NUTRITIONAL MANAGEMENT OF BITTER GOURD (*Momordica charantia* L) IN RELATION TO PEST AND DISEASE INCIDENCE

By

C. R. REKHA

THESIS

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DECLARATION

I hereby declare that the thesis entitled **'Nutritional management of bitter gourd (*Momordica charantia* L.) in relation to pest and disease incidence'** is a bonafide record of research work done by me during the course of research and that the thesis has not previously formed the basis for the award to me of any degree, diploma, fellowship or other similar title of any other University or Society.

Vellanikkara
10-05-1999

C.R.REKHA

Dr. T.R. Gopalakrishnan
Associate Professor and Head,
K.H.D.P. (R & D)
Vellanikkara, Thrissur

CERTIFICATE.

Certified that the thesis entitled **'Nutritional management of bitter gourd (*Momordica charantia* L.) in relation to pest and disease incidence'** is a record of research work done independently by **Ms. C.R.REKHA** under my guidance and supervision and that it has not previously formed the basis for the award of any degree, diploma, fellowship or associateship to her.

(Dr. T.R.Gopalakrishnan)
Chairman, Advisory Committee

CERTIFICATE

We, the undersigned members of the Advisory Committee of **Ms. C.R.REKHA,** a candidate for the degree of **Master of Science in Horticulture,** agree that the thesis entitled **'Nutritional management of bitter gourd (*Momordica charantia* L.) in relation to pest and disease incidence'** may be submitted by Ms. C.R. Rekha, in partial fulfilment of the requirement for the degree.

Dr. T.R. Gopalakrishnan
Chairman
Associate Professor and Head
K.H.D.P. (R & D)
Vellanikkara

Dr. S. Rajan
Professor and Head (i/c)
Department of Olericulture
College of Horticulture
Vellanikkara
(Member)

Dr. A. Sukumara Varma
Associate Professor and Head(i/c)
Department of Plant Pathology
College of Horticulture
Vellanikkara
(Member)

Dr. Maicykutty P. Mathew
Associate Professor (Ent.)
K.H.D.P. (R & D)
Vellanikkara
(Member)

EXTERNAL EXAMINER

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LOVINGLY DEDICATED TO

MY PAPPA AND AMMA

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Introduction

1. INTRODUCTION

Bitter gourd (*Momordica charantia* L.), a unique vegetable having high nutritive and medicinal values is being widely cultivated in the tropical as well as subtropical regions of the world. Compared to other cucurbitaceous vegetables, it is rich in vitamin C (88 mg), carbohydrate (4.2 g), protein (1.6 g) and carotene (120 μg) per 100g (Chauhan, 1980). The fruit is also a rich source of Iron (1.8 mg per 100 g) with low sugar content and is considered to have a prominent role in the diet of diabetic patients. It also possess cooling, stomachic, carminative, antipyretic, aphrodisiac and vermifuge properties (Nadkarni, 1954). The immature fruit after attaining maximum size is harvested and consumed in many ways. It is relished as cooked vegetable, and also sliced and dehydrated.

Bitter gourd is the leading vegetable crop of Kerala. High yield and maximum net returns make it the most preferred vegetable crop of farmers. Being an indeterminate and fast growing crop with succulent plant parts and high productivity, bitter gourd is severely affected by a number of pests and diseases particularly mosaic, downy mildew, jassids, fruit fly etc. (KAU, 1996). This has resulted in considerable reduction in the area and production of bitter gourd during the last few years in the state. The incidence and intensity of different pests and diseases vary from season to season. The nutritional imbalance especially by the increased use of nitrogenous fertilizers and the indiscriminate use of synthetic plant protection chemicals play major role in the pest and disease out break in the traditional bitter gourd growing tracts of the state.

A detailed study on the biotic stresses in bitter gourd will throw light on the strategy for raising a pest or disease free crop or to reduce the pest or disease incidence during cropping periods. This will in turn increase the production and decrease our dependence on external sources for our vegetable requirement. Hence there is ample scope for scientific research for increasing productivity of bitter gourd and it will be the basic step for solving the burning problems of small and marginal vegetable farmers and landless agricultural workers who are looking for bitter gourd production for their livelihood.

Keeping in view of the above facts, the present investigation was undertaken with the following objectives:

1. To study the major biotic stresses affecting the productivity of bitter gourd
2. To study the seasonal influence on major biotic stresses in bitter gourd
3. To study the effect of crop growth and nutrition on biotic stresses in bitter gourd
4. To study the crop growth and nutrition on productivity of bitter gourd

Review of literature

2. REVIEW OF LITERATURE

Cucurbits are widely grown throughout the year in the tropical and subtropical regions of the world. As majority of cucurbits are vigorously growing and succulent in nature, they are affected by a number of pests and diseases. Earlier studies indicate that cucurbits respond well to manures and fertilizers and it plays a significant role in the growth, development, productivity and pest or disease resistance of plants. According to Panda (1998) nutrient imbalance is one of the main reasons of low productivity in acid soils. The productivity and incidence of pests and diseases are also influenced by seasons. The important works related to the study are reviewed under the following heads:

2.1 Nutrition and growth on productivity of cucurbits with special reference to bitter gourd

Nath *et al.* (1994) observed that all gourds, cucumber and pumpkin respond well to manuring and fertilizer application and the dose of manures and fertilizers depend on the type of soil, climate and variety.

Srivastava and Srivastava (1976) reported a positive correlation for yield with number of female flowers, fruits and lateral branches in bitter gourd. Ramachandran (1978) also found high correlation for yield with length of main vine, fruit weight, fruit length, number of fruits, number of female flowers and number of primary branches per plant in bitter gourd.

Dhesi *et al.* (1966) conducted nutritional studies in bitter gourd for two years using 0, 56 and 112 kg ha^{-1} of N, 0 and 56 kg ha^{-1} of P_2O_5 and 0 and 56 kg ha^{-1} of K_2O. They found that yield increased with nitrogen and was maximum at 56 kg ha^{-1}.

Phosphorus also increased the yield while there was a slight reduction in yield by addition of potash. Katyal (1977) observed that application of FYM 50 t ha^{-1} as basal dose and a top dressing of ammonium sulphate at the rate of 100 kg ha^{-1} soon after flowering was sufficient for a successful crop of bitter gourd. In Karnataka, the recommended dose for bitter gourd is 18 t ha^{-1} FYM, 62.5 kg ha^{-1} of N and 50 kg ha^{-1} of P_2O_5 (KAU., 1978). In an experiment at KAU, highest fruit yield in bitter gourd was recorded with a fertilizer combination of 50:50:50 kg ha^{-1} NPK (KAU., 1980). Another study based on the effect of graded doses of N, P and K on growth and yield of bitter gourd has resulted in maximum yield when nutrients were given at the rate 50:25:50 kg ha^{-1} (KAU, 1981). An experiment conducted at the College of Horticulture, Vellanikkara revealed the effect of nitrogen and potash on the yield of bitter gourd. The plants grown under low dose of N and P failed to set fruits and all the female flowers dropped off within 3-7 days after their appearance (KAU, 1983). Thomas (1984) studied the response of bitter gourd to different fertility levels in summer rice fallows and found that higher levels of fertilizers increased the leaf area index, dry matter production, number of fruits and yield. The maximum yield was obtained from plants receiving 18 t ha^{-1} of FYM and 60: 30: 60 kg ha^{-1} of NPK in bitter gourd (KAU, 1984). Lingaiah *et al.* (1988) conducted an experiment to study the influence of nitrogen and phosphorus on yield of bitter gourd in the coastal regions of Karnataka and it revealed that treatment which received 80: 30: 0 kg ha^{-1} NPK gave maximum yield. Ravikrishnan (1989) studied the influence of different levels of NPK on growth and yield of bitter gourd under partially shaded conditions of coconut garden and the maximum yield was obtained from 90: 25: 50 kg ha^{-1} NPK. Rajput and Gautam (1995) studied the effect of N and P at Faizabad and the seed yield were highest with 60 kg ha^{-1} of N and 80 kg ha^{-1} of P_2O_5. Ali *et al.* (1995) found that the highest yield in bitter gourd was obtained at 80 kg ha^{-1} of N. Application of FYM @ 20 to 25 t ha^{-1} as basal dose along with half dose of N (35 kg) and full doses of P (25 kg) and K (25 kg), the remaining dose of N (35 kg) in two equal split doses at vining and at the time of full blooming is recommended for getting higher yield in bitter gourd in Kerala (KAU, 1996). Jansirani *et al.* (1999) conducted a fertilizer trial with four graded levels of N (0, 30, 60, 90 kg ha^{-1}), three levels of P (0, 30, 60 kg ha^{-1}) and two levels of K (0, 30 kg ha^{-1}) and recorded the highest fruit yield of 20.48 t ha^{-1} with 60:60:30 kg ha^{-1} of NPK.

Nutritional studies were conducted by many scientists in other cucurbits also. Pandey and Singh (1973) found that nitrogen at 50 or 100 kg ha^{-1} increased pistillate and staminate flowers, fruits and yield in bottle gourd. Das *et al.*, (1987) reported that higher rates of nitrogen application always showed a pronounced effect in increasing vine length, number of vines per plant, number of nodes per vine and number of fruits per plant in pointed gourd and the results indicated the positive effect of nitrogen on growth and development.

In cucumber, Bishop *et al.* (1969) realized the importance of phosphorus in yield response than nitrogen or potash and found that nitrogen and phosphorus at 50 and 100 kg ha^{-1} respectively were adequate. According to Pettiet (1971) lack of potassium did not inhibit early growth, but potassium additions were found to be beneficial to growth of cucumbers. Penny *et al.* (1976) observed poor growth of cucumber in potassium deficient soil than in full nutrient soil. Sharma and Shukla (1972) observed a significant increase in yield of pumpkin with increase in levels of nitrogen in both rainy and summer seasons. Dheshi *et al.* (1964) obtained higher yields in squash melon with a combination of 56:28:28 kg ha^{-1} of NPK.

In a field experiment to find out the influence of fertilizer placement and micronutrient rate on composition and yield of watermelon, Locascio *et al.* (1972) found that the mean length of vine and fresh weight of plants were significantly improved under higher doses of nitrogen. Mahakal *et al.* (1977) reported an optimum dose of nitrogen, phosphorus and potassium at 75:50:100 kg ha^{-1} for water melon from trials conducted on medium heavy soil. Highest fertilizer dose (75:100:150 kg ha^{-1} of NPK) gave only a slight increase in yield. Deshwal and Patil (1984) observed that among the major inputs, nitrogen is having a controlling effect on growth and development in watermelon. The maximum weight of fruits were recorded from the vines treated with 70 kg ha^{-1} of nitrogen. Singh *et al.* (1983) reported that out of the four levels of nitrogen and phosphorus; the maximum number of fruits, maximum weight of fruits, seed yield and 1000 seed weight in round melon were at 75 kg ha^{-1} of nitrogen and 30 kg ha^{-1} of P_2O_5.

Randawa *et al.* (1981) reported that the best results with regard to plant growth, number of fruits per vine, fruit weight per vine and fruit quality were from plots receiving NPK level at 50:37.5:37.5 kg ha^{-1} in musk melon. According to Srinivas and Doijode (1984) application of potassium fertilizers increased the percentage of perfect flowers in musk melon. Prabhaker (1985) observed a significant increase in yield due to nitrogen up to 50 kg ha^{-1} in musk melon and increasing levels of nitrogen significantly increased dry matter production. He also found application of potassium @ 60 kg ha^{-1} increased fruit yield by 75 per cent. Snake gourd exhibited remarkable fruit yield response to nitrogen and maximum fruit yield was obtained with 105 kg ha^{-1} of nitrogen (Syriac *et al.*, 1999)

2.2 Major biotic stresses affecting productivity in bitter gourd

Nath and Agnihotri (1984) reported that the major pests limiting the profitable cultivation of bitter gourd in India are fruit fly (*Bactrocera cucurbitae*), aphids (*Aphys gossypii*), red pumpkin beetle (*Aulacophora foveicolis*) and epilachna beetle (*Henosepilachna septima*). Severe incidence of Jassids (*Empoasca motti*) also has been reported from Kerala.

