2	1.48	0.73	1.99	0.71	2.67	2.89
D_5P_3	1.39	0.68	1.96	0.70	2.53	2.77
SEm±	0.13	0.16	0.17	0.13	0.15	0.05
CD at 1 %	0.39	0.46	0.50	0.39	0.46	0.15

Note: DAS - Days After Sowing

Table 19. Effect of dates of sowing and stage of pinching on crude protein content of fenugreek seeds

Treatments	Crude protein (%)
Dates of sowing (D)	
D_1 : 1st October	2.79
D_2 : 15th October	4.79
D_3 : 1st November	3.78
D_4 : 15th November	2.95
D_5 : 1st December	3.32
S Em±	0.08
CD @ 1 %	0.23
Stage of pinching (P)	
P_1 : Pinching at 25 DAS	3.39
P_2 : Pinching at 35 DAS	3.71
P_3 : No pinching (Control)	3.48
S Em±	0.06
CD @ 1 %	0.17
Interaction effects (D x P)	
D_1P_1	2.69
D_1P_2	2.87
D_1P_3	2.80
D_2P_1	4.60
D_2P_2	5.08
D_2P_3	4.68
D_3P_1	3.70
D_3P_2	3.88
D_3P_3	3.75
D_4P_1	2.88
D_4P_2	3.04
D_4P_3	2.94
D_5P_1	3.11
D_5P_2	3.61
D_5P_3	3.24
SEm±	0.14
CD @ 1 %	0.40

Note: DAS - Days After Sowing

Table 20. Scoring of pest and diseases as influenced by different dates of sowing and pinching in fenugreek

Treatments	Pest incidence (%) (*Spodoptera sp.*)	Disease infestation (%) (Powdery mildew)	Disease score	Disease reaction
D_1P_1	___	___	0	Immune
D_1P_2	___	___	0	Immune
D_1P_3	___	___	0	Immune
D_2P_1	___	___	0	Immune
D_2P_2	___	___	0	Immune
D_2P_3	___	___	0	Immune
D_3P_1	11.66	___	0	Immune
D_3P_2	11.50	___	0	Immune
D_3P_3	13.00	___	0	Immune
D_4P_1	___	8	1	Resistant
D_4P_2	___	9	1	Resistant
D_4P_3	___	3	1	Resistant
D_5P_1	___	6.62	1	Resistant
D_5P_2	___	13.66	2	Moderately resistant
D_5P_3	___	15.53	2	Moderately resistant

4.5 Economics

The data on effect of different dates of sowing and stage of pinching on cost economics of fenugreek seed production is presented in table 21.

The maximum gross return (91,848.80 Rupees/ha), net return (66,436.80 Rupees/ha) and cost benefit ratio (2.62) was recorded in treatment combination D_2P_2 (Sowing on 15th October and pinching at 35 DAS) followed by D_2P_3 which recorded 84,096.80 Rupees/ha of gross returns, 59,984 Rupees/ha of net returns and cost benefit ratio of 2.49. The minimum gross return (24,976.80 Rupees/ha), net return (-435.2 Rupees/ha) and cost benefit ratio (-0.017) was recorded in the treatment combination D_1P_1 (Sowing on 1st October and Pinching at 25 DAS).

Table 21. Effect of dates of sowing and stage of pinching on economics of fenugreek (*Trigonella foenum - graecum* L.) cultivation

Treatment	Cost of cultivation (Rs /ha)	Gross returns (Rs /ha)	Net returns (Rs /ha)	B:C ratio
D_1P_1	25412	24976.80	-435.20	-0.017
D_1P_2	25412	30620.00	5208.00	0.21
D_1P_3	24112	27708.80	3596.80	0.15
D_2P_1	25412	67675.20	42263.20	1.67
D_2P_2	25412	91848.80	66436.80	2.62
D_2P_3	24112	84096.80	59984.80	2.49
D_3P_1	25912	57307.20	31395.20	1.22
D_3P_2	25912	66960.00	41048.00	1.58
D_3P_3	24612	62788.00	38176.00	1.55
D_4P_1	25912	42156.80	16244.80	0.63
D_4P_2	25912	49768.80	23856.80	0.92
D_4P_3	24612	46350.40	21738.40	0.88
D_5P_1	25912	41054.40	15142.40	0.58
D_5P_2	25912	45198.40	19286.40	0.74
D_5P_3	24612	43293.04	18681.00	0.76

Note:

Dates of sowing

D_1 – Sowing on 1st October
D_2 – Sowing on 15th October
D_3– Sowing on 1st November
D_4– Sowing on 15th November
D_5– Sowing on 1st December

Pinching intervals

P_1– Pinching at 25 days after sowing
P_2– Pinching at 35 days after sowing
P_3– No pinching

DISCUSSION

V. DISCUSSION

Spices are the food adjuncts that have been used as flavouring and colouring agents and as preservatives for thousands of years. With the ever growing demand for natural foods, spices, pharmaceuticals, perfumes, flavours and cosmetic products, the cultivation of spices has now become popular in international market and economically viable proposition. Spices have also been found to possess medicinal properties. Fenugreek is one of the major seed spices grown in India, which apart from being used for its greens and seeds as condiment also have a significant position in the pharmaceutical sector. The seeds possess carminative, aphrodisiac, emollient, antibacterial, antiemetic, antipyretic and also treat colonitis.

Date of sowing is an important agronomic factor affecting productivity of the crop owing to changes in environmental conditions to which phonological stages of crop are exposed. The modified environment resulting from different dates of sowing may thus influence the crop growth and development. Sowing date is a very important parameter in crop production. The optimum sowing date paves the way for better-use of time, light, temperature, precipitation and other factors. Since environmental factors explicitly influence growth, development and yield of the crop, studying the effect of these factors is crucially important.

Pinching is done to affect canopy structure and is normally accomplished by removing the growing tip. Cutting management or pinching practice greatly influences the growth and yield attributes in fenugreek (Baboo, 1997). Cutting of herbage at early stages of growth induces uniformity in growth, flowering and seed setting. Pinching is commonly practiced to promote bushy growth of the canopy by counteracting the apical dominance. However, removal of apical dominance enhances the growth of lateral branches. It has direct relationship with plant form and subsequent potential for yield increment too (Martin, 1987).

Growth, productivity and quality of any crop is influenced by several factors, such as environmental factors, genetic constitution and agronomic practices. Several attempts

have been made in cultivation of fenugreek in the past to increase the productivity and quality, out of which optimum date of sowing and pinching plays an important role to boost the productivity. There is a need to increase both seed yield and quality in fenugreek.

The investigation was carried out to study the growth and yield of fenugreek (*Trigonella foenum – graecum* L.) as affected by different dates of sowing and stage of pinching at the Department of Plantation, Spices, Medicinal and Aromatic Crops, College of Horticulture Mudigere, University of Agricultural and Horticultural Sciences, Shivamogga from October 2014 to March 2015. The results of the studies are discussed here with the support of available literature.

5.1 Effect of different dates of sowing

5.1.1 Growth parameters

The maximum germination of seeds was observed in 1st December sown crop (99.37 %), whereas minimum was in 1st October sown crop (40.06 %). The temperature prevailed during 1st December maintained optimum relative humidity which was more congenial for better germination, thus enhanced the seed germination. Similar results were also reported by Castillo *et al.* (1994) in pea.

The plant height was significantly influenced by different sowing dates at all stages of growth. At 30 DAS, 60 DAS and at harvest, seeds sown on 1st November were found tallest (13.03 cm, 32.96 cm and 42.31 cm respectively) as compared to other sowing dates, whereas minimum plant height (23.91 cm) was recorded in D_1 (1st October). The increased plant height may be due to the mean temperature requirement of fenugreek which closely coincided with the prevailing temperature in the month of November. Similar results were also reported by Israel (1988) in coriander and Nandre *et al*. (2011) in fenugreek.

The plant spread and the number of branches per plant were significantly influenced by different sowing dates. Significantly more plant spread (76.69 cm^2) and number of branches per plant (10.90) were noticed in the crop sown on 15th October,

whereas minimum plant spread (29.58 cm^2) and branches per plant (4.15) were noticed in 1st October sown crop. This might be attributed to the optimum temperature and relative humidity prevailing during crop period which might have given the plants an adequate opportunity for photosynthesis, so the branch bearing capacity increased. The results are in agreement with Ayub *et al*. (2008) in fennel and Israel (1988) in coriander.

There was a significant difference observed for the leaf area, leaf area index and leaf area duration of the crop. The maximum leaf area (4.557 cm^2) and leaf area index (0.019) were observed in 1st November sown crop, whereas minimum leaf area (3.989 cm^2) and leaf area index (0.013) were observed in D_1 (1st October) sown crop. Leaf area duration was also maximum (0.432 days) under the same sowing date at 30-60 days duration and minimum in D_1 (1st October) (0.376 days). Crop sown on 1st November enjoyed a favourable environmental condition at the crop growth stage which is evident from the increased leaf area, leaf area index and leaf area duration of the crop. The results are in line with Khoja (2004) in coriander, Ayub *et al*. (2008) in fennel and Singh *et al*. (2014) in mustard.