2.2.1 Fruit fly

A number of species of *Bactrocera* have been reported damaging the cucurbit fruits and *B. cucurbitae* is comparatively more common and destructive.

Doharey (1983) reported the preference of bitter gourd by *B. cucurbitae*. The duration of larval development and life cycle was shorter on bitter gourd than pumpkin. However, the pre oviposition period and life span of females were largest on bitter gourd. The female flies puncture the soft and tender fruits with stout and hard ovipositor and lay eggs below the epidermis, four to ten eggs per fruit each time. Infested fruits can be identified by the presence of brown resinous juice which oozes out of the puncture made by the flies for oviposition. These punctures also serve as an entry for various bacteria and fungi and fruits start rotting, get distorted and malformed in shape and fall off from the plants prematurely (Butani and Jotwani, 1984).

Though the exact loss caused by the fruit flies has not been systematically worked out it is reported that more than 50 per cent of fruits are either partially or fully damaged (Singh, 1966). Patel (1976) recorded three to 100 per cent infestation of *Bactrocera ciliatus* on *Cucurbita indica* fruits. Ranganath *et al.* (1997) revealed that melon flies are the major problem in the cultivation of cucurbits in South Andaman and the damage to the crop often goes as high as 85 per cent.

Fang (1989) reported that bagging the fruits of bitter gourd in Taiwan at the stage of three to four cm fruit length with two layers of paper bags every two to three days, against *B. cucurbitae,* greatly promoted quality and yield and net income was increased by 45 per cent. Ranganath *et al.* (1997) reported that application of insecticide is ineffective and environmentally hazardous. Keeping this in view, use of safer insecticides and botanicals were found the best in lowering damage in cucumber and neem cake extract at the rate of 4.0 per cent or DDVP at the rate of 0.2 per cent was effective in bringing down the damage to 9.1 per cent in ridge gourd. Patel and Patel (1998) observed that the emerging time of most of the adult fruit flies, that is between eight to ten in the morning, is ideal for the management of pests.

2.2.2 Jassids

Mathew (1996b) reported severe incidence of leaf hopper in bitter gourd at Vellanikkara during January to March, 1995. The species was identified as *Empoasca motti.* This is the first report of *E. motti* on bitter gourd from India. Severe hopper burn symptoms appeared on bitter gourd leaves due to the feeding of leaf hoppers. Initially white spots were appeared on leaves at feeding sites. This was followed by gradual yellowing of leaf margins, drying of leaf tips and later complete yellowing and drying of the affected leaves resulted in crop failure.

In India potato plants have been severely attacked by *Empoasca* Kerri. var. *motti* and according to Pruthi (1940) it is also common in North India in linseed, cowpea, mung, .castor and cotton. Saxena and Rizvi (1993) have reported several species of leaf hoppers on potato crop from different regions of the country.

Rawat and Sahu (1973) reported that Okra suffers seriously during rainy and summer seasons in Madhya Pradesh due to jassids (*E. devastans*) every year. According to Nagaich *et al.* (1974) both nymphs and adults suck sap from mesophyll and cause direct damage to the potato foliage. Some of the leaf hoppers are vectors of mycoplasmal diseases viz. witches broom, purple top roll and marginal flavescence in the hills and plateau regions.

2.2.3 Epilachna beetle

According to Butani and Jotwani (1984) epilachna beetles are the major pests of various vegetable crops including brinjal, cucurbits, potato, tomato and peas. Among cucurbits bitter gourd is their preferred host. Both grubs and adults feed voraciously by scrapping the chlorophyll of leaves, causing characteristic skeletonization of leaf lamina. Affected leaves gradually dry and droop down. A severe infestation kills the young plants outright, while the older vines shows stunted growth and poor yield.

In India, the first report of an epilachna beetle attacking crops was by cotes (1891). Subramaniam (1923) recorded the host plants of epilachna as *Solanum melongena, Momordica charantia* and *Cucurbita moschata.* Kapur (1966) indicated that *E. septima* was the species feeding commonly on bitter gourd.

Greber (1969) proved that water melon mosaic virus can be transmitted to pumpkins and squashes by epilachna beetle in a persistent manner. Mohanasundaram and Uthamasamy (1973) studied the host range of epilachna beetles and reported that grubs and adults collected from brinjal did not feed on leaves of bitter gourd and vice versa.

The biology of *E. ocellata* Redt. on bitter gourd was studied by Dhingra *et al.* (1983) and reported that the incubation, larval and pupal periods lasted for 3.6 to 5.6, 12.5 to 15.4 and 5.14 to 7.32 days respectively. The total life cycle from egg to adult took 21.3 to 28.3 days. Longevity of male and female beetles varied from 20 to 28.6 and 27.3 to 35.0 days respectively. The pest completed four generations during July to November and it under went hibernation in adult stage.

2.2.4 Mosaic

In bitter gourd mosaic like symptom has been observed since 1933 in India and it was first reported by Uppal (1933). Long narrow projection of leaf apices called 'shoe strings' was found to be caused by a virus (Hariharasubramanian and Badami, 1964). Nagarajan and Ramakrishnan (1971 a) reported a mosaic disease in bitter gourd which was characterised by a mosaic pattern of irregular dark green and light green patches of leaf lamina. This was caused by bitter gourd mosaic virus which had a narrow host range confining to the family cucurbitaceae. Symptoms of bitter gourd mosaic was mostly limited to the leaves and the leaves at the apical end of secondary branches produced symptoms of the disease. Some leaves had vein clearing in one or two lobes and severely infected plant showed reduction in their size. Some leaves showed marked reduction in the development of lamina resulting in 'shoe string' effect. Pandey and Joshi (1989) observed a reduction in chlorophyll content due to induced chlorophyllase activity in bitter gourd leaves infected by *Cucumis* virus. Estimation of loss due to mosaic in bitter gourd revealed that early infection by the virus significantly reduced the number of leaves, leaf area, internodal length, thickness of vines, length of vines, number of branches, number of flowers, number of fruits, fruit size and weight and total yield.

Mathew (1996a) conducted a survey in nine districts of Kerala during 1995 to study the incidence of virus and its vector and found that the mosaic disease was prevalent in all the districts. All the cultivated varieties of bitter gourd were found to be affected by the virus. The virus also infects cucumber and little gourd. The symptoms first appear as pale chlorotic patches in the young leaves. This is followed by typical mosaic symptom, up ward leaf curling, crinkling, mottling and severe stunting. The internodal length of the vine is very much reduced and early infected seedlings will not trail on pandal. They will be absolutely stunted. The fruits of diseased plants are small in size and number. A large number of flowers get dried up and fall off. In cucumber and coccinea also the symptoms are almost similar to that on bitter gourd.

Pillai (1971) reported stunted growth, sparse flowering and low fruit set in snake gourd due to mosaic incidence. Joseph and Menon (1981) reported that cucumber mosaic virus infection on snake gourd in the early stage resulted complete failure of fruit set, whereas the late infected plants yielded fewer fruits. Raghunadhan (1989) found that snake gourd plants infected with virus at the early stage significantly reduced the number of leaves, leaf area, length of vine and yield.

Vasudeva and Lal (1943) observed that when bottle gourd is affected by mosaic in the early stages remained stunted, sparsely flowered and set only few fruits. Singh and Dey (1976) assessed the loss due to mosaic virus infection in the yield of bottle gourd and found 64 per cent reduction. Singh (1989) studied the loss due to WMV in yield of bottle gourd and observed 100 per cent yield reduction during early stage of infection.

Doolittle (1924) studied the loss due to cucumber mosaic virus in USA and estimated a loss of $ 75,000 in a single locality. The infection of melon plants at the sixth leaf stage caused 40 per cent reduction in yield (Hills *et al.*, 1961). Martyn (1968) reported occurrence of seventeen viruses in cucurbits. According to Fletcher *et al.* (1969) cucumber plants affected by cucumber green mottle mosaic virus caused fifteen per cent loss in yield in early infection while late infection had little effect on yield. Blua and Perring (1989) recorded 76 – 94 per cent reduction in yield of marketable fruits of *Cucumis melo* infected by mosaic.

Demski and Chalkley (1974) observed that the mosaic affected water melon varieties produced shorter runners and smaller leaves which reduced the fresh weight by 55 per cent. The number and size were also reduced.

Schmelzer (1967) observed that cucumber mosaic virus could cause wilt and dying off in pumpkin and vegetable marrow. The plants infected early may develop mosaic and stunting. Shankar *et al.* (1972) observed that the symptoms of pumpkin mosaic virus disease first appeared as mosaic mottling of the leaves. Sometime the leaves showed chlorosis of veins and veinlets leaving interveinal areas green. The leaf lamina was very often distorted and reduced. The severely affected vines were extremely dwarf and sometime did not bear leaves or flowers, as the whole vine was turned into thread like structures. Bhargava (1977) found that different strains of WMV varied in extent of yield reduction caused by them. Jayasree (1984) while studying yellow vein mosaic disease of pumpkin in Kerala reported that the symptoms of disease appeared as faint yellowing of finer veins which later developed into characteristic vein yellowing. In advanced stages of infection chlorotic area were seen on the leaf lamina along with vein yellowing symptoms. The size of leaves was decreased markedly and the overall growth of infected plant was severely retarted. The infected plants produced less number of flowers and when infected at a later stage produced under sized fruits. The host range included *Cucurbita pepo, Luffa acutangula, Trichosanthes anguina* and *Momordica charantia.* Infection of plants at an early stage of growth caused reduction in number of leaves, leaf size, internodal length, number of branches, total vine length and number of flowers and also resulted in complete loss of yield. Umamaheswaran (1985) observed severe mottling and disfiguration in the leaves of *Cucurbita moschata* which were naturally infected with virus. The infected seedlings remained stunted and they flowered very sparingly with less number of female flowers and fruit setting. Singh (1986) assessed the loss due to water melon mosaic virus in pumpkin and found that plants inoculated at early stages of growth produced shorter runners and internodes. Balakrishnan (1988) recorded the yield loss of pumpkin due to yellow vein mosaic virus infection as 100 per cent when plants were inoculated at seedling stage. Latha (1992) reported that fruit yield and contributing characters were significantly influenced by dates of sowing and the sowing in October was found to yield maximum because of delayed incidence of mosaic in pumpkin.

Nagarajan and Ramakrishnan (1971a) reported that bitter gourd mosaic virus in bitter gourd was neither seed transmissible nor sap transmissible but transmitted by *Aphys gossypii, A. malvae, A. nerri* and *Myzus persicae.* Purushothaman (1994) also revealed that *A. gossypii* and *A malvae* were the most efficient vectors. However Mathew (1996a) conducted a survey to assess the incidence of the mosaic disease of bitter gourd in major vegetable growing areas of Kerala and to identify the vector of the virus and he revealed that the vector of virus as white fly (*Bemisia tabaci*).

Greber (1969) proved that WMV 2 can be transmitted to pumpkin and squashes by a lady bird beetle *(Henosepilachna vigintioctopunctata)* in a persistent manner while Tripathi and Joshi (1985) reported the mechanical transmission of water melon mosaic virus in pumpkin. Nagarajan and Ramakrishnan (1971 b) reported that transmission of WMV in snake gourd is through seeds while Thomas (1980) reported the transmission of WMV by *Myzus persicae*.

Pillai (1971) and Pejcinovski (1978) reported the mechanical transmission of cucumber mosaic virus in snake gourd and cucumber respectively. According to Sharma and Chohan (1973)*Cucumis* mosaic virus I in vegetable marrow and cucumis mosaic virus 3 in bottle gourd are seed transmissible.

Dubey (1974) reported sap transmission of cucumber mosaic virus in snake gourd. Similarly Raychaudhari and Varma (1978) in musk melon and Pejcinovski (1978) in snake gourd also reported sap transmission of cucumber green mottle mosaic virus. Roy and Mukhopadhyay (1980) reported mechanical transmission of pumpkin mosaic virus in pumpkin.

2.2.5 Downy mildew

Downy mildew of cucurbits is wide spread in tropical regions, in some semi arid regions such as southern USA in the middle east and in temperate regions of America, Europe, Japan, Australia and South Africa (Palti, 1974). In India, downy mildew was first observed in 1910 in *Luffa* sp. and *Trichosanthes* sp., at Pusa and on melon in Punjab (Butler, 1918).

Bains and Jhooty (1978) reported that symptoms of downy mildew appear on upper surface of the leaves as angular yellow spots. During favourable condition the under sides of these spots are covered with a greyish mouldy growth. As the spots enlarge a general yellowing of the leaf occurs followed by death of tissue. The leaves subsequently wither and die. Temperature between 20^0 and 22^0 C along with extended rainy periods are ideal for infection and spread.

Simon (1996) recorded lowest disease intensity in bitter gourd variety, Preethi at 45 DAS and 70 DAS; and the crop yield was double in the sprayed plots (chlorothalonil 0.25 %) than in the unsprayed plots.

2.3 Effect of growth and nutrition on biotic stresses

Reddy and Rao (1982) reported that the use of fertilizers greatly influence the white fly population and the plants which receive more nitrogenous fertilizers became more vulnerable to white fly attack. According to Peter and Gopalakrishnan (1989) about 63 per cent of the observation on various diseases in vegetables revealed the positive effect of K in resistance. Potassium was effective against Fusarium yellows, white rot and basal rot of cucurbits and Fusarium wilt of muskmelon. Balaji and Veeravel (1995) studied the influence of different levels of nitrogen with constant levels of P and K on the incidence of white fly in brinjal and the result revealed that the lowest incidence at 0:60:60 kg ha^{-1} and highest at 200:60:60 kg ha^{-1} NPK. Singh *et al.* (1995) found that aphid infestation increased with increase in level of nitrogen and he concluded that the nitrogen rich medium might have led to increased protein content and succulence of plant rendering it more susceptible to aphid attack. At zero level of N even though the aphid population was low, the yield was very low. However, an optimum level of nitrogenous manuring is needed for the normal health of plant. He also found that fertilization with K had pronounced effect and the population of aphids decreased with increased level of potassium. Lack of available P induced susceptibility and the population of aphid was maximum at zero level of phosphorus.

2.4 Seasonal influence of major biotic stresses and productivity in cucurbits

2.4.1. Seasonal influence on pest infestation

Fang and Chang (1984) conducted a field study at various sites in central Taiwan on the seasonal occurrence of *Dacus cucurbitae* on different fruits and vegetable crops. The population density of the fly was highest on bitter gourd. Peak numbers were generally reached in November. Temperature and rainfall were thought to be important factors involved in population regulation. Davis (1996) reported that the bitter gourd sown in April met with the severe incidence of *Bactrocera cucurbitae* while in case of September , October-November sown crops; there was no incidence at all. Patel and Patel (1996) studied the influence of weather parameters on incidence of fruit fly (*Dacus ciliatus*) on little gourd and found that the fruit infestation was present throughout the year during 1991-'92. The fruit fly incidence was practically negligible during the month of December – January. Infestation started from the month of February and reached its peak in third week of March (46.9%) and in second week of April (47.7%). There after the infestation slightly declined in the months of May – June and again reached the peak in the second week of July (42 %). However, the incidence gradually declined from the month of August. According to them, variation in seasonal incidence of fruit fly might be due to different cropping patterns and ecological conditions at different localities.

Borah (1996) studied the influence of sowing season and varieties on the infestation of fruit fly in cucumber in the hill zone of Assam, during 1993, 1994 and 1995 with three sowing seasons (summer, kharif and rabi). The results from three years of pooled data revealed that the response of different sowing seasons on the fruit fly infestation as well as yield were found to be significant. The highest yield was recorded in summer crop with 27.6 per cent fruit fly infestation followed by kharif crop while rabi crop recorded minimum fruit fly infestation (20.3 %). Butani and Jotwani (1984) reported that the population is generally low during dry months and increases rapidly with adequate rainfall. Pre oviposition, egg, maggot and pupal periods last for 9-21, 1-1½, 3-9 and 6-8 days respectively. During winter the larval and pupal stages are extended upto three and four weeks respectively. Single life cycle is completed in 10 to 18 days in rainy season but it takes 12 to13 weeks in winter.

Tripathi and Misra (1991) studied the effect of temperature on development of *Epilachna dodecastigma* on leaves of ghiatorai and the duration of development was found to be longest at 20^0C and shortest at 40^0C. Davis (1996) observed that bitter gourd crops sown in December, January and February were severely affected by Jassids and bitter gourd crops sown during April and September were affected by epilachna beetle. Lal (1997) observed that during March and April the temperature had a rise and the longevity of males and females proportionately decreased. It was also observed that some females lived even upto 100 days during winter seasons. During January and the first week of February, eggs were not laid due to low atmospheric temperature. In March and April when the temperature increased, the pre oviposition period was on an average 8.5 days.

2.4.2 Seasonal influence on disease incidence

Kassanis (1957) reported that most of the plant viruses multiplied less rapidly as the temperature rose from 30^0 C and some ceased to multiply at temperature around 36^0 C. He also reported complete masking of symptoms of watermelon mosaic virus, cucumber mosaic virus and squash mosaic virus in muskmelon at 18.3^0 C.

Latha (1992) observed maximum incidence of yellow vein mosaic during January, pumpkin mosaic during March, cucumber mosaic during May and watermelon mosaic during rainy season in pumpkin. She also found that incidence of yellow vein mosaic and population of white flies (*Bemisia tabaci*), the vector of yellow vein mosaic, were positively correlated with temperature and negatively correlated with rainfall and relative humidity. Population of white fly was maximum during summer and minimum during rainy season. Mathew (1996a) also found that during summer, the average incidence of virus was greater than 80 per cent and in rainy season the incidence was about 20 per cent. The population of white flies (*B. tabaci*), vector of the virus was very high during summer and low during rainy season. Davis (1996) reported that bitter gourd crops sown during January – February were severely infected with mosaic.

Palti (1974) reported that rainfall can be considered as the limiting factor for most downy mildew epidemics. Royle (1976) also revealed that *Pseudoperenospora* requires wet plant surface for conidial infection.

Bains and Jhooty (1978) reported that temperature between 20^0C and 22^0C along with extended rains provides ideal condition for the infection and spread of downy mildew. Kuznetson (1980) found that the optimum temperature for sporangial germination of *Pseudoperenospora cubensis* was 15 to 18^{0}C. Ullasa and Amin (1988) showed that the day temperature of 15 to 21^{0}C and relative humidity 75 per cent favoured the infection in *Luffa acutangula* by *P. cubensis* and the infection caused a decrease in yield by 61 per cent. Singh and Singh (1992) stated that hot, dry weather had a significant influence on the spread of *P. cubensis* in muskmelon. Davis (1996) observed that the downy mildew was more in the crops sown during May, June, July and August.

2.4.3 Seasonal influence on productivity

According to Matsuo (1968), seasonal influence on yield may be through different ways such as the influence on sex differentiation, pollination, germination, fruit set etc. and he also found that temperature and photoperiod had great influence on sex differentiation and thereby yield of cucurbits.

Surlekov and Ivanov (1969) reported that cucumber sown in April produced plants with the largest number of fruits, the highest fruit weight, the greatest seed number and weight. Mohammed *et al.* (1989) found that delaying the planting of *Cucumis melo* var. *flexuosus* decreased the plant dry weight, average fruit weight, total fruit weight and yield significantly. Lyutova and Kamontseva (1992) were worked with cucumber sown in December and January and found that early and total yields in terms of number and weight of fruits per plant were highest in December sowing.

Bose and Ghosh (1970) reported that the bitter gourd seeds did not germinate at low temperature (18^{0}C) and short days help in increasing female flower production.

Jacob (1986) studied the effect of date of sowing on growth and yield of bitter gourd variety Priya and found that the crop can be raised successfully in summer season by sowing in December first. Nath *et al.* (1987) found that bitter gourd can be grown under both tropical and sub tropical climate but warm climate is considered the best. Optimum temperature requirement is 24 – 27^{0}C. Huyskens *et al.* (1992) observed that germination of *Momordica charantia* was optimum at temperature between 25^{0}C and 35^{0}C and inhibited at 8^{0}C, 12^{0}C, 40^{0}C and 45^{0}C. They also reported more flowers in spring to summer under long days and high temperature than in autumn to winter under short days and low temperature.

Davis (1996) observed highest yield in October sown crop followed by January and November sown crop in bitter gourd. Lowest yield was in May sown crop. Maximum length, weight and number of fruits and number of female flowers were also obtained in October sown crop. He also found that the lowest node at which the female flower produced was in February sown crop.

Materials and methods

3. MATERIALS AND METHODS

The present investigation was undertaken in the Department of Olericulture, College of Horticulture, Vellanikkara, Thrissur during 1997 - 1998.

3.1 MATERIALS

The field experiments were laid out in the research fields of the Kerala Horticulture Development Programme (R & D unit) (Site I) and in the research field of Department of Olericulture, College of Horticulture, Vellanikkara (Site II). The experimental sites were located 500 m apart and at an altitude of 22.25 m above M.S.L., $10^{0}32^{''}$ latitude and $76^{0}16$"E longitude. The region enjoys a warm humid tropical climate. Data on maximum temperature, minimum temperature, rainfall and relative humidity during the entire cropping period were collected from the Meteorological Observatory of the College of Horticulture and are presented in weekly averages (Appendix I).

Both the experimental sites have sandy loam soils and the chemical composition of the soil is given in Table 1.

Table 1. Chemical composition of soils of experimental sites for estimation

Sl. No.	Constituents ($kg\ ha^{-1}$)	Site I	Site II	Methods used
1	Available N	198	220	Alkaline permanganate method
2	Available P_2O_5	37	40	Chlorostannous reduced molybdophosphoric blue colour method
3	Available K_2O	12	14	Neutral ammonium acetate extract, flame photometric method

3.1.1 Seasons of experimentation

To depict the real growing condition in the farmers fields, the crops were raised during three cropping seasons viz., kharif, rabi and summer seasons (Table 2).

Table 2. Periods of cropping during the experimentation

Sl. No.	Cropping season	Cropping period	Location	Site Number
1	Kharif season crop	May to October, 1997	Research fields of K.H.D.P. (R&D)	Site I
2	Rabi season crop	September, 1997 to January, 1998	Research fields of K.H.D.P. (R&D)	Site I
3	Summer season crop	January to May, 1998	Dept. Of Olericulture, College of Horticulture.	Site II

3.1.2 Variety

The high yielding and widely grown variety, Preethi developed by the Department of Olericulture, College of Horticulture, Kerala Agricultural University was selected for the study. Due to the white, spiny and medium long fruits with tuberculate shape, Preethi is fairly accepted by the growers as well as consumers in the state.