Sowing on different dates showed significant variation on dry matter production of leaves, stem, pods and seeds. Sowing on 15th October recorded maximum dry matter of leaves (0.202 g), stem (0.203 g), pods (0.305 g) and seeds (0.247 g), whereas minimum dry matter of leaves, stem, pods and seeds (0.105 g, 0.098 g, 0.222 g and 0.191 g respectively) was recorded in 1st October sown crop. The total dry matter production was also maximum under 15th October sowing (1.636 g), whereas minimum was in 1st October sowing (0.492 g) at the time of harvest. This might be due to temperature mediated effect which has lead to better utilization of light and moisture inturn resulted in maximum accumulation of dry matter. Similar results in coriander were also given by Israel (1988) and Khoja (2004).

In the present study, it was found that the Absolute Growth Rate (AGR), Crop Growth Rate (CGR), Relative Growth Rate (RGR) and Net Assimilation Rate (NAR) increased with increase in the crop duration. Crop growth rate is a widely used character for estimating production efficiency per unit land area and enables to make comparisons

between the aspects of study (Watson, 1952). At 60 DAS till harvest, maximum AGR (0.546 g/plant/day), CGR (0.186 g/m^2/day), RGR (0.024 g/g/day) and NAR (0.023 g/dm^2/day)were noticed in the crop sown on 15th October as compared to 1st October sowing which recorded minimum values for these parameters. This seems to be mainly due to favourable environment particularly that might have helped in better physiological functions of plant and maximum dry matter accumulation of plants which has manifested in increased AGR, CGR, RGR and NAR. Biological yield was also significantly high in 15th October sown crop. This might be due to more number of branches per plant, plant spread and dry matter accumulation, which improved the yield attributing characters. These results corroborate to the findings of Baswana *et al*. (1989) and Khoja (2004) in coriander.

Days taken for first flowering, for 50 per cent flowering and for harvesting were found to be significantly influenced by different sowing dates. In the present study, sowing on 15th October recorded minimum days for first flowering (38.48 days), 50 per cent flowering (46.57 days) and for harvesting (82.44 days).These results can be attributed to the prevalence of low temperature during the month of November which has accelerated early flowering, early maturity and harvest.

The minimum growth parameters were recorded in D_1 (1st October) because of the rainfall that prevailed during the month of October due to cyclonic effect which resulted in crop loss.

5.1.2 Yield and quality parameters

In the present study it was observed that different dates of sowing had significant effect on the various pod and seed characters. The maximum number of pods per plant (12.40), pod length (10.13 cm) and fresh weight of pod (0.30 g) were noticed under the crop sown on 15th October. Similarly, maximum number of seeds per pod (13.04), weight of seeds per pod (0.24 g) and thousand seed weight (20.58 g) were registered in D_2 (15th October), whereas minimum values for these pod and seed characters were noticed in 1st October sown crop. Seed yield was also maximum in D_2 (3.04 g/plant and 1015.09 kg /ha). D_2 (15th October) also recorded maximum harvest index (27.43 %). This might be

due to better vegetative growth in terms of more number of branches per plant, higher dry matter accumulation, more number of pods per plant and seeds per pod due to better photosynthetic efficiency and translocation of photosynthates from source to sink. Further, maximum seed yield resulted in maximizing the harvest index. The maximum seed weight was because of better reproductive growth and seed filling period which significantly increased the harvest index. Results are in agreement with that of Ayub *et al*. (2008), Azadi (2013) in lentil and Selim *et al*. (2013) in fennel.

In the present study, the chlorophyll content in leaves varied significantly with different dates of sowing. At 60 DAS, maximum chlorophyll 'a', 'b' and total chlorophyll (2.49, 1.34 and 3.15 mg/g respectively) was registered in 15th October sown crop, whereas 1st October sown crop recorded minimum chlorophyll 'a', 'b' and total chlorophyll (1.58, 0.52 and 2.62 mg/g respectively). The protein content in seeds was also influenced due to sowing dates. The crop sown in 15th October recorded maximum protein (4.79 per cent), minimum in the crop sown on 1st October. This might be due to better plant growth due to favourable climatic conditions prevailing during the period and more photosynthetic activity has resulted in better seed filling resulting in the quality seeds in terms of higher protein content. The results are in line with Khoja (2004) in coriander and Babaleshwar, (2014) in kasuri methi.

5.1.3 Scoring of pest and diseases

There was a great impact of sowing date on the incidence of pest and diseases. The maximum incidence of *Spodoptera sp.* (12.05 %) was noticed in 1st November sown crop. This might be due to the fact that, the temperature prevailing during the month of November was very congenial for the caterpillars to remain active. As the temperature was slightly increased in the later stages there was no insect pest infestation. Thus the caterpillar population was decreased. The results corroborate with the findings of Deshwal (2007).

Powdery mildew incidence was maximum in the late sown crop *i.e*. 1st December (11.93 %) while the other sowings did not exhibit any symptoms and they were free from the attack of disease. Relatively cool temperature and excess relative humidity prevailing

in the month of December was very congenial for the pathogen to multiply and hence promoted the disease incidence. Similar results were also reported by Parashkar and Lodha (2012) in fennel. Thus the early sown fenugreek crop suffered least due to low inoculum potential and unfavourable weather conditions for pathogen, whereas late sown crop suffered more because of ready availability of inoculum build up in early sown crop which is in agreement with Sharma and Sharma (1999) in pea.

5.2 Effect of stage of pinching

5.2.1 Growth parameters

In the present study it was observed that at 60 DAS and at the time of harvest, the plant height was maximum in P_3- (No pinching) *i.e.* 25.88 cm and 34.19 cm respectively, whereas minimum in P_1 (Pinching at 25 DAS) *i.e.* 23.15 cm and 29.15 cm, whereas the number of branches per plant and plant spread were maximum in P_2 (Pinching at 35 DAS) *i.e.* 8.45 and 53.78 cm^2 respectively. Minimum number of branches per plant and plant spread were observed in P_1 (Pinching at 25 DAS). Decrease in plant height and increase in number of branches with pinching could be ascribed to pinching of apical bud which curb the vertical growth of plant resulting in translocation of photosynthates to leaf axils thus, encouraging axillary branches. Activation of lateral dormant buds by arresting the terminal growth through pinching of apical bud would have facilitated the significant increase in number of branches per plant. The results are in agreement with Thakral *et al.* (1991), Menon and Khader (1997), Sajjan (2002) and Jabbar *et al*. (2007) in okra, Baloch and Zubair (2010) in chick pea and Vasudevan *et al*. (2008) and Krishnaveni *et al*. (2014) in fenugreek.

Pinching had significant effect on various leaf parameters of the crop. At 60 DAS, P_2 (Pinching at 35 DAS) recorded the maximum leaf area (4.371 cm^2), leaf area index (0.017) and leaf area duration (0.416 days), whereas minimum leaf area (4.168 cm^2), leaf area index (0.012) and leaf area duration (0.396 days) was registered in P_1 (Pinching at 25 DAS).

Dry matter production of leaves, stem, pods and seeds were significantly influenced by pinching. Pinching at 35 DAS (P_3) recorded maximum dry matter of leaves (0.110 g), stem (0.508 g), pods (0.281g) and seeds (0.220 g), whereas minimum dry matter of leaves (0.102 g), stem (0.333 g), pods (0.262 g) and seeds (0.207 g) were in P_1 (Pinching at 25 DAS). The total dry matter production was also maximum in P_3 (1.122 g), whereas minimum in P_1 (0.886 g) at the time of harvest. This might be due to maximum accumulation of photosynthates resulting from more number of branches per plant and plant spread in the plant parts due to pinching. Similar results were also reported by Jabbar *et al*. (2007) in okra and Krishnaveni *et al*. (2014) in fenugreek.

The effect of pinching was also significant with respect to AGR, CGR, RGR and NAR. Significantly maximum AGR (0.460 g/plant/day), CGR (0.157 g/m^2/day) , RGR (0.026 g/g/day) and NAR (0.021 g/dm^2/day)were recorded in pinching at 35 DAS (P_3) while, minimum AGR (0.291 g/plant/day), CGR (0.098 g/m^2/day), RGR (0.010 g/g/day) and NAR (0.014 g/dm^2/day) were registered in P_1 (Pinching at 25 DAS) at 60 DAS till harvest. It is clear that optimum sink capacity in fenugreek as represented by branches per plant, pods per plant and seeds per pod may be obtained with pinching at 35 DAS. It is an established fact that sink capacity largely governs crop productivity (Evans, 1975). Thus the maximum dry matter accumulation in pinched plants has resulted in higher values for these parameters.