3.1.3 Manures and fertilizers

Dried farm yard manure (FYM), fresh farm yard manure and poultry manure as the organic sources and urea as the inorganic source were used as the source of nitrogen. Rajphos and Muriate of Potash were used as the sources of phosphorus and potassium

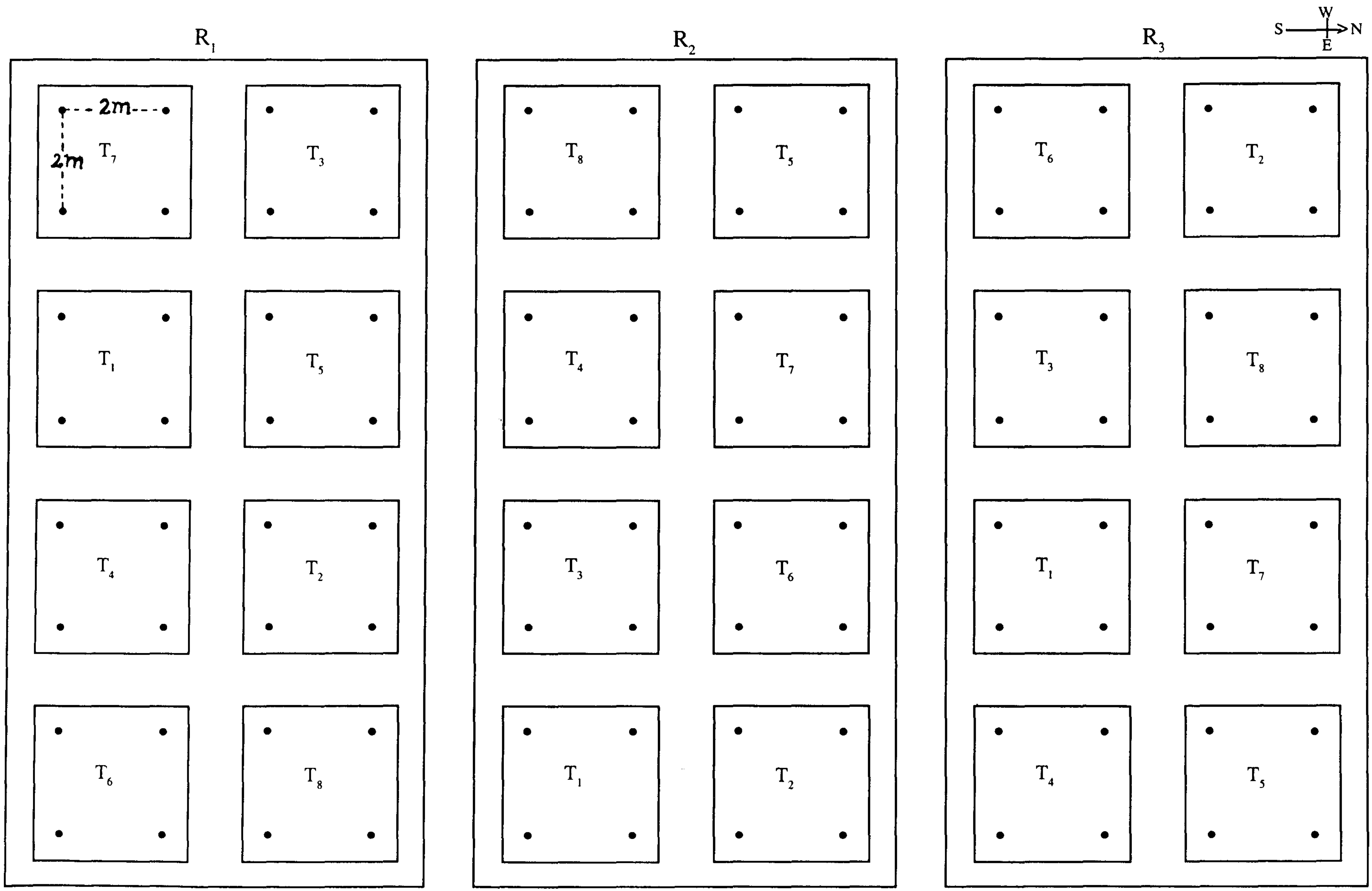

Fig. 1. Layout of the experimental field

respectively. The nutrient contents of the various organic manures and inorganic fertilizers used for the study are furnished in Table 3.

Tablel 3. NPK status of manures and fertilizers (%) used for experimentation

Sl. No.	Manures and Fertilizers	N	P_2O_5	K_2O
1	Dried FYM	0.40	0.30	0.20
2	Fresh FYM	1.57	0.25	0.18
3	Poultry manure	1.20 - 1.50	Nil	Nil
4	Urea	46	Nil	Nil
5	Rajphos	Nil	18	Nil
6	Muriate of potash	Nil	Nil	60

3.2 METHODS

3.2.1. Design and Layout

The experiment was laid out in completely randomised block design with eight treatments replicated thrice (Fig. 1). Four pits at a spacing of 2 m x 2 m constituted one treatment and the gross plot size was 16 m^2 per treatment per replication.

3.2.2 Treatments

Different management practices by changing the N and K ratio, sources, form and time of application of organic manures constituted the following eight treatments.

T_1 FYM @ 25 t ha^{-1} alone

T_2 FYM @ 25t ha^{-1} + NPK @ 70:25:25 kg ha^{-1}

T_3 FYM @ 25t ha^{-1} + NPK @ 70:25:50 kg ha^{-1}

T_4 FYM @ 25t ha^{-1} + NPK @ 70:25:75 kg ha^{-1}

T_5 FYM @ 20 t ha^{-1} +poultry manure @ 2.5 t ha^{-1}+fresh cowdung (equivalent to 2.5 t ha^{-1} of dry cowdung) slurry (2 %) drenching at fortnightly interval.

T_6 T_5 + NPK @ 70:25:25 kg ha^{-1}

T_7 T_5+ NPK @ 70:25:50 kg ha^{-1}

T_8 T_5+ NPK @ 70:25:75 kg ha^{-1}

3.2.3 Application of manures and Fertilizers

Manures and Fertilizers were applied as per the treatment in the following schedule:

3.2.3.1 Farm yard manure

Entire quantity of dried farm yard manure was applied as basal dose at the time of preparation of pits, except in T_1 where half was applied as basal and remaining half in two equal splits at 30 and 60 days after sowing.

3.2.3.2 Fresh cowdung

Fresh cowdung equivalent to 2.5 t ha^{-1} of dry cowdung was applied as slurry (2 %) by drenching at fortnightly interval from 45 days after sowing in T_5, T_6, T_7 and T_8

3.2.3.3 Poultry manure

Dried poultry manure @ 2.5 t ha^{-1} was applied as top dressing 30 days after sowing in the treatments T_5, T_6, T_7 and T_8

3.2.3.4 Inorganic fertilizers

Nitrogen was applied as urea; 50 per cent as basal and remaining 50 per cent at five equal split doses at fortnightly interval. Phosphorus was applied as Rajphos as basal dose before sowing. Half the dose of potassium was applied as basal dose before sowing and remaining half in two equal splits in the form of muriate of potash at 30 and 45 days after sowing.

3.2.4 Sowing and after cultivation

Sowing was done on 30 May, 22 September and 15 January for kharif, rabi and summer seasons respectively. Overnight water soaked seeds were sown in the prepared pits of 45 cm^3 @ 4 or 5 seeds per pit. Fifteen days after sowing, the plants were thinned to three seedlings per pit. Regular weeding operations were carried out to keep the plots weed free during the entire cropping period. Before vining of the plants, pandals of six feet height were made with coir and bamboo poles or GI pipes and plants were trained to the pandals by fixing thin twigs in the pit. Separate pandals were provided for each treatment to prevent the intermingling of vines with the vines of adjacent plots.

During summer season, irrigation was given once in three days for the entire cropping period. During rabi season, need based irrigation was given as there was intermittent rainfall. No irrigation was done for the kharif season crop. Fruits were picked at harvestable maturity for vegetable purpose.

3.2.5 Plant protection

During the entire cropping period, a schedule of sprays with organic pesticides and need based plant protection chemicals were followed. In the vegetative and reproductive phase the plants were sprayed with neem oil soap emulsion (neem oil 2 % and soap 6 g per 100 ml neem oil) and neem oil with garlic extract (neem oil 2.5 % and garlic 2%) alternately at biweekly interval. Tobacco decoction was also sprayed whenever the aphid infestation was noticed. Bait traps (Mysore Poovan with Furadan granules) were used to trap the fruit fly adults. Apart from this, the diseased and pest affected plant parts were removed and destroyed as and when noticed. In severe cases of disease or pest outbreak the following need based safer insecticides or fungicides were applied (Table 4).

Table 4. Insecticides or fungicides used for the control in severe pest or disease incidence

Pest or disease	Trade name	Chemical name
Epilachna beetle	Sevin 50 WP	Carbaryl (0.2%)
Jassids	Rogor	Dimethoate (0.3%)
Downy mildew	Kavach	Chlorothalonil (0.2%)

3.2.6. Biometrical observations

3.2.6.1 Vegetative characters

1. Length of vine (m)

Total length of the main vine was measured after the final harvest of the crop.

2. Number of branches

Number of primary branches were counted after final harvest of the crop.

3.2.6.2 Earliness

1. Days to first male flower anthesis
2. Node at which the first male flower is formed
3. Days to first female flower anthesis
4. Node at which the first female flower is formed
5. Days to first harvest
6. Fruiting period

Four plants from each treatment were considered for taking observation of the above characters.

3.2.6.3 Yield and quality attributes.

1. Marketable yield per plot (kg per 16 m^2)
2. Unmarketable yield per plot (kg per 16 m^2)
3. Total yield per plot (kg per 16 m^2)
4. Number of marketable fruits per plot
5. Number of unmarketable fruits per plot
6. Total number of fruits per plot
7. Number of harvests
8. Length of fruit (cm)
9. Girth of fruit (cm)
10. Average fruit weight (g)

For recording the fruit characters five fruits were taken from each of the fifth, sixth and seventh harvests and the mean values were computed to obtain the length, girth and average weight of the fruit.

3.2.7 Pests and diseases

Observations on the incidence of major pests or diseases viz. fruit fly, jassids epilachna beetle, mosaic and downy mildew were recorded. The following observations were recorded for each pest and disease.

1. Days for the first occurrence of each pest or disease
2. Days for the severe incidence of each pest or disease
3. Population of pests

Pest population was assessed either by counting the number of pest per leaf or by assessing pest incidence index suggested by Wheeler (1969).

$$\text{Pest incidence index} = \frac{\text{Sum of all numerical ratings x 100}}{\text{Total number of plants observed x Maximum rating}}$$

For calculating the pest incidence, plants were rated into the following six groups based on the percentage of damage of total foliage (Table 5).

Table 5. Rating of pest infestations

Sl. No.	Percentage of damage	Rating
1.	No damage	1
2.	Below 10	3
3.	11-25	5
4.	26-50	7
5.	51-75	9
6.	> 75	11

Based on this rating, the pest incidence index ranged from 9.09 per cent indicating the absence of pest to 100 per cent indicating maximum infestation.

4. Intensity of diseases

For finding out the intensity of diseases the leaves were rated into the six groups based on the percentage of leaf area infected (Table 6).

Table 6. Rating of disease intensity

Sl. No.	Percentage of leaf area infected	Disease rating
1.	No infection	1
2.	Below 10	3
3.	11-25	5
4.	26-50	7
5.	51-75	9
6.	>75	11

Based on the rating percentage of disease intensity was calculated using the following formula (Wheeler 1969)

$$\text{Percentage of disease intensity} = \frac{\text{Sum of all numerical ratings x 100}}{\text{Total number of leaves assessed x maximum disease rating}}$$

It ranged from 9.09 per cent indicating the absence of disease to 100 per cent indicating maximum disease intensity.

Percentage of disease incidence ranging fron zero to 100 per cent was also calculated by using the formula

$$\text{Percentage of disease incidence} = \frac{\text{Number of plants affected by disease x 100}}{\text{Total number of plants}}$$

3.2.7.1 Pests

1. Fruit fly

During each harvest the number of fruits damaged by fruit fly was noted and the percentage of loss was calculated with the total number of fruits harvested.

2. Jassids

To assess the population of jassids fifteen leaves were selected from one pit of each plot. The number of nymphs resting on the lower surface of the leaves were counted and the population was expressed as number of pest per leaf.

The plants were also rated into the six groups as mentioned in Table 5 based on the typical hopper burn symptom of the leaves and the pest incidence index was calculated.

3. Epilachna beetle.

For assessing pest incidence index rating was done based on the damage of total foliage as given in Table 5.

3.2.7.2 Diseases

1. Downy mildew

The lower most five leaves from each plant were selected for recording the percentage of disease intensity (Wheeler, 1969).

2. Mosaic

For finding out the percentage of disease intensity, ten leaves were collected starting from the vine tip. Other than yellowing, severely mosaic affected leaves were also included in the maximum disease category (Wheeler, 1969).

3.2.8 Statistical analysis

Data related to each character were analysed for RBD as suggested by Panse and Sukhatme (1967). Duncan's Multiple Range Test was used for comparing the treatments. To determine the seasonal influence on each character, pooled analysis over seasons were also carried out.

Results

4. RESULTS

The general analysis of variance indicated significant variation for majority of the economic characters during kharif season (season 1, S_1). Variation due to treatments were significant for ten out of the eighteen characters during this season. During rabi (season 2,S_2) and summer (season 3, S_3) seasons seven and six characters respectively exhibited significant variation (Table 7). Total yield per plot exhibited significant variation in all the three seasons.