5.2.2 Yield and quality parameters

Among the pinching treatments, P_1 (Pinching at 25 DAS) registered more number of days (43.61) for first flowering, whereas P_3 (No pinching) recorded relatively less days to first flowering *i.e.* 38.72 days. Similarly P_1 recorded maximum days for 50 per cent flowering (54.19 days) and for harvesting (88.75 days) while non-pinched plants recorded minimum days for 50 per cent flowering (47.54 days) and for harvesting (86.22 days). The earliness in non-pinched plants and advancement in number of days for first flowering , 50 per cent flowering and for harvesting in pinched plants may be related to alter in source – sink relationship and because of more production of secondary branches

there by advancing the reproductive phase. The results are in agreement with Guha *et al.* (2013) in coriander, Vasudevan *et al.* (2008) and Krishnaveni *et al.* (2014) in fenugreek.

Pinching registered significant difference for various yield parameters. The number of pods per plant (9.29), pod length (9.25 cm), fresh weight of pod (0.28 g), number of seeds per pod (11.61g), weight of seeds per pod (0.21 g) and 1000 seed weight (18.94 g) were maximum in the plants pinched at 35 DAS (P_2), while P_1 (Pinching at 25 DAS) recorded minimum number of pods per plant (7.85), pod length (8.79 cm), fresh weight of pod (0.26 g), number of seeds per pod (11.10), weight of seeds per pod (0.209 g) and 1000 seed weight (17.67 g). These results have attributed mainly because of maximum number of branches which inturn has resulted in maximum number of pods per plant, pod length, fresh weight of pod and 1000 seed weight in P_2 as compared to P_1. Beneficial effect noticed with pinching perhaps could be related to effective synthesis and translocation of photosynthates from source to sink which is evident with higher seed weight. The results are in line with Vasudevan *et al.* (2008), Krishnaveni *et al.* (2014) in fenugreek, Olfati and Malakouti (2013) in faba bean and Baloch and Zubair (2010) in chick pea.

Seed yield per plant and seed yield per hectare also differed significantly due to pinching. The maximum seed yield (2.07 g/plant and 694.79 kg/ha) was obtained in P_2 (Pinched at 35 DAS) while, minimum was noticed in the plants pinched at 25 DAS (1.68 g/plant and 563.30 kg/ha) and no pinching (1.91 g/plant and 642.39 kg/ha). Maximum translocation of assimilates in P_2 has resulted in maximum number of seeds per pod and weight of seeds per pod which in turn increased the seed yield. This increasing trend of number of seeds and weight of seeds per pod has resulted in maximum harvest index. Thus the maximum harvest index (23.90 %) was recorded in P_2 (Pinched at 35 DAS) while minimum (21.26 %) in P_1. Similar results were also reported by Sajjan (2002) and Jabbar *et al*. (2007) in okra, Baloch and Zubair (2010) in chick pea, Guha *et al.* (2013) in coriander and Olfati and Malakouti (2013) in faba bean.

The chlorophyll content in leaves differed significantly with pinching. Among the pinching treatments the plants pinched at 35 DAS recorded maximum Chlorophyll ‘a’,

chlorophyll ‘b’ and total chlorophyll (2.18, 0.92 and 2.98 mg/g respectively) at 60 DAS. These results are attributed mainly because the pinching of plants prolongs the vegetative growth which is very well evidenced from the delayed flowering in the plants pinched at 35 DAS. As the vegetative growth was extended the photosynthetic activity was also maximum in P_2 as compared to P_1 and no pinching. Thus pinching improves the translocation of photosynthates from source to sink increasing the chlorophyll content in leaf tissue in turn resulted in the significant increase in crude protein content (Table 18) due to pinching at 35 DAS. These results may be may be attributed due to increased nitrogen concentration in seed which is an integral part of protein.

5.3 Effect of interaction between dates of sowing and stage of pinching

Interaction effect of date of sowing and pinching was significant on growth, yield and quality of fenugreek at different intervals after sowing.

5.3.1 Growth parameters

The interaction effect of sowing on different dates and stage of pinching on plant height was found significant at all stages of the plant growth. The treatment combination D_3P_3 (Sowing on 1st November and no pinching) recorded significantly maximum plant height at the time of harvest (48.24 cm) while, D_1P_1 (Sowing on 1st October and pinching at 25 DAS) registered minimum plant height (21.24 cm) (Fig. 2). This may be due to prevailing temperature in the month of November. Further because of no pinching plants continued its growth and resulted in maximum height. Similar results were also observed by Israel (1988) in coriander, Vasudevan *et al*. (2008), Nandre *et al*. (2011) in fenugreek and Krishnaveni *et al*. (2014) in fenugreek.

With respect to number of branches per plant and plant spread. Among the treatment combination, D_2P_2 (Sowing on 15th October and pinching at 35 DAS) recorded significantly higher number of branches per plant (9.50 and 12.06) and plant spread (96.33 cm^2 and 51.62 cm^2) at 60 and at the time of harvest respectively (Fig. 3 and 4). Lower values for these parameters were recorded in D_1P_1 (Sowing on 1st October and pinching at 25 DAS).Under this combination, the plants had adequate opportunity for

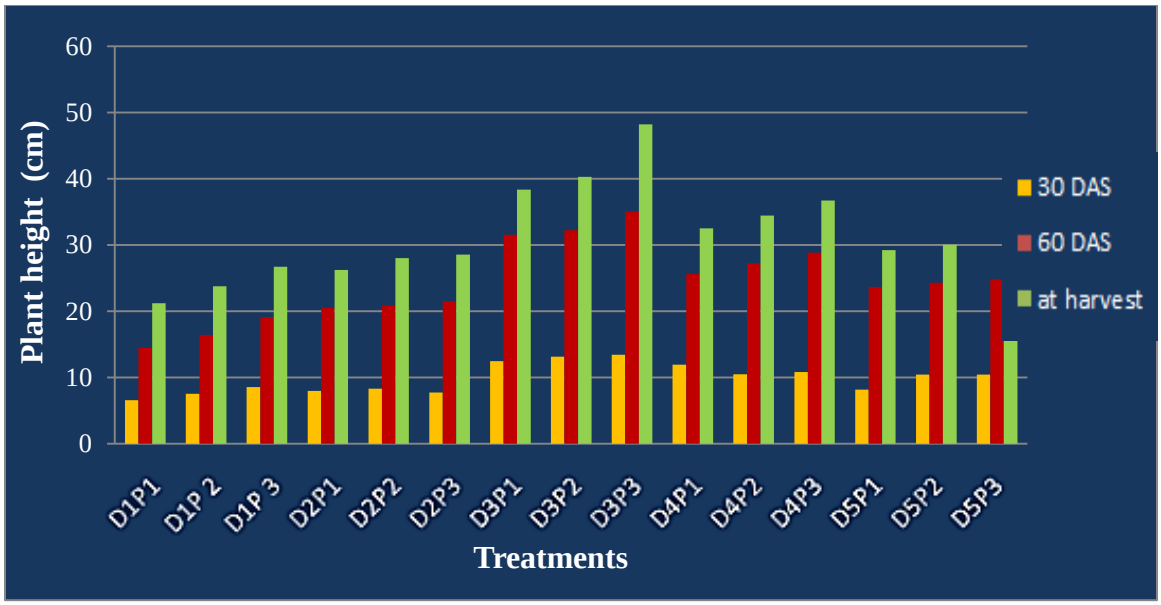


Fig. 2. Effect of different dates of sowing and stage of pinching on plant height at different stages of crop growth in fenugreek

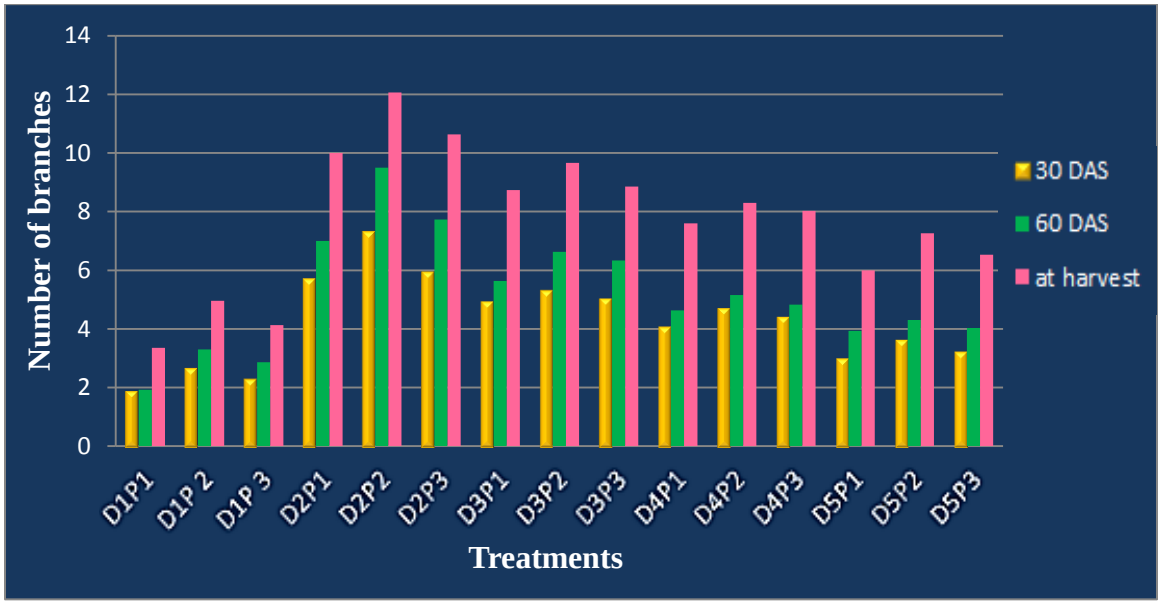


Fig. 3. Effect of different dates of sowing and stage of pinching on number of branches per plant at different stages of crop growth in fenugreek