4.1 Vegetative characters

4.1.1 Length of vine (m)

Variation in vine length due to the different treatments was significant during kharif season only. During this season vine length was maximum in T_7 (7.10 m) which was on par with T_3 (6.90 m), T_6 (6.90 m), T_2 (6.80 m), T_4 (6.80 m) and T_1 (6.70 m) (Table 8). Treatments T_5 and T_8 varied significantly from all other treatments and recorded minimum value (5.80 m).

During rabi season the different treatments did not make any effect on the vine length, while variation due to replication was significant. Vine length was maximum in T_6 (6.69 m) and minimum in T_7 (4.36 m). During the summer season the vine length was maximum in T_4 (6.78 m) and minimum in T_5 (5.04 m).

Seasonal influence was manifested in the length of vine and maximum length was during kharif season (6.60 m) while during summer and rabi seasons vine length was more or less same (5.80 m and 5.90 m respectively).

Table 7. Analysis of variance for various quantitative characters

Source of variation	Season	Degrees of freedom	Mean squares: Length of vine (m)	Number of Branches	Days to first male flower anthesis	Node at which first male flower is formed	Days to first female flower anthesis	Node at which first female flower is formed	Days to first harvest	Fruiting period	Marketable yield per plant (kg per plot)	Unmarketable yield (kg per plot)	Total yield (kg per plot)	Number of marketable fruits per plot	Number of unmarketable fruits per plot	Total number of fruits per plot	Number of harvests	Length of fruit (cm)	Girth of fruit (cm)	Average fruit weight (g)
Replication (block)	S1	2	0.17	0.88	0.67	9.13	13.17	6.13	41.54	60.54*	17.17*	7.16	38.35*	878.00*	2211.13	3953.63	0.54	0.049	0.03	31.98
	S2	2	5.19**	8.00	3.38	8.67	15.17*	15.29	281.79**	105.88*	24.42	0.285	34.44	4682.17*	1352.79**	11014.63**	0.88*	5.08	0.14	59.96
	S3	2	1.25	11.54	12.79*	4.88	52.04*	6.79	37.04*	37.04*	16.78	0.79	23.79	5328.38	330.04	7755.17	1.2*	1.3	5.72*	2136.02
	Pooled	2	1.32	#	1149.60**	1.39	2255.68**	#	2405.43**	527.05**	184.18**	#	211.48**	#	#	14337.13**	36.29**	127.01*	15.71**	6152.44
Treatment	S1	7	0.77**	14.57**	21.91	11.79	25.12*	24.45	33.8	24.76	10.98*	8.01*	29.79**	565.98	2403.14	5033.28*	0.52	6.47**	2.07**	5318.08**
	S2	7	1.55	11.09	11.09*	13.02*	11.95*	25.31**	22.36	34.57	24	1.47	43.97*	1077.91	297.71	1908.76	0.286	7.24**	2.03	570.49**
	S3	7	1.23	25.47	5.79	6.47	8.33	9.41*	12.47	12.47	34.56*	1.23	45.2*	5809.5*	303.38	8243.23*	1.14	1.81	4.64**	1002.38
	Pooled	7	0.57	#	15.71	2.9	20.75*	#	28.44	28.83	54.48**	#	93.06**	#	#	13929.04**	0.73	8.28*	6.10**	882.02**
Error	S1	14	0.07	2.59	11.76	14.7	6.83	15.36	19.16	13.4	3.73	2.34	6.7	220.91	926.6	1196.82	0.3	1.16	0.43	40.89
	S2	14	0.71	12.00	2.66	3.1	3.36	4.15	17.84	19.45	9.36	0.84	10.6	1030.55	157.7	1327.53	0.16	1.5	1.51	50.27
	S3	14	1.16	28.07	2.84	4.83	9.47	3.32	6.76	6.76	9.62	0.56	12.6	1521.66	187.52	2295.21	0.48	1.7	0.91	2597.4
	Pooled	42	1.61	#	5.75	7.54	6.82	#	14.59	13.2	7.57	#	10.22	#	#	1820.12	0.32	1.45	0.95	896.19

*P = 0.05, **P = 0.01

- Error mean squares are heterogenous. Interaction between treatments and seasons is absent. There fore no pooled analysis is carried out

Table 8. Length of vine in different seasons (m)

Treatments	Seasons			Mean
	Kharif (S_1)	Rabi (S_2)	Summer (S_3)	
T_1	6.70 ^{A}	5.32	5.22	5.63
T_2	6.80 ^{A}	6.37	6.51	6.45
T_3	6.90 ^{A}	5.80	5.53	6.04
T_4	6.80 ^{A}	6.08	6.78	6.50
T_5	5.80 ^{B}	6.07	5.04	5.70
T_6	6.90 ^{A}	6.69	6.36	6.64
T_7	7.10 ^{A}	4.36	5.96	5.81
T_8	5.80 ^{B}	5.63	5.45	5.63
Mean	6.60	5.80	5.90	6.10

Table 9. Number of branches in different seasons

Treatments	Seasons			Mean
	Kharif (S_1)	Rabi (S_2)	Summer (S_3)	
T_1	13.00 ^{C}	19.33	14.00	15.44
T_2	14.00 ^{BC}	20.67	17.33	17.33
T_3	16.00 ^{AB}	22.67	15.67	18.11
T_4	17.00 ^{A}	16.33	20.33	17.89
T_5	18.00 ^{A}	19.00	12.33	16.44
T_6	13.00 ^{BC}	20.67	11.67	15.11
T_7	12.00 ^{C}	18.00	15.67	15.22
T_8	13.00 ^{BC}	20.33	12.67	15.33
Mean	14.50	19.63	14.96	16.36

Pooled analysis showed maximum vine length due to the treatment T_6 (6.50 m) which received 20 t ha^{-1} of FYM, 2.5 t ha^{-1} of poultry manure and 2.5 t ha^{-1} of fresh cowdung slurry at fortnightly interval with 70:25:25 kg ha^{-1} of NPK.

4.1.2 Number of branches

Treatment variation on the number of branches per plot was significant only during kharif season. Number of branches were maximum in T_5 (18) which was on par with T_4 (17) and T_3 (16) (Table 9) and it was less in T_2 (14), T_1(13), T_6 (13), T_7 (12) while T_7 which recorded minimum value (12) varied significantly from T_5, T_4 and T_3.

During rabi and summer seasons there was no significant variation between treatments. However branching was more during rabi season as indicated by a mean value of 19.63 compared to 14.5 during kharif season. There was no seasonal influence on the number of branches due to various treatments.

Pooled analysis showed maximum number of branches in T_3 (18.11) and minimum in T_6 (15.11).

4.2 Earliness

4.2.1 Days to first male flower anthesis

During kharif season days taken for the first male flower opening was minimum in T_7 (43.67) and maximum in T_5 (52.33)(Table 10). During rabi season days for first male flower anthesis exhibited significant variation due to treatments. T_1 took minimum number of days (33.33) for opening of first male flower and T_5 took maximum number (39.67) which on par with T_2 (37.00). The treatment T_5 showed significant variation from all other treatments in the opening of male flower. During summer season days for the

Table 10. Days to first male flower anthesis in different seasons

Treatments	Seasons			Mean
	Kharif (S_1)	Rabi (S_2)	Summer (S_3)	
T_1	48.33	33.33 C	35.33	39.00
T_2	45.33	37.00 AB	34.67	39.00
T_3	46.00	34.67 BC	35.00	38.56
T_4	45.00	35.33 BC	33.33	37.89
T_5	52.33	39.67 A	32.67	41.56
T_6	47.33	35.33 BC	34.00	38.89
T_7	43.67	35.00 BC	35.00	37.89
T_8	45.33	34.67 BC	31.33	37.11
Mean	46.67	35.76	33.92	38.75

Table 11. Node at which the first male flower is formed in different seasons

Treatments	Seasons			Mean
	Kharif (S_1)	Rabi (S_2)	Summer (S_3)	
T_1	14.33	12.33 ABC	11.00	12.56
T_2	13.33	14.67 A	10.33	12.78
T_3	9.00	8.67 D	11.33	9.67
T_4	12.33	10.67 BCD	12.00	11.67
T_5	13.33	14.00 AB	9.33	12.22
T_6	9.33	12.67 ABC	11.33	11.11
T_7	10.33	9.67 CD	14.00	11.13
T_8	12.00	12.67 ABC	9.67	11.44
Mean	11.75	11.92	11.13	11.66

first male flower opening was maximum in T_1 (35.33) which was on par with T_3 (35.00), T_7 (35.00) and T_2 (34.67) and was minimum in T_8 (31.33).

Seasonal influence was noticed in the days taken for the first male flower opening and the maximum number of days was during kharif season (46.67). During summer and rabi seasons it was more or less same (35.76 and 33.92 respectively).

Pooled analysis revealed that maximum number of days for the opening of first male flower was by the treatment T_5 (41.56) which received FYM 20 t ha^{-1} and poultry manure 2.5 t ha^{-1} with fresh cowdung slurry @ 2.5 t ha^{-1} at fortnightly interval. The minimum number of days were taken in the treatments T_8 (37.11) which received FYM 20 t ha^{-1}, poultry manure 2.5 t ha^{-1} and fresh cowdung slurry drenching @ 2.5 t ha^{-1} at fortnightly interval with 70:25:75 kg ha^{-1} of NPK and T_8 was on par with T_7 (37.89) and T_4 (37.89).

4.2.2 Node at which the first male flower is formed

The treatment effect on the number of nodes for the emergence of first male flower was not significant during kharif season. However during rabi season it exhibited significant difference.

During rabi season the first male flower was formed in the lowest node in T_3 (8.67) which was on par with T_7 (9.67) (Table 11). Number of nodes for the emergence of first male flower was maximum in T_2 (14.67) which was on par with T_5 (14.00). The treatment T_3 varied significantly from all other treatments.

As in kharif season the treatment effect on the number of nodes for the first male flower was not significant during summer also.

Table 12. Days to first female flower anthesis in different seasons

Treatments	Seasons			Mean
	Kharif (S_1)	Rabi (S_2)	Summer (S_3)	
T_1	58.33 ^{AB}	38.67 ^{B}	42.00	46.11
T_2	53.33 ^{BCD}	39.67 ^{B}	38.33	43.78
T_3	58.00 ^{ABC}	36.33 ^{B}	38.67	44.33
T_4	54.67 ^{BCD}	38.67 ^{B}	38.33	43.89
T_5	60.33 ^{A}	43.00 ^{A}	37.33	46.89
T_6	52.67 ^{D}	38.00 ^{B}	37.33	42.67
T_7	54.33 ^{BCD}	38.00 ^{B}	40.33	44.22
T_8	53.00 ^{CD}	37.33 ^{B}	37.33	42.55
Mean	55.50	38.71	38.71	44.31

Table 13. Node at which first female flower is formed in different seasons

Treatments	Seasons			Mean
	Kharif (S_1)	Rabi (S_2)	Summer (S_3)	
T_1	20.00	20.67 ^{AB}	15.00 ^{AB}	18.56
T_2	21.00	18.33 ^{BCD}	13.00 ^{B}	17.44
T_3	19.67	14.33 ^{E}	16.00 ^{AB}	16.67
T_4	25.67	22.67 ^{A}	17.33 ^{A}	21.89
T_5	19.67	19.33 ^{ABC}	16.00 ^{AB}	18.33
T_6	21.00	17.33 ^{BCDE}	16.00 ^{AB}	18.11
T_7	26.67	15.00 ^{DE}	17.33 ^{A}	19.67
T_8	24.33	15.67 ^{CDE}	12.67 ^{B}	17.56
Mean	22.25	17.92	15.42	18.53

Seasonal influence was manifested in the individual treatments for the node at which first male flower to be formed. However the means of different season were more or less same during kharif, rabi and summer seasons (11.75, 11.92 and 11.13 respectively).

4.2.3 Days to first female flower anthesis

Treatment effect for the opening of female flower was significant in kharif and in rabi seasons. During the kharif season T_5 took maximum number of days (60.33) and T_6 took minimum (52.67) for the first female flower anthesis (Table 12). Duncan's multiple range test (DMRT) revealed that T_6 varies significantly from all other treatments.