Treatment Details

Dates of sowing:
D_1: Sowing on 1st October
D_2: Sowing on 15thOctober
D_3: Sowing on 1stNovember
D_4: Sowing on 15th November
D_5: Sowing on 1stDecember

Stage of Pinching:
P_1: Pinching at 25 DAS
P_2: Pinching at 35 DAS
P_3: No pinching

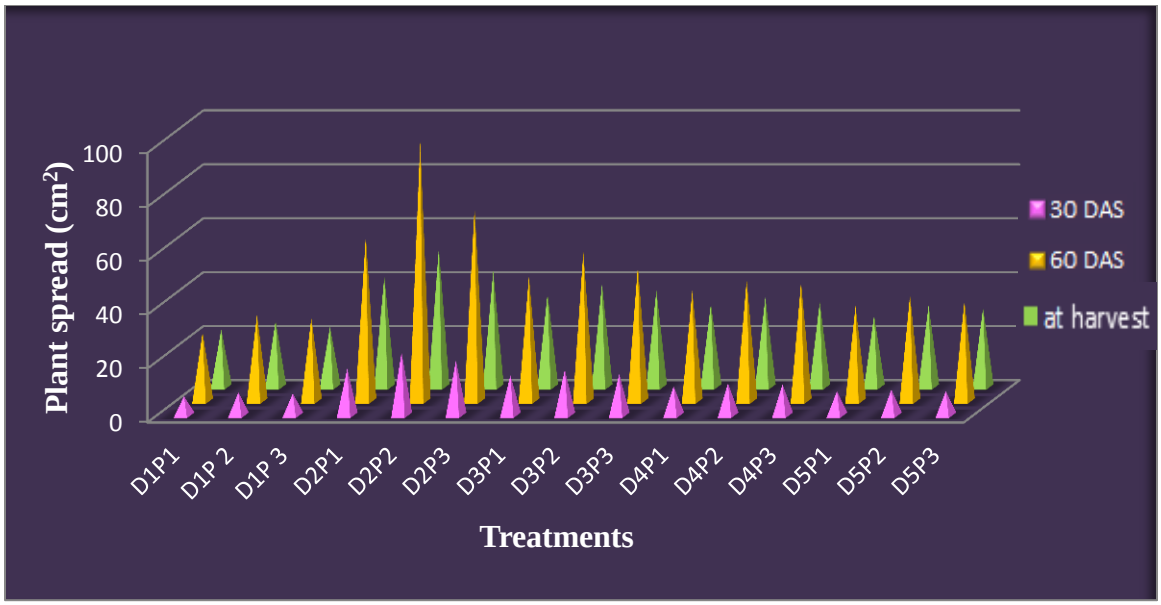


Fig. 4. Effect of different dates of sowing and stage of pinching on plant spread at different stages of crop growth in fenugreek

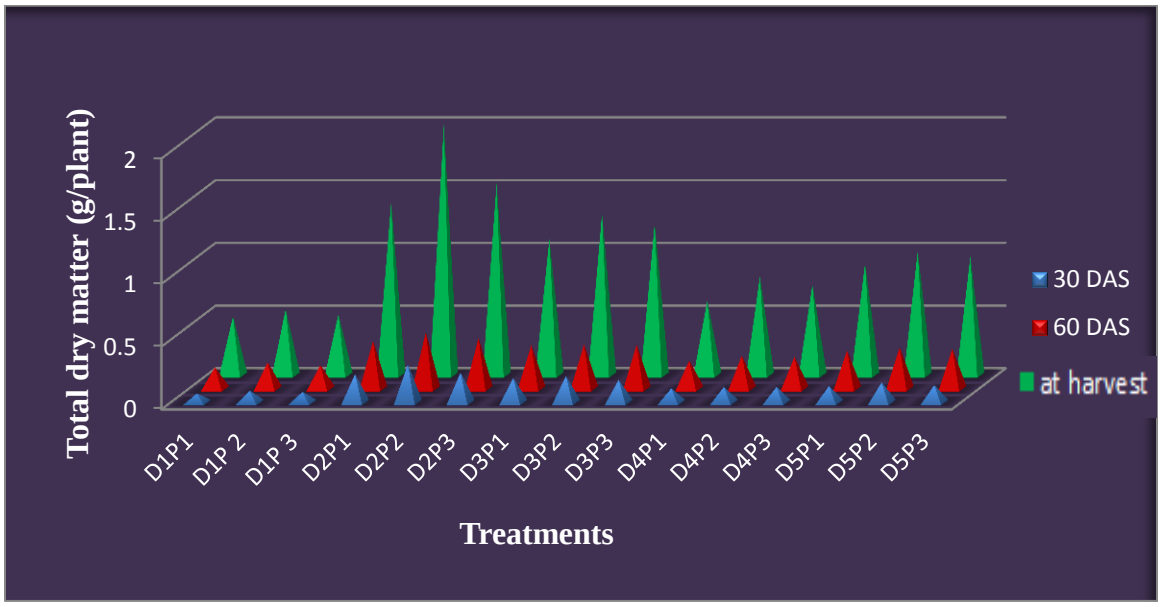


Fig. 5. Effect of different dates of sowing and stage of pinching on total dry matter production at different stages of crop growth in fenugreek

Treatment Details

Dates of sowing:
D_1: Sowing on 1st October
D_2: Sowing on 15th October
D_3: Sowing on 1st November
D_4: Sowing on 15th November
D_5: Sowing on 1st December

Stage of Pinching:
P_1: Pinching at 25 DAS
P_2: Pinching at 35 DAS
P_3: No pinching

photosynthesis, resulting in increasing the number of branches and plant spread due to pinching of apical bud. The results are in agreement with Ayub *et al*. (2008) in fennel, Israel (1988) and Guha *et al.* (2013) in coriander, Vasudevan *et al.* (2008) and Krishnaveni *et al.* (2014) in fenugreek.

The treatment combination D_3P_2 recorded maximum leaf area (5.056 cm^2), leaf area index (0.019) and leaf area duration of the crop (0.446 days) while, D_1P_1 recorded the least leaf area (3.700 cm^2), leaf area index (0.012) and leaf area duration of the crop (0.370 days). Crop sown on 1st November enjoyed a favourable environmental condition at the crop growth stage which is evident from the increased leaf area, leaf area index and leaf area duration of the crop and pinching has resulted in the increase of the leaf parameters because of more photosynthetic activity. The results are in line with Ayub *et al*. (2008) in fennel and Singh *et al*. (2014) in mustard.

The treatment combination D_2P_2 (Sowing on 15th October and pinching at 35 DAS) recorded maximum dry matter of leaves (0.143 g), stem (1.196 g), pods (0.326 g), seeds (0.266 g) and total dry matter production (2.00 g), whereas minimum dry matter of leaves (0.066 g), stem (0.170 g), pods (0.213 g), seeds (0.186 g) and total dry matter production (0.470 g) in D_1P_1 (Sowing on 1st October and pinching at 25 DAS) at the time of harvest (Fig. 5). This might be due to temperature mediated effect which has lead to better utilization of light and moisture in turn resulted in maximum accumulation of dry matter. Further, pinching the plants restrict the vertical growth and results in maximum plant spread and accumulation of photosynthates in the plant parts which has resulted in maximum dry matter production. Similar results were also given by Israel (1988) in coriander, Jabbar *et al*. (2007) in okra and Krishnaveni *et al*. (2014) in fenugreek.

Interaction effects of sowing dates and stage of pinching also registered significant influence on Absolute Growth Rate (AGR), Crop Growth Rate (CGR), Relative Growth Rate (RGR) and Net Assimilation Rate (NAR) (Fig. 6 and 7). The treatment combination D_2P_2 (Sowing on 15th October and pinching at 35 DAS) recorded maximum AGR (0.847 g/plant/day), CGR (0.288 g/m^2/day), RGR (0.026 g/g/day) and NAR 0.028 g/dm^2/day) while, D_1P_1 (Sowing on 1st October and pinching at 25 DAS)

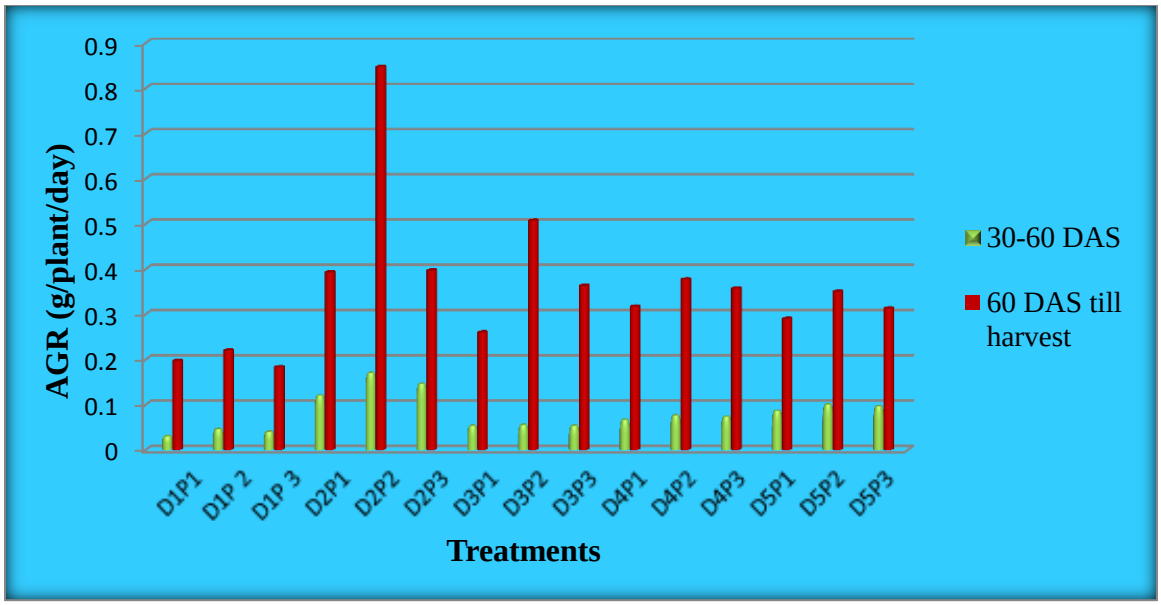


Fig. 6. Effect of different dates of sowing and stage of pinching on Absolute Growth Rate (AGR) of fenugreek

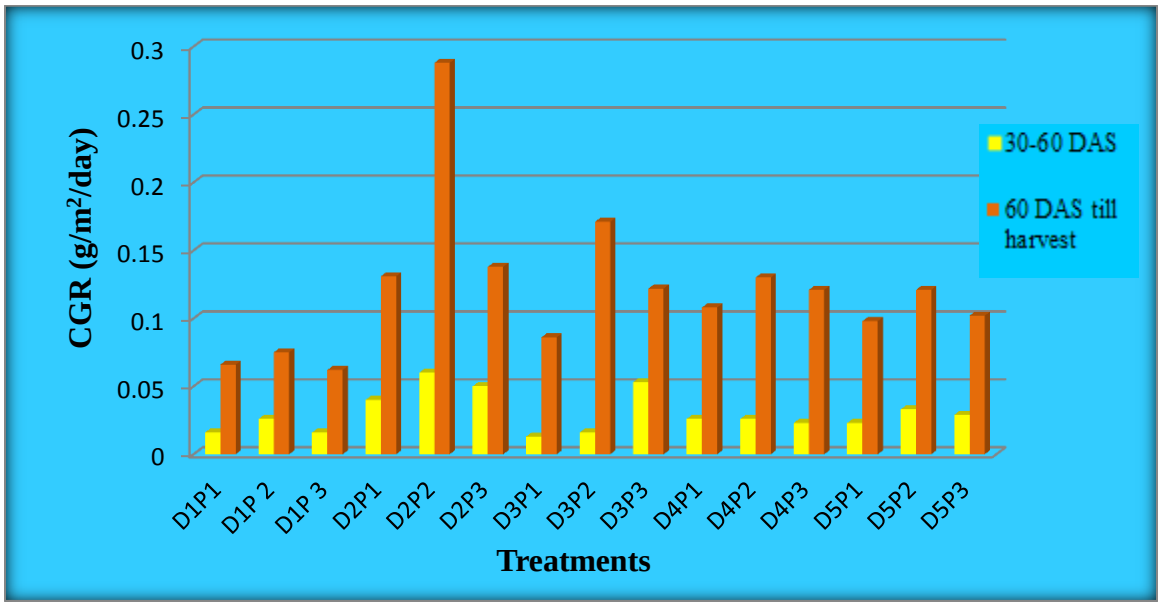


Fig. 7. Effect of different dates of sowing and stage of pinching on Cumulative Growth Rate (CGR) of fenugreek

Treatment Details

Dates of sowing:
D_1: Sowing on 1st October
D_2: Sowing on 15thOctober
D_3: Sowing on 1stNovember
D_4: Sowing on 15th November
D_5: Sowing on 1stDecember

Stage of Pinching:
P_1: Pinching at 25 DAS
P_2: Pinching at 35 DAS
P_3: No pinching

recorded least AGR (0.197 g/plant/day), CGR (0.066 g/m^2/day), RGR (0.013 g/g/day) and NAR (0.010 g/dm^2/day). This might be due to increase in the dry matter production which had the cumulative effect on AGR, CGR, RGR and NAR.

5.3.2 Yield and quality parameters

The interaction effect of sowing on different dates and stage of pinching recorded significant difference for days to first flowering, days for 50 per cent flowering and for harvesting. The treatment combination D_2P_3 (Sowing on 15th October and no pinching) proved to be the best by registering minimum number of days for first flowering (36.00 days), for 50 per cent flowering (43.66 days) and for harvesting (80.66 days) while, D_1P_1(Sowing on 1st October and pinching 25 DAS) took maximum number of days for first flowering (46.40 days), for 50 per cent flowering (58.63 days) and for harvesting (91.00 days). Low temperature during the month of October which has accelerated early flowering parameters and also minimum days for harvesting. Further pinching of plants at 35 DAS resulted in production of more branches which advanced the reproductive phase. The results are in agreement with Guha *et al.* (2013) in coriander, Vasudevan *et al.* (2008) and Krishnaveni *et al.* (2014) in fenugreek.

Various yield parameters were also significantly influenced by different sowing dates and stage of pinching. The treatment combination D_2P_2 (Sowing on 15th October and pinching at 35 DAS) recorded maximum number of pods per plant (13.80), pod length (10.34 cm), fresh weight of pod (0.31 g), number of seeds per pod (13.60), weight of seeds per pod (0.25 g) and 1000 seed weight (21.09 g) (Fig. 8,9 and 10). The results are in agreement with Ayub *et al*. (2008), Azadi (2013) and Selim *et al*. (2013) in fennel. This may be because of maximum number of branches, more number of pods per plant, better vegetative growth and accumulation of more photosynthates which in turn has resulted in better seed and pod parameters.

Interaction between dates of sowing and pinching resulted significant difference for seed yield and harvest index. Among the treatment combinations D_2P_2 (Sowing on 15th October and pinching at 35 DAS) recorded maximum seed yield (3.44 g/plant and 1148.11 kg /ha) and harvest index (29.16 %) while, D_1P_1 (Sowing on 1st October and

pinching at 25 DAS) recorded minimum values for seed yield (0.93 g/plant and 312.21 kg/ha) and harvest index (12.52%) (Fig. 11). The maximum seed yield can be attributed to more number of branches per plant, pods per plant and seeds per pod. The maximum seed weight was because of better reproductive growth and seed filling period which significantly increased the harvest index. Further maximum translocation of assimilates in pinched plants resulted in maximum number of seeds per pod and weight of seeds per pod which in turn increased the seed yield. Similar results were also observed by Sajjan (2002) and Jabbar *et al*. (2007) in okra, Ayub *et al*. (2008) in fennel, Baloch and Zubair (2010) in chick pea, Azadi (2013) in lentil, Guha *et al.* (2013) in coriander and Olfati and Malakouti(2013) in faba bean.

With respect to interaction, a significant difference was recorded for the chlorophyll content in leaves. At 60 DAS, D_2P_2 (Sowing on 15th October and pinching at 35 DAS) recorded maximum Chlorophyll 'a', chlorophyll 'b' and total chlorophyll (2.49, 1.76 and 3.25 mg/g, respectively) while, minimum in D_1P_1 (Sowing on 1st October and pinching at 25 DAS) which recorded minimum Chlorophyll 'a', chlorophyll 'b' and total chlorophyll (1.07, 0.55 and 2.54 mg/g respectively). Favourable environment particularly optimum cardinal temperatures might have helped in better physiological functions of the plant resulted in maximum chlorophyll accumulation in leaf tissues. Similar results were also observed by Mc William and Naylor (1967).

Protein content was also significantly maximum in the treatment combination D_2P_2 (Sowing on 15th October and pinching at 35 DAS) *i.e*.5.08 per cent (Fig. 12). Maximum chlorophyll accumulation in the 15th October sown crop along with the pinching has resulted in increased nitrogen content in seeds inturn, producing protein rich seeds.

5.3.4 Economics

Benefit cost ratio is an important and ultimate factor which decides the optimum levels of input to be used for maximization of production and returns of any crop. In the present study, the benefit cost ratio of fenugreek was worked out for sowing on different dates with stage of pinching.