During the rabi season the maximum number of days taken for the first flower opening was in T_5 (43.00) and minimum number was in T_3 (36.33) which was on par with T_8 (37.33), T_6 (38.00), T_7 (38.00), T_4 (38.67), T_1 (38.67) and T_2 (39.67). DMRT revealed that T_5 varies significantly from all other treatments. In the summer season the treatment effects were not significant.

Seasonal variation was present for days to first female flower opening. The number of days for first female flower anthesis was maximum during kharif season (55.50) while the number of days for the female flower anthesis was same during the rabi and summer seasons (38.71). Pooled analysis showed that the female flower opening was earlier in the treatment T_8 (42.52) followed by T_6 (42.67).

4.2.4 Node at which the first female flower is formed

Treatment effect on the node to bear the first female flower was significant only during rabi and summer seasons. During rabi the lowest node at which the first female flower formed was in T_3 (14.33) and the farthest was in T_4 (22.67) (Table 13). During the

Table 14. Number of days to first harvest in different seasons

Treatments	Seasons			Mean
	Kharif (S_1)	Rabi (S_2)	Summer (S_3)	
T_1	68.00	53.33	52.33	57.89
T_2	68.00	55.60	47.67	57.11
T_3	70.00	49.67	47.67	55.78
T_4	68.00	53.33	49.00	56.78
T_5	72.67	55.67	47.67	58.67
T_6	61.00	49.67	51.00	53.89
T_7	66.67	49.67	49.00	55.11
T_8	66.00	49.67	46.00	53.89
Mean	67.54	52.09	48.79	56.14

Table 15. Fruiting period in different seasons

Treatments	Seasons			Mean
	Kharif (S_1)	Rabi (S_2)	Summer (S_3)	
T_1	59.00	63.67	52.67	58.44
T_2	59.00	63.67	57.33	60.00
T_3	57.00	67.33	57.33	60.56
T_4	59.00	63.67	56.00	59.56
T_5	57.00	60.00	57.33	58.11
T_6	66.00	67.33	54.00	62.44
T_7	60.33	71.00	56.00	62.44
T_8	61.00	67.33	59.00	62.44
Mean	59.79	65.50	56.21	60.50

summer season the lowest node for first female flower formation was in T_8 (12.67) which was on par with T_2 (13.00), T_1 (15.00), T_3 and T_6 (16.00), T_5 (17.33). At the same time the T_7 and T_4 produced the first female flower on the farthest nodes (17.33).

Even though the seasonal variation was not manifested in the node at which first female flower formed; the farthest node for the first female flower formation was during kharif season (22.25) compared to rabi and summer (17.92 and 15.42). Pooled analysis indicated that the lowest node at which the first female flower formed was in the treatment T_3 (16.67) which received FYM @ 25 t ha^{-1} with NPK 70:25:50 kg ha^{-1}.

4.2.5 Days to first harvest

The treatments did not impart significant influence on first harvest in any of the seasons. During rabi and summer block variation was significant.

Seasonal variation was present in the number of days for the first harvest and the earlier harvest was obtained in the summer season (48.79) followed by rabi (52.09) (Table 14). Maximum number of days for the first harvest was taken during kharif season (67.54).

Pooled analysis revealed that the minimum number of days taken for the first harvest was in T_6 and T_8 (53.89) while the maximum was in T_5 (58.67) in which the manures applied were FYM @ 20 t ha^{-1}, poultry manure 2.5 t ha^{-1} and fresh cowdung slurry drenching @ 2.5 t ha^{-1} at fortnightly interval without any fertilizers.

4.2.6 Fruiting period

As in the case of days to first harvest the treatment effect was also not significant on the fruiting period in any of the seasons. Seasonal influence was observed in the

Table 16. Total yield per plot (16 m^2) in different seasons

Treatments	Seasons			Mean
	Kharif (S_1)	Rabi (S_2)	Summer (S_3)	
T_1	11.43 ^{C}	11.34 ^{A}	6.38 ^{C}	9.72
T_2	17.80 ^{AB}	18.27 ^{A}	17.82 ^{A}	17.96
T_3	17.34 ^{B}	17.89 ^{A}	14.70 ^{AB}	16.64
T_4	16.96 ^{B}	20.92 ^{A}	14.89 ^{AB}	17.59
T_5	19.21 ^{AB}	19.41 ^{A}	10.27 ^{BC}	16.30
T_6	19.36 ^{AB}	21.47 ^{A}	13.19 ^{AB}	18.01
T_7	22.66 ^{A}	24.26 ^{A}	18.13 ^{A}	21.68
T_8	17.67 ^{B}	21.33 ^{A}	14.59 ^{AB}	17.86
Mean	17.81	19.36	13.75	16.97

Table 17. Total number of fruits per plot (16 m^2) in different seasons

Treatments	Seasons			Mean
	Kharif (S_1)	Rabi (S_2)	Summer (S_3)	
T_1	171.33 ^{D}	189.67	99.33 ^{C}	153.44
T_2	249.33 ^{ABC}	234.67	260.33 ^{A}	248.11
T_3	326.00 ^{BCD}	226.33	230.00 ^{AB}	227.44
T_4	211.00 ^{CD}	245.67	224.67 ^{AB}	227.11
T_5	257.67 ^{ABC}	260.00	156.67 ^{BC}	224.78
T_6	257.00 ^{ABC}	262.67	195.00 ^{A}	238.22
T_7	301.00 ^{A}	267.67	241.33 ^{A}	270.00
T_8	281.67 ^{AB}	241.33	221.00 ^{AB}	248.00
Mean	244.38	241.00	203.54	229.64

fruiting period. The harvesting period was maximum during rabi season (65.5) while it was more or less same during kharif and summer seasons (59.79 and 56.21 respectively) (Table 15).

Pooled analysis showed that the minimum harvesting period was due to the treatments T_5 (58.11) which received FYM 20 t ha^{-1}, poultry manure 2.5 t ha^{-1} and fresh cowdung slurry drenching @ 2.5 t ha^{-1} at fortnightly interval and in T_1 (58.44) which received FYM @ 25 t ha^{-1} only. The fruiting period was maximum in T_6, T_7 and T_8 (62.44)

4.3 Yield and yield attributes

4.3.1 Total yield (kg per 16 m^2)

Productivity of the crop was significantly influenced by different treatments in all the three seasons. The treatment T_7 yielded maximum in all the seasons. During kharif season T_7 yielded maximum (22.66 kg) which was on par with T_6 (19.36 kg) and T_5 (19.21 kg) (Table 16). During rabi and summer, T_7 yielded 24.26 and 18.13 kg respectively.

Seasonal influence was manifested in total yield and it was maximum during rabi season (19.36 kg) and minimum in summer (13.75 kg). Pooled analysis also revealed maximum yield due to the treatment T_7 (21.68 kg) which received FYM @ 20 t ha^{-1}, poultry manure @ 2.5 t ha^{-1} and fresh cowdung slurry drenching @ 2.5 t ha^{-1} with NPK 70:25:50 kg ha^{-1}. In all the seasons total yield was minimum in T_1 (9.72 kg) which received FYM @ 25 t ha^{-1} only.

4.3.2 Total number of fruits

During kharif and summer season the number of fruits were significantly influenced by the various treatments. During kharif season maximum number of fruits were obtained from T_7 (301.0) which was on par with T_8 (281.7) (Table 17).

During rabi block variation was significant for total number of fruits. During summer T_2 yielded maximum number of fruits (260.3) and was followed by T_7 (2414.3), T_3 (230.0), T_4 (224.7), T_8 (221.0) and T_6 (195.0).

Seasonal variation was manifested in the number of fruits and was maximum (244.38) during kharif season which was more or less same with rabi season (241.00). The total number of fruits was minimum during summer (203.54). From the pooled analysis it was observed that the maximum number of fruits was in T_7 (270.00) which received FYM @ 20 t ha^{-1}, poultry manure @ 2.5 t ha^{-1} and fresh cowdung slurry drenching @ 2.5 t ha^{-1} with NPK 70:25:50 kg ha^{-1}. Minimum number of fruits were recorded in T_1 (153.44) in all the three seasons.

4.3.3 Marketable yield (kg per 16 m^{-2})

Yield of marketable fruits exhibited significant variation due to various treatment during kharif and summer seasons. During kharif season marketable yield was maximum in T_7(13.72 kg). Minimum marketable yield was in T_1(7.23 kg) which was significantly different from all other treatments (Table 18). During rabi season also maximum yield was obtained in T_7 (19.94 kg). During summer, the marketable yield was almost same in T_2 and T_7 (15.82 and 15.62 kg respectively). Minimum marketable yield was in T_1 (5.72 kg).

Table 18. Marketable yield in different seasons (kg per 16 m^2)

Treatments	Seasons			Mean
	Kharif (S_1)	Rabi (S_2)	Summer (S_3)	
T_1	7.23 ^{B}	10.61	5.72 ^{C}	7.85
T_2	11.39 ^{A}	15.67	15.82 ^{A}	14.29
T_3	11.00 ^{A}	15.01	13.06 ^{AB}	13.02
T_4	10.87 ^{A}	18.17	13.20 ^{AB}	14.08
T_5	12.79 ^{A}	16.56	8.77 ^{BC}	12.71
T_6	11.90 ^{A}	17.96	11.61 ^{AB}	13.83
T_7	13.72 ^{A}	19.94	15.62 ^{A}	16.43
T_8	11.91 ^{A}	17.77	12.61 ^{AB}	14.10
Mean	11.35	16.46	12.05	13.29

Table 19. Number of marketable fruits per plot (16 m^2) in different seasons

Treatments	Seasons			Mean
	Kharif (S_1)	Rabi (S_2)	Summer (S_3)	
T_1	78.33	144.00	91.00 ^{C}	102.78
T_2	105.33	172.33	219.67 ^{A}	165.78
T_3	100.00	167.00	202.67 ^{AB}	156.33
T_4	92.67	179.33	204.00 ^{AB}	158.67
T_5	113.00	203.67	133.67 ^{BC}	150.11
T_6	107.67	182.00	170.00 ^{AB}	153.22
T_7	114.00	201.00	208.00 ^{AB}	174.33
T_8	112.00	180.00	185.00 ^{AB}	159.00
Mean	102.25	178.67	176.75	152.56

Seasonal variation was significant in the marketable yield and maximum (16.46) was during rabi season and it was more or less same during kharif and summer seasons (11.35 and 12.05 kg respectively). Pooled analysis revealed maximum marketable yield in the treatment T_7 (16.43 kg) which received FYM @ 20 t ha^{-1} poultry manure @ 2.5 t ha^{-1} and fresh cowdung slurry @ 2.5 t ha^{-1} at fortnightly interval with 70:25:50 kg ha^{-1} of NPK. Minimum yield was recorded in T_1 (7.8 kg) which received FYM @ 25 t ha^{-1} only.

4.3.4 Number of marketable fruits

The different treatments had significant effect on number of marketable fruits in summer seasons and maximum number of marketable fruits were obtained in T_2 and minimum in T_1. During summer season the number of marketable fruits were maximum in T_2 (219.7) which was on par with T_7 (208.0), T_4 (204.0), T_3 (202.7). The treatment T_1(91.0) recorded minimum number of marketable fruits among the eight treatments (Table 19).

Pooled analysis showed maximum number of marketable fruits in T_7 (174.33) in which FYM 20 t ha^{-1}, poultry manure 2.5 t ha^{-1}, fresh cowdung slurry drenching @ 2.5 t ha^{-1} with NPK 70: 25: 50 kg ha^{-1} was applied. It was minimum in T_1 102.78 which received FYM @ 25 t ha^{-1} only.