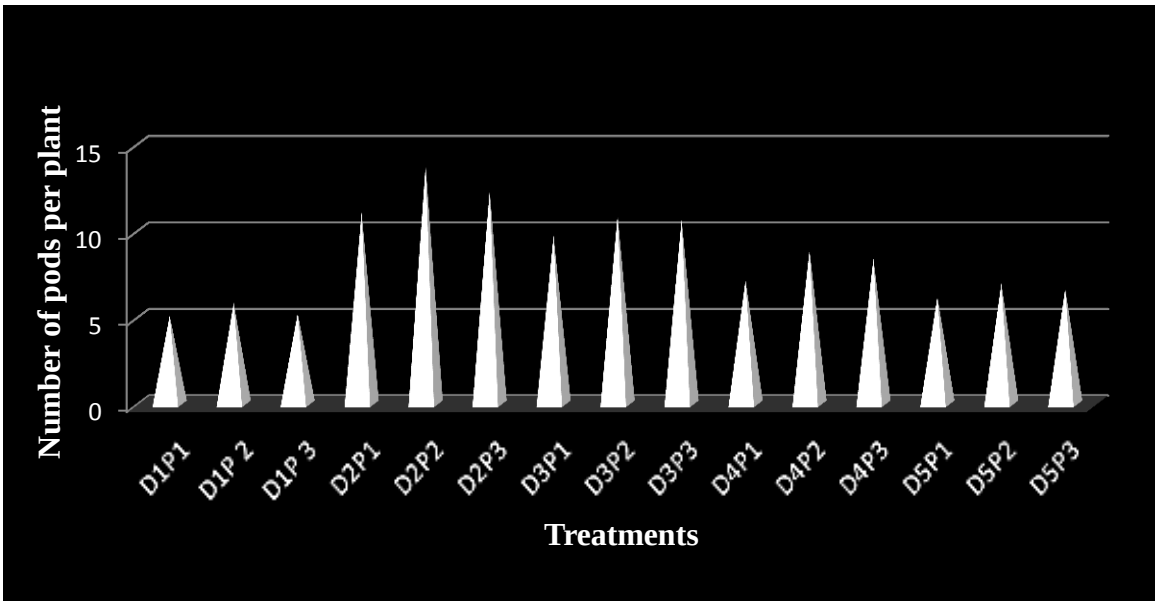


Fig. 8. Effect of dates of sowing and stage of pinching on number of pods per plant of fenugreek

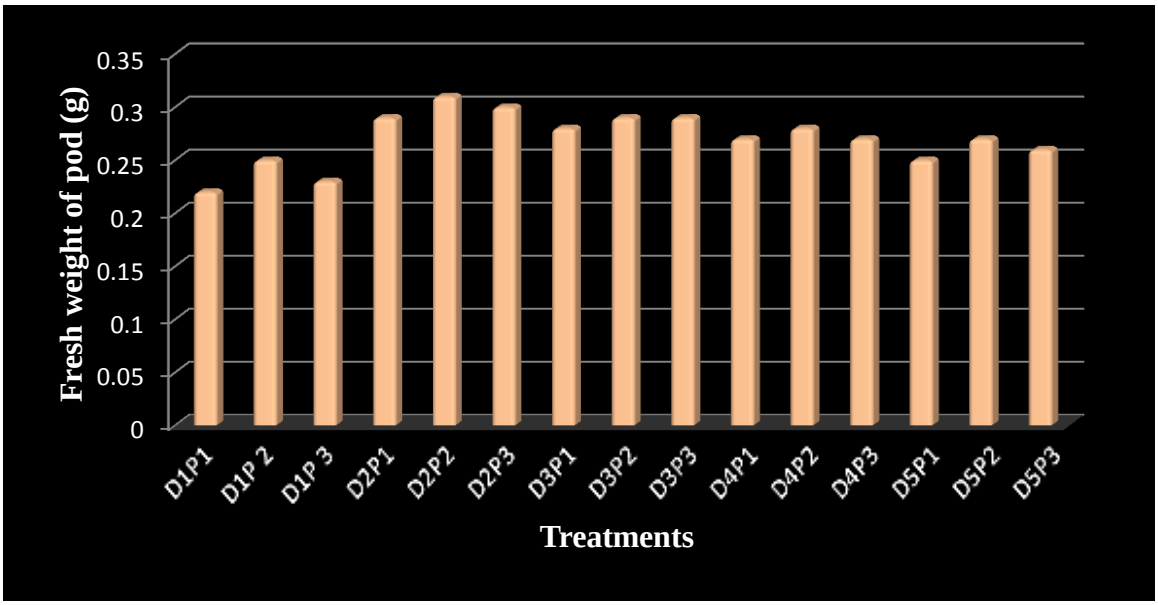


Fig. 9. Effect of dates of sowing and stage of pinching on fresh weight of pod of fenugreek

Treatment Details

Dates of sowing:
D_1: Sowing on 1st October
D_2: Sowing on 15thOctober
D_3: Sowing on 1stNovember
D_4: Sowing on 15th November
D_5: Sowing on 1stDecember

Stage of Pinching:
P_1: Pinching at 25 DAS
P_2: Pinching at 35 DAS
P_3: No pinching

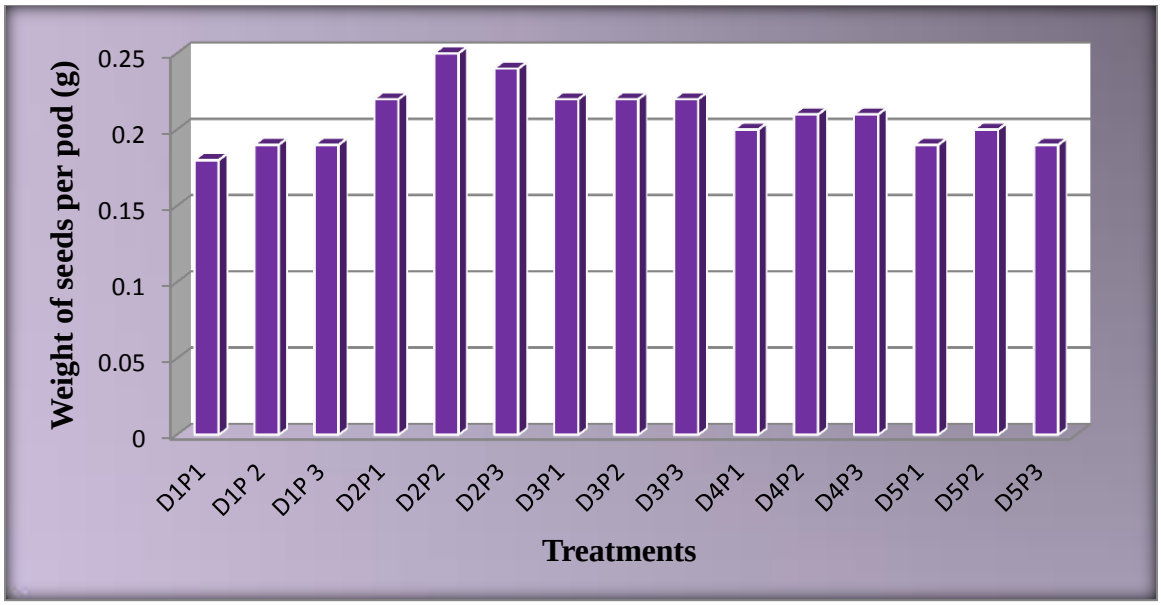


Fig. 10. Effect of dates of sowing and stage of pinching on weight of seeds per pod of fenugreek

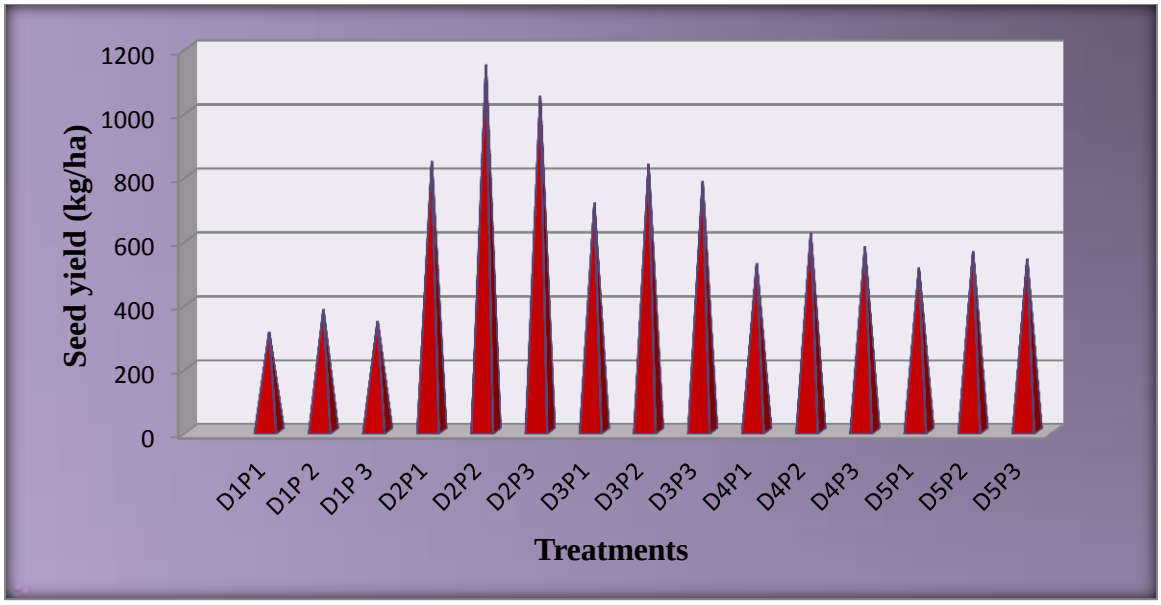


Fig. 11. Effect of dates of sowing and stage of pinching on seed yield of fenugreek

Treatment Details

Dates of sowing:
D_1: Sowing on 1st October
D_2: Sowing on 15thOctober
D_3: Sowing on 1stNovember
D_4: Sowing on 15th November
D_5: Sowing on 1stDecember

Stage of Pinching:
P_1: Pinching at 25 DAS
P_2: Pinching at 35 DAS
P_3: No pinching

Cost economics of fenugreek was also significantly influenced by sowing on different dates and stage of pinching. The maximum gross return (91,848.80 Rupees/ha), net return (66,436.80 Rupees/ha) and cost benefit ratio (2.62) was recorded in treatment combination D_2P_2 (Sowing on 15th October and pinching at 35 DAS) and the minimum gross return (24,976.80 Rupees/ha), net return (-435.2 Rupees/ha) and cost benefit ratio (-0.017) was recorded in the treatment combination D_1P_1 (Sowing on 1st October and Pinching at 25 DAS) (Fig.13). This might be due to better seed yield and least incidence of pest and diseases in the treatment combination which resulted in higher returns.

Salient findings of the study

- ✓ Sowing on 15th October found to be the best compared to other dates of sowing with respect to plant growth, seed yield and quality of fenugreek.
- ✓ Pinching the plants at 35 DAS registered maximum plant growth, seed yield and quality parameters of fenugreek.
- ✓ Interaction effect of different dates of sowing and stage of pinching on growth, seed yield and quality of fenugreek was also studied and the treatment combination D_2P_2*i.e.* sowing on 15th October and pinching at 35 DAS proved to be the best for getting higher yields and better quality in fenugreek.
- ✓ Incidence of insect pests was recorded. Infestation of *Spodoptera sp*. was maximum in the crop sown on 1st November while there was no pest infestation in the other sowings.
- ✓ Incidence of powdery mildew disease was more in 1st December sown crop followed by 15th November sown crop.
- ✓ The economics was worked out and the B:C ratio was found to be maximum (2.62) in the treatment combination D_2P_2 (Sowing on 15th October and pinching at 35 DAS).

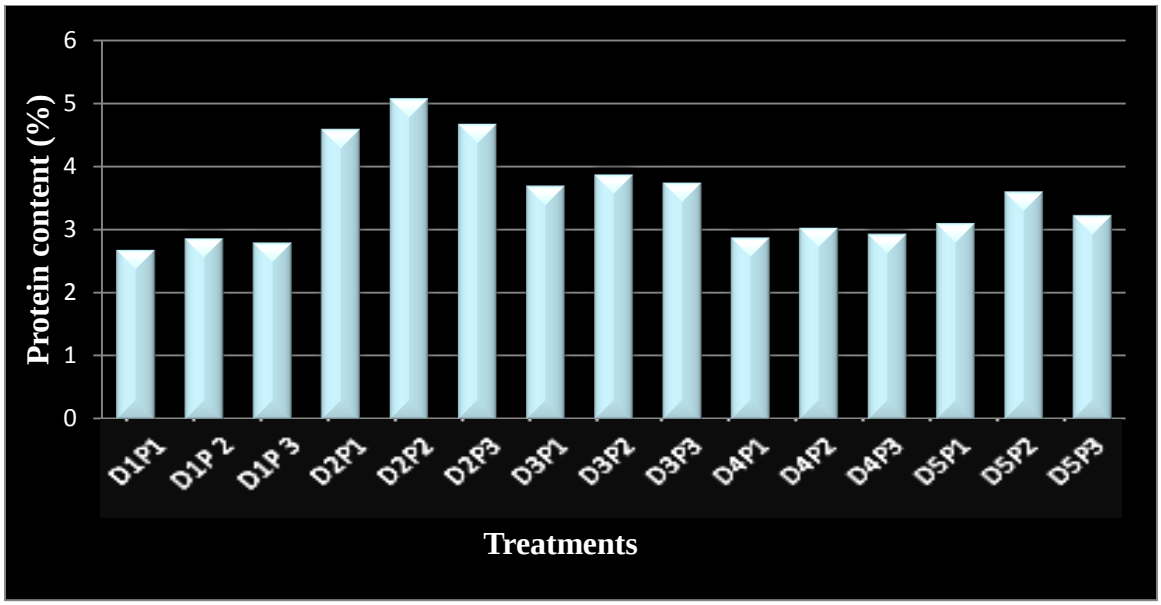


Fig. 12. Effect of dates of sowing and stage of pinching on crude protein content of fenugreek seeds

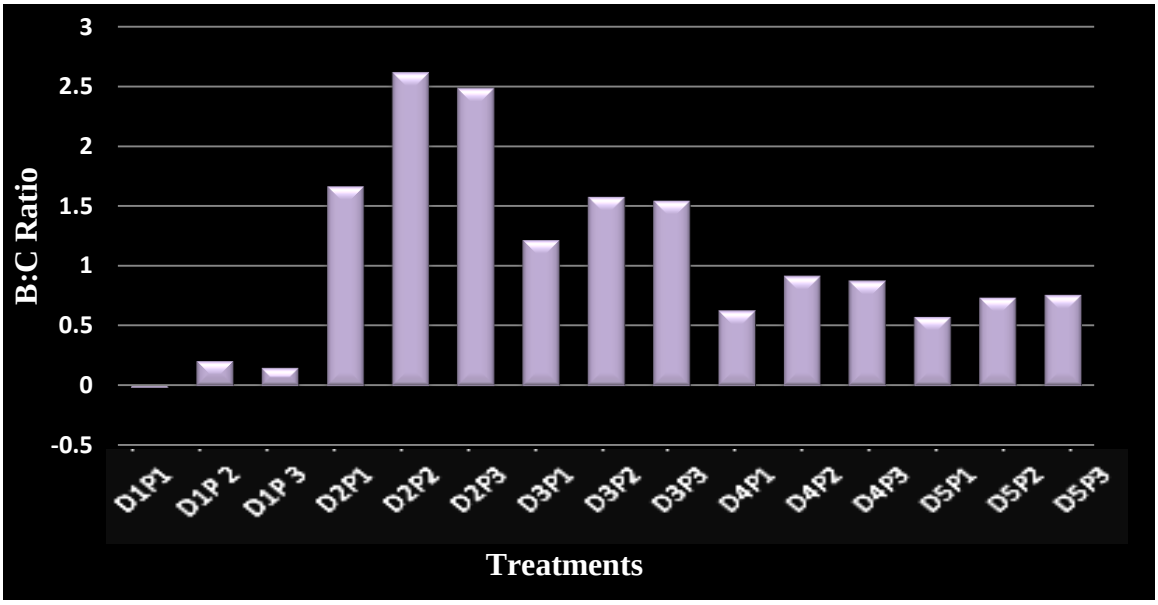


Fig. 13. Effect of dates of sowing and stage of pinching on B:C of fenugreek

Treatment Details

Dates of sowing:
D_1: Sowing on 1st October
D_2: Sowing on 15thOctober
D_3: Sowing on 1stNovember
D_4: Sowing on 15th November
D_5: Sowing on 1stDecember

Stage of Pinching:
P_1: Pinching at 25 DAS
P_2: Pinching at 35 DAS
P_3: No pinching

Future line of work

Based on the current study, the following line of work may be suggested for future investigation

- ✓ Sowing of fenugreek at different dates during late rabi and early summer months under hill zone and their effect on seed yield and quality may be studied.
- ✓ Effect of growth regulator sprays on green leaf yield, seed yield and quality of fenugreek may be studied.
- ✓ Effect of bio fertilizers on phytochemical constituents of seeds may be carried out.

SUMMARY

VI. SUMMARY

The present field experiment on "Standardization of sowing dates and stage of pinching for growth, yield and quality of fenugreek (*Trigonella foenum – graecum* L.) under hill zone of Karnataka" was conducted at farm field of the division of Plantation, Spices, Medicinal and Aromatic Crops, College of Horticulture Mudigere, University of Agricultural and Horticultural Sciences, Shivamogga from October 2014 to March 2015, with the objective to study the effect of sowing dates and stage of pinching on growth, yield and quality of fenugreek and also to work out the benefit cost ratio.

In this experiment five dates of sowing (1st October, 15th October, 1st November, 15th November and 1st December) and three levels of pinching (Pinching at 25 DAS, Pinching at 35 DAS and No pinching) were tried in all possible combinations and assessed for growth, yield and quality characters under field condition. The salient findings of the investigation are summarized below.