4.3.5 Unmarketable yield (kg per 16 m^2)

Various treatments significantly influenced unmarketable yield only during kharif season. In this season maximum unmarketable yield was in T_8 (9.19 kg) (Table 20). During rabi and summer, unmarketable yield was maximum in T_7 (4.32 and 2.52 kg respectively). Even though the seasonal variation was not present the

Table 20. Unmarketable yield per plot (kg per 16 m^2) in different seasons in different seasons

Treatments	Seasons			Mean
	Kharif (S_1)	Rabi (S_2)	Summer (S_3)	
T_1	4.20 ^{B}	2.06	0.28	2.18
T_2	6.41 ^{AB}	2.60	2.00	3.67
T_3	6.33 ^{AB}	2.88	1.64	3.62
T_4	6.09 ^{A}	2.76	1.70	3.51
T_5	6.42 ^{A}	2.85	1.49	3.59
T_6	7.46 ^{A}	3.51	1.57	4.18
T_7	9.00 ^{A}	4.32	2.52	5.28
T_8	9.19 ^{A}	3.56	2.00	4.92
Mean	6.89	3.07	4.40	4.72

Table 21. Number of unmarketable fruits per plot (16 m^2) in different seasons

Treatments	Seasons			Mean
	Kharif (S_1)	Rabi (S_2)	Summer (S_3)	
T_1	98.00	45.67	8.33	50.67
T_2	144.00	62.33	40.67	82.33
T_3	126.00	59.33	27.33	70.89
T_4	118.30	66.33	20.67	68.43
T_5	114.70	56.33	23.00	64.67
T_6	149.30	80.67	25.00	84.99
T_7	187.00	66.67	32.67	95.45
T_8	169.70	61.33	36.00	89.01
Mean	138.38	62.33	26.71	75.81

unmarketable yield was more during kharif season (6.89 kg). During rabi it was less (3.07 kg) than the summer (4.40 kg).

In the pooled analysis the treatment T_7 recorded maximum unmarketable yield (5.28) in which FYM 20 t ha^{-1}, poultry manure 2.5 t ha^{-1} and fresh cowdung slurry @ 2.5 t ha^{-1} at fortnightly interval with 70:25:50 kg ha^{-1} of NPK were applied. In all the seasons unmarketable yield was minimum in T_1 (2.18 kg) which received FYM 25 t ha^{-1} only.

4.3.6 Number of unmarketable fruits

The various treatments did not show significant effect on number of unmarketable fruits in any of the three seasons. However, the number of unmarketable fruits were maximum in T_7 (187.00) during kharif season, T_6 (80.63) during rabi and T_2 (40.67) during summer seasons (Table 21). In all the seasons T_1 which received FYM only recorded minimum number of unmarketable fruits. Seasonal variation was not significant for the number of unmarketable fruits. It was maximum during kharif season (138.38) and minimum during summer (26.71).

Pooled analysis revealed maximum number of unmarketable fruits in the treatment T_8 (89.01) in which FYM 20 t ha^{-1}, poultry manure 2.5 t ha^{-1} and fresh cowdung slurry @ 2.5 t ha^{-1} with NPK 70:25:75 kg ha^{-1} were applied.

4.3.7 Number of harvests

The number of harvests were not significantly influenced by any of the treatments in any of the seasons. During rabi and summer block variation was significant. During rabi maximum number of harvest were obtained from T_7 (11.0) (Table 22).

Table 22. Number of harvests in different seasons

Treatments	Seasons			Mean
	Kharif (S_1)	Rabi (S_2)	Summer (S_3)	
T_1	8.33	10.33	9.00	9.22
T_2	8.33	10.33	10.67	9.78
T_3	8.00	10.67	10.67	9.78
T_4	8.00	10.33	10.33	9.56
T_5	7.67	10.00	10.67	9.44
T_6	9.00	10.67	10.00	9.89
T_7	8.33	11.00	10.33	9.89
T_8	8.67	10.67	11.00	10.11
Mean	8.29	10.50	10.33	9.71

Table 23. Length of fruits (cm) in different seasons

Treatments	Seasons			Mean
	Kharif (S_1)	Rabi (S_2)	Summer (S_3)	
T_1	22.00 ^{D}	20.60 ^{B}	18.87	20.49
T_2	24.17 ^{BC}	24.13 ^{A}	20.70	23.00
T_3	26.70 ^{A}	24.67 ^{A}	19.13	23.50
T_4	23.77 ^{BCD}	24.03 ^{A}	19.43	22.41
T_5	22.90 ^{CD}	24.17 ^{A}	19.17	22.08
T_6	23.00 ^{CD}	24.20 ^{A}	20.43	22.54
T_7	25.20 ^{AB}	25.13 ^{A}	20.07	23.47
T_8	24.27 ^{BC}	21.80 ^{B}	20.83	22.30
Mean	24.00	23.61	19.83	22.47

Seasonal variation was significant for the number of harvests. During rabi and summer number of harvests were more or less same (10.50 and 10.33), but it was less during kharif season (8.29). Pooled analysis showed that maximum number of harvests in T_8 (10.11) in which FYM @ 20 t ha^{-1}, poultry manure @ 2.5 t ha^{-1} and fresh cowdung slurry drenching @ 2.5 t ha^{-1} at fortnightly interval were applied with NPK 70:25:50 kg ha^{-1}.

4.3.8 Length of fruit (cm)

Fruit length was significantly influenced by different treatments in kharif and rabi seasons. During kharif season the length of fruit was maximum in T_3 (26.70 cm) which was on par with T_7 (25.20 cm). T_1 recorded minimum fruit length (22.0 cm) and was inferior to all other treatments (Table 23).

During the rabi season T_7 recorded maximum fruit length (25.13 cm) which was on par with T_3 (24.67 cm), T_6 (24.20 cm), T_5 (24.17 cm) and T_4 (24.03 cm). During summer length of fruit was maximum in T_8 (20.83 cm).

Length of fruit varied significantly with seasons. The length of fruit and was maximum during kharif season (24.00 cm) which was more or less same with rabi (23.61 cm). Minimum fruit length was recorded during summer (19.83 cm).

Pooled analysis indicated maximum fruit length due to the treatments T_3 and T_7 (23.50 and 23.47 cm respectively) and minimum in T_1 (20.49 cm).

4.3.9 Girth of fruit (cm)

The various treatments had significant influence on girth of fruit during kharif and summer. During kharif and rabi seasons, girth of fruit was maximum in T_7 (18.03 and 18.17 cm respectively) and minimum in T_1 in both the seasons (15.40 and 15.90 cm

Table 24. Girth of fruits (cm) in different seasons

Treatments	Seasons			Mean
	Kharif (S_1)	Rabi (S_2)	Summer (S_3)	
T_1	15.40 ^{C}	15.90	13.90 ^{C}	15.07
T_2	17.17 ^{AB}	17.40	17.23 ^{A}	17.27
T_3	16.17 ^{BC}	17.67	15.70 ^{ABC}	16.51
T_4	17.10 ^{AB}	16.13	16.20 ^{AB}	16.48
T_5	17.40 ^{AB}	16.83	14.47 ^{BC}	16.23
T_6	17.53 ^{A}	17.97	16.00 ^{AB}	17.17
T_7	18.03 ^{A}	18.17	17.20 ^{A}	17.80
T_8	17.17 ^{AB}	17.00	14.63 ^{BC}	16.27
Mean	17.00	17.13	15.67	16.66

Table 25. Average fruit weight (g) in different seasons

Treatments	Seasons			Mean
	Kharif (S_1)	Rabi (S_2)	Summer (S_3)	
T_1	134.10 ^{D}	223.10 ^{B}	208.30	188.50
T_2	231.50 ^{B}	229.60 ^{B}	204.20	221.77
T_3	236.70 ^{B}	254.00 ^{A}	200.00	230.23
T_4	239.80 ^{B}	256.60 ^{A}	166.70	221.03
T_5	259.00 ^{A}	254.70 ^{A}	200.00	237.90
T_6	259.40 ^{A}	257.90 ^{A}	167.30	228.20
T_7	260.20 ^{A}	258.80 ^{A}	213.90	224.30
T_8	208.30 ^{C}	245.90 ^{A}	183.30	212.53
Mean	228.63	247.58	192.96	223.06

respectively). T_2 recorded maximum fruit girth (17.23 cm) and T_1 recorded minimum (13.90 cm) during summer. T_2 and T_7 were superior to all other treatments.

Girth of fruit varied with seasons and was minimum during summer (15.67cm.) and it was more or less same during kharif and rabi seasons (17.00 and 17.13cm respectively).

Pooled analysis revealed the maximum fruit girth in T_7 (17.80) in which FYM @ 20 t ha^{-1}, poultry manure @ 2.5 t ha^{-1} and fresh cowdung slurry drenching @ 2.5 t ha^{-1} at fortnightly interval was applied. Fruit girth was more less same in T_2 (17.27cm.) and T_6 (17.17cm.). Minimum fruit girth was in T_1 (15.07cm.).

4.3.10 Average fruit weight (g)

Average fruit weight was significantly influenced by different treatments in S_1 and S_2 During kharif season the average fruit weight was maximum in T_7 (260.2 g) which was on par with T_6 (259.4 g) and T_5 (259.0 g) (Table 25). The minimum fruit weight was recorded in T_1 (134.1g) which was significantly inferior to all other treatments. During rabi also average fruit weight was maximum in T_7 (258.8 g) which was on par with T_6 (257.9 g), T_4 (256.6 g), T_5 (254.7 g), T_3 (254.0 g) and T_8 (245.9 g).

The weight of fruit varied significantly with seasons and it was maximum during rabi (247.58 g) and minimum during summer (192.96 g). Pooled analysis showed maximum fruit weight in T_7 (224.3 g), which received FYM @ 20 t ha^{-1}, poultry manure @ 2.5 t ha^{-1} and fresh cowdung slurry drenching @ 2.5 t ha^{-1} at fortnightly interval with NPK 70:25:50 kg ha^{-1}. Fruit weight was minimum in T_1 (188.5 g) which received the FYM @ 25 t ha^{-1} only.

Table 26. Days taken for the first appearance of pest and disease in bitter gourd

Seasons	Fruitfly	Jassids	Epilachna beetle	Mosaic	Downy mildew
Kharif (S1)	53	120	55	25	50
Rabi (S2)	56	15	20	30	30
Summer (S_3)	45	20	50	50	nil

Table 27. Days for severe incidence of pest and disease in bitter gourd

Seasons	Fruitfly	Jassids	Epilachna beetle	Mosaic	Downy mildew
Kharif (S1)	90	NS	65	35	60
Rabi (S2)	120	NS	43	45	50
Summer (S_3)	93	35	NS	70	NS

NS - Not Severe

Plate No. 1 Bitter gourd fruit infested by fruit fly

4.4 Pests

4.4.1. Fruit fly

The days for the first incidence of fruit fly ranged from 45 to 56 depending on the season (Table 26). The infestation became very severe at 90 DAS during kharif season, 120 DAS during rabi and 93 DAS during summer (Table 27). The number of fruits damaged by fruit fly was maximum during kharif season in all treatments and it decreased gradually during rabi and was minimum during summer (Table 28). But there was no significant variation due to various treatments in any of the three seasons.

During kharif season the percentage of loss on the basis of number of fruits were maximum in T_7 (61.81 %) closely followed by T_8 (59.10 %) and was minimum in T_3 (55.72 %), T_4 (55.73 %) and T_5 (55.78 %).During rabi, percentage of loss in terms of number of fruits was maximum in T_6 (31.11 %)followed by T_4 (27.62 %), T_2 (26.60 %) and T_3 (26.74 %) while the loss was minimum in T_5 (21.02 %). During summer the percentage of loss was maximum in T_8 (16.03 %) while it was minimum in T_1 (8.19 %).

Percentage of loss on the basis of fruit weight was also maximum during kharif season in all treatments and it decreased gradually during rabi and became minimum in summer. However in T_5 loss was more or less same during rabi and summer. Fruit fly infested fruit was given in Plate 1. The treatments did not have significant effect on fruit fly population in any of the three seasons. During kharif season the loss of fruits based on weight by the fruit fly was maximum in T_8 (59.21 %) and minimum in T_5 (33.32 %). During rabi it was in T_6 (45.96 %) and T_4 (13.20 %) respectively. During summer the maximum percentage of loss in weight due to fruit fly was observed in T_5 (14.71 %) and minimum in T_1 (4.49 %) (Table 29).