Maximum germination percentage was noticed in 1st December (93.37 %) sown crop as compared to the other sowing dates. Increased plant height (42.31 cm), leaf area (4.557 cm^2), leaf area index (0.019) and leaf area duration (0.432 days) were recorded in the 1st November sown crop than the crop sown on other dates. With respect to pinching treatments, the maximum plant height (34.19 cm) was recorded in the non-pinched plants, whereas, the maximum leaf area (4.371 cm^2), leaf area index (0.017) and leaf area duration (0.416 days) was recorded in the plants pinched at 35 DAS.

Significantly maximum number of branches per plant (10.90), plant spread (45.26 cm^2), dry matter production of leaves (0.132 g), stem (0.901 g), pods (0.305 g), seeds (0.247 g) and total dry matter production (1.636 g) were registered in the crop sown on 15th October while minimum were recorded in 1st October sown crop. Pinching also had significant effect on dry matter production of leaves, stem, pods, seeds and total dry matter production. Pinching the plants 35 DAS registered maximum number of branches per plant (8.45), plant spread (35.66 cm^2), dry matter production of leaves (0.110 g), stem

(0.508 g), pods (0.281 g), seeds (0.220 g) and total dry matter production (1.122 g) as compared to control (No pinching).

Various growth parameters *viz.* Absolute Growth Rate (AGR), Crop Growth Rate (CGR), Relative Growth Rate (RGR) and Net Assimilation Rate (NAR) were significantly influenced due to different dates of sowing. Maximum values for AGR (0.546 g/plant/day), CGR (0.186 g/m^2/day), RGR (0.024 g/g/day) and NAR (0.023 g/dm^2/day) were noticed in the crop sown on 15th October whereas, minimum were in 1st October sown crop. These parameters were also varied significantly with respect to pinching. Plants which were pinched at 35 DAS recorded maximum AGR (0.460 g/plant/day), CGR (0.156 g/m^2/day), RGR (0.026 g/g/day) and NAR (0.021 g/dm^2/day) as compared to the plants which were not pinched.

Phonological phases of the plant were also varied due to the effect of sowing dates. The crop sown on 15th October recorded minimum days for first flowering (38.48 days), 50 per cent flowering (46.57 days) and for harvesting (82.44 days). Similarly, these parameters were also influenced by pinching. Non pinched plants took relatively minimum number of days for first flowering (38.72 days), 50 per cent flowering (47.54 days) and for harvesting (86.22 days) while, pinching delayed all these phonological phases which took maximum days for all these parameters.

Various pod characters were also differed significantly due to dates of sowing and pinching. Maximum number of pods per plant (12.40), pod length (10.13 cm) and fresh weight of pod (0.30 g) were noticed under the crop sown on 15th October, whereas 1st October sowing noticed minimum pod values. The plants pinched at 35 DAS registered maximum number of pods per plant (9.29), pod length (9.25 cm) and fresh weight of pod (0.28 g) as compared to no pinching.

Maximum number of seeds per pod (13.04), weight of seeds per pod (0.24 g) and 1000 seed weight (20.58 g)were recorded in the 15th October sown crop while, minimum in 1st October sowing. With respect to pinching treatments, the maximum number of seeds per pod (11.61), weight of seeds per pod (0.22 g) and 1000 seed weight (18.94 g)

were recorded in the plants that were pinched 35 DAS as compared to control (No pinching).

Different dates of sowing had also significant influence on seed yield, harvest index and 1000 seed weight. 15th October sowing registered maximum seed yield (3.04 g/plant and 1015.09 kg /ha) and harvest index (27.43 %) while, crop sown on 1st October recorded minimum values. All these parameters were also varied significantly with respect to pinching. Pinching the plants 35 DAS recorded maximum seed yield (2.07 g/plant and 694.79 kg /ha) and harvest index (23.90 %) while minimum in non-pinched plants.

Maximum chlorophyll content in leaves was noticed in the 15th October sown crop which recorded maximum chlorophyll 'a', 'b' and total chlorophyll (2.49, 1.34 and 3.15 mg/g fresh weight, respectively) while, minimum was registered in 1st October sown crop. The chlorophyll content was also differed significantly with respect to pinching. Maximum Chlorophyll 'a', chlorophyll 'b' and total chlorophyll (2.18, 0.92 and 2.98 mg/g fresh weight respectively) was registered in the plants pinched at 35 DAS as compared to non-pinched plants.The highest protein content in seed (4.79 %) was recorded in the 15th October sown crop and the the plants pinched at 35 DAS recorded maximum protein content (3.71 %).

Dates of sowing had marked influence on the occurance of pest and diseases. Maximum insect pest infestation (*Spodoptera sp*.) was noticed in the crop sown on 1st November (12.05 %) while, there was no pest infestation in the other sowings. Powdery mildew incidence was noticed in the late sown crop*i.e.*in 1st December (11.93 %) wherein, the maximum incidence was in the 1st December sown crop whereas other sowing dates did not reported any symptoms of the disease.

Sowing of the crop on 15th October and pinching the plants at 35 DAS has resulted in maximum net return (66,436.80 Rupees/ha) with a benefit cost ratio of 2.62.

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*originals not seen

APPENDICES

APPENDIX- I

Monthly meteorological data for the experimental period (2014 -15) recorded at the ZAHRS, Mudigere

Month	Rainfall (mm)	Temperature (^{0}C)		Relative humidity (%)
		Maximum	Minimum	
	2014-2015	2014- 2015	2014- 2015	2014- 2015
January 2014	Nil	26.90	14.62	63.25
February 2014	Nil	27.12	15.16	60.53
March 2014	Nil	32.00	18.50	68.00
April 2014	188.7	31.41	18.78	78.90
May 2014	265.6	31.53	18.53	74.54
June 2014	306.4	28.25	17.80	73.60
July 2014	1185.4	26.40	17.19	72.38
August 2014	542.6	26.29	17.35	88.22
September 2014	365.4	27.41	18.75	90.63
October 2014	88	26.46	18.01	81.70
November 2014	12	26.96	15.41	73.46
December 2014	19	26.80	17.41	74.29
January 2015	Nil	27.14	14.91	63.58
February 2015	Nil	28.28	15.20	60.46
March 2015	Nil	32.20	18.37	53.12

APPENDIX-II

Physico-chemical properties and fertility status of soil of the experimental site

Sl. No.	Soil properties	Characterization	Method employed
I Physical properties (oven dry basis)			
1	Coarse Sand (%)	47.50	Hydrometer method (Piper, 1950)
2	Fine sand (%)	15.00	-do-
3	Silt (%)	17.50	-do-
4	Clay (%)	19.50	-do-
4	Texture	Sandy clay loam	-do-
II Chemical properties			
1	Soil pH	5.5	P^H meter (Jackson, 1973)
2	Soil E.C (ds/m at 25^0 C)	0.31	Conductivity bridge (Jackson, 1973)
3	Available nitrogen (kg/ha)	486.0	Modified Kjeldahl' s method (Jackson, 1967)
4	Available phosphorus (kg/ha)	32.0	Olsen' s method (Jackson, 1967)
5	Available potassium (kg/ha)	315.0	Flame photometer method (Jackson, 1967)

APPENDIX-III

List of abbreviations and symbols

%	Per cent
@	At the rate
^{0}C	Degree centigrade
CD	Critical difference
cm	Centimeter
Cm^2	Square centimeter
dm^2	Deci meter square
et. al.	Et allii (and other)
ha	Hectare
i.e.,	That is
S. Em.	Standard Error of Mean
viz.,	Videlicet
DAS	Days After Sowing

APPENDIX-IV

Per hectare input utilization pattern in fenugreek seed production

Sl. No.	Items	Unit	Total quantity
1	Seeds	Kg	12
2	Fertilizers		
3	FYM	Tonnes	8
4	N	Kg	25
5	P	Kg	25
6	K	Kg	50
7	Labour	Man days	130
8	Bullock pair	Pair days	10

APPENDIX-V

Economics of fenugreek cultivation

	D_1P_1	D_1P_2	D_1P_3	D_2P_1	D_2P_2	D_2P_3	D_3P_1	D_3P_2	D_3P_3	D_4P_1	D_4P_2	D_4P_3	D_5P_1	D_5P_2	D_5P_3
Seeds	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
FYM	8000	8000	8000	8000	8000	8000	8000	8000	8000	8000	8000	8000	8000	8000	8000
Chemical fertilizers	3240	3240	3240	3240	3240	3240	3240	3240	3240	3240	3240	3240	3240	3240	3240
Labour and material cost for cultural operations	10660	10660	10660	10660	10660	10660	10660	10660	10660	10660	10660	10660	10660	10660	10660
Labour cost for pinching	1300	1300	----	1300	1300	----	1300	1300	----	1300	1300	----	1300	1300	----
Plant protection	----	----	----	----	----	----	500	500	500	500	500	500	500	500	500
Interest on working capital @ 10%	1212	1212	1212	1212	1212	1212	1212	1212	1212	1212	1212	1212	1212	1212	1212
Total cost of cultivation	25412	25412	24112	25412	25412	24112	25912	25912	24612	25912	25912	24612	25912	25912	24612