Table 28. Percentage of loss by fruit fly on fruit number basis (%)

Treatments	Season			Mean
	Kharif (S1)	Rabi (S2)	Summer (S_3)	
T_1	57.17	24.00	8.19	29.79
T_2	58.17	26.60	13.80	32.86
T_3	55.72	26.74	12.47	31.64
T_4	55.73	27.62	9.52	30.96
T_5	55.78	21.02	14.69	30.50
T_6	57.91	31.11	12.82	33.95
T_7	61.81	24.01	13.52	33.11
T_8	59.10	25.48	16.03	33.54
Mean	57.67	25.82	12.63	32.04

Table 29. Loss by fruitfly on fruit weight basis (%)

Treatments	Season			Mean
	Kharif (S1)	Rabi (S2)	Summer (S_3)	
T_1	37.07	16.24	4.49	19.27
T_2	36.59	14.36	9.80	20.25
T_3	36.66	16.87	11.79	21.77
T_4	35.85	13.20	11.60	20.22
T_5	33.32	14.67	14.71	20.90
T_6	38.66	45.96	12.02	32.21
T_7	39.08	17.37	13.86	23.44
T_8	59.21	16.85	13.33	29.80
Mean	39.66	17.61	11.45	11.45

Plate No. 2 Nymphs of jassids

Plate No. 3 Hopper burn symptom due to jassids

Table 30. Jassid infestation during summer

Treatments	No. of pests per leaf				Pest infestation index (%)			
	30 DAS	45 DAS	60 DAS	90 DAS	30 DAS	45 DAS	60 DAS	90 DAS
T_1	2.10	7.57	1.02	1.93	9.09	32.57	55.56	75.75
T_2	2.70	9.78	0.91	1.24	9.09	39.39	65.15	81.82
T_3	1.60	5.96	0.84	1.55	9.09	40.91	75.75	81.82
T_4	2.60	9.08	0.93	1.38	9.09	39.39	65.15	69.70
T_5	1.20	4.44	0.84	1.53	9.09	32.57	50.00	63.63
T_6	2.80	10.84	0.91	1.20	9.09	35.61	60.60	81.82
T_7	1.80	6.09	1.16	0.74	9.09	34.85	56.26	62.97
T_8	2.00	6.36	1.00	1.31	9.09	30.30	59.09	69.70

4.4.2. Jassids.

During kharif season the jassids (Plate 2) appeared very late i.e. at 120 DAS and it was under control and did not caused any damage to the plants (Table 26). During rabi the jassids appeared early (15 DAS) and almost all plants were effected at 22 DAS. However there was not much damage to the leaves during rabi.

During summer the infestation was observed at 20 DAS. Number of jassids per leaf were very low at 30 DAS and hopper burn symptom was absent. After 35 days of sowing the infestation became severe and within one week hopper burn symptom was appeared. The number of jassids per leaf was maximum in T_6 (10.84) followed by T_2 (9.78) and T_4 (9.08) at 45 DAS, while percentage of infestation was maximum in T_3 (40.91) followed by T_2 and T_4 (39.39)(Table 30). At 60 DAS the number of jassids per leaf was maximum in T_7 (1.16) and minimum in T_3 and T_5 (0.84). The hopper burn symptom was more in T_3 (75.75) followed by T_2 and T_4 (65.15) and minimum in T_5 (50.0). At 90 DAS T_1 recorded maximum number of pest per leaf (1.93) and T_7 recorded minimum (0.74). However the percentage of infestation was maximum in T_2, T_3 and T_6(81.82) followed by T_1 (75.75) and minimum in T_7(62.97). Table 30.

Even though the jassid population was decreased after 60 days of sowing, the hopper burn symptom or yellowing (Plate 3) once started was not recovered and it showed gradual increase in all the treatments.

4.4.3.Epilachna beetle

During kharif season epilachna beetle (Plate 4) appeared 55 DAS and infestation became severe (Plate 5) at 65 DAS only in one treatment i.e., T_7. At the same time low

Plate No. 4 Epilachna beetle

Plate No. 5 Skeletonization by epilachna beetle

Table 31 Pest infestation index due to epilachna beetle during rabi (%)

Treatments	30 DAS	45 DAS	75 DAS	100 DAS	115 DAS
T_1	9.09	9.09	46.97	44.29	72.76
T_2	9.09	9.09	54.55	75.24	65.15
T_3	21.21	9.09	69.70	59.76	66.31
T_4	21.21	21.21	71.21	68.09	75.76
T_5	21.21	9.09	59.09	49.76	51.51
T_6	21.21	9.09	60.43	74.28	83.82
T_7	9.09	9.09	50.00	47.86	75.76
T_8	27.27	48.18	60.61	72.84	81.82

infestation was observed in T_2 and T_8 and in all other treatments were almost free from epilachna beetle.

During rabi infestation of epilachna was observed at 20 DAS in plants of T_8. After one week the infestation was also noticed in T_3, T_4, T_5 and T_6, recorded a pest infestation index of 21.21 at 30 DAS and it was maximum in T_8 (27.27) (Table 31). At the same time T_1, T_2 and T_7 were not affected by epilachna beetle. The infestation of epilachna at 45 DAS increased in the T_8 only and no damage was observed in T_1, T_2 and T_7. The pest infestation index decreased in T_3, T_5 and T_6. At 75 DAS pest infestation became more in all the treatments and maximum infestation was in T_4 (71.21) followed by T_3 (69.70) and minimum in T_1 (46.97). The infestation became increased at 100 DAS in T_2, T_6 and T_8 and maximum infestation was in T_2 (75.24). Infestation index decreased in other five treatments and T_1 recorded minimum value (44.29) followed by T_7 (47.86). At 115 DAS, infestation became higher in all treatments except T_2 (65.15). The maximum infestation was in T_8 (81.82) and minimum in T_2 (65.15). Among the eight treatments T_8 only showed gradual increase of pest infestation from first appearance of pest to the completion of crop.

During summer epilachna infestation was noticed only in T_7, T_2 and T_4 at 50 DAS. After that no infestation was observed in any of the treatments.

4.4.4. Other pests

1. Aphids

Aphids were present during all the three seasons. However it could be easily controlled by spraying tobacco decoction.

Table 32. Occurrence of mosaic during kharif season

	Disease incidence (%)			Disease intensity (%)		
Treatments	30 DAS	60 DAS	120 DAS	30 DAS	60 DAS	120 DAS
T_1	8.320	77.78	81.33	45.45	27.73	48.13
T_2	2.770	77.77	81.82	9.09	30.30	51.58
T_3	24.990	66.67	83.33	21.21	23.33	60.03
T_4	8.320	77.78	91.67	51.52	33.74	67.42
T_5	8.320	61.11	81.82	21.21	21.06	35.02
T_6	8.320	72.22	90.90	27.27	22.72	46.17
T_7	0.000	86.11	86.11	9.09	22.63	37.34
T_8	2.767	77.78	77.78	9.09	41.82	83.46

Table 33. Occurence of mosaic during rabi season

	Disease incidence (%)			Disease intensity (%)		
Treatments	30 DAS	60 DAS	120 DAS	30 DAS *	60 DAS	120 DAS
T_1	44.450	100.00	100.00	33.33 A	50.00	75.76
T_2	16.670	100.00	100.00	15.91 B	60.61	69.70
T_3	11.110	100.00	100.00	12.12 B	59.09	57.58
T_4	8.330	100.00	100.00	16.82 B	53.03	63.64
T_5	30.560	100.00	100.00	22.73 AB	50.76	45.46
T_6	16.670	100.00	100.00	13.64 B	53.03	63.64
T_7	11.100	100.00	100.00	13.63 B	57.58	51.51
T_8	11.110	100.00	100.00	9.09 B	59.09	57.57

Table 34. Occurence of mosaic during summer season

	Disease incidence (%)			Disease intensity (%)		
Treatments	30 DAS	60 DAS	120 DAS	30 DAS	60 DAS	120 DAS
T_1	0.000	100.00	100.00	9.09	50.50	68.79
T_2	0.000	100.00	100.00	9.09	42.42	76.16
T_3	0.000	100.00	100.00	9.09	23.34	63.64
T_4	0.000	100.00	100.00	9.09	37.37	73.48
T_5	0.000	100.00	100.00	9.09	27.68	48.48
T_6	0.000	100.00	100.00	9.09	53.03	73.99
T_7	0.000	100.00	100.00	9.09	26.16	45.35
T_8	0.000	100.00	100.00	9.09	33.03	75.76

* P = 0.05

Plate No. 6 Initial symptom of mosaic

Plate No. 7 Bitter gourd plant severely affected by mosaic

2. Leaf folders

Leaf folders also caused some damage on plants during all the three seasons and it could be easily controlled by collection and destruction, when ever noticed.

4.5 Diseases

4.5.1 Mosaic

During kharif season mosaic disease appeared (Plate 6) as early as 25 DAS and became severe at 35 DAS. During rabi it was further delayed by five days to appear and it became severe (Plate 7) only after 45 days of sowing. During summer the symptoms appeared 50 DAS and took another 20 days to become severe.

At 30 DAS, mosaic incidence was maximum in T_3 (24.99 %) while T_7 was not at all effected during kharif season (Table 32). However during later stages of growth mosaic spread quickly and T_7 had maximum disease incidence at 60 DAS (86.11 %). At the peak fruiting stage all the treatments had heavy infection and it ranged from 61.11 per cent in T_5 to 86.11 per cent in T_7.

The percentage of disease intensity when assessed at 30 DAS, T_4 recorded maximum (51.52 %) closely followed by T_1(45.45 %) and there was no disease in three treatments viz. T_2, T_7 and T_8. However the disease intensity at 60 DAS was more or less same in all the treatments ranging from 21.06 per cent in T_5 to 33.74 per cent in T_4, except T_8 which recorded 41.82 per cent. In treatments T_1, T_4, T_5 and T_6 the percentage of disease intensity was less at 60 DAS compared to 30 DAS.

During rabi season, at 30 DAS the mosaic incidence was maximum in T_1 (44.45 %) followed by T_5 (30.56 %) and was minimum in T_4 (8.33 %). At 60 DAS all

Table 35. Occurrence of downy mildew during kharif season

Treatments	Disease incidence (%)		Disease intensity (%)	
	30 DAS	60 DAS	30 DAS	60 DAS
T_1	0	100	9.09	44.54
T_2	0	100	9.09	47.58
T_3	0	100	9.09	47.37
T_4	0	100	9.09	44.64
T_5	0	100	9.09	35.35
T_6	0	100	9.09	35.35
T_7	0	100	9.09	41.82
T_8	0	100	9.09	52.42

Plate No. 8   Downy mildew of bitter gourd

the plants in all treatments were affected by mosaic and recorded 100 per cent disease incidence in all treatments (Table 33).

At 30 DAS percentage of disease intensity was maximum in T_1 (33.33 %) followed by T_5(22.73 %) and T_1 significantly varied from all other treatments. At the same time there was no disease in T_8 and all other treatments had almost the same intensity. Disease intensity increased gradually in all the treatments and at 60 DAS the maximum disease intensity was in T_2 (60.61 %) closely followed by T_3 and T_8 (59.09 %). At 120 DAS the disease intensity was further increased in T_1, T_2, T_4 and T_6 and T_1 recorded maximum (75.76 %). At the same time percentage of disease intensity decreased in T_3, T_5, T_7 and T_8.

During summer, none of the plants were affected by mosaic at 30 DAS and the mosaic symptom appeared initially in T_1, T_2 and T_5 at 50 DAS. All plants in all the treatments were affected by mosaic after 60 days of sowing and the percentage of disease incidence was 100 per cent in all treatments (Table 34). At 60 DAS the percentage of disease intensity was maximum in T_6 (53.03 %) followed by T_1 (50.50 %) and the minimum was in T_3 (23.34 %) and T_7 (26.16 %). The intensity of mosaic increased gradually in all the treatments and it was maximum in T_2 (76.16 %) followed by T_8 (75.76 %) and was minimum in T_7 (45.35 %) at 120 days after sowing.

4.5.2 Downy mildew

During kharif season downy mildew appeared (Plate 8) 50 DAS (Table 26) and became severe at 20 days after the first appearance. But during rabi the symptoms appeared 30 DAS and it became severe after another 20 days (Table 27). The plants were not affected by downy mildew during summer.

Table 36. Occurrence of downy mildew during rabi season

	Disease incidence (%)			Disease intensity (%)		
Treatments	30 DAS	60 DAS	75 DAS	30 DAS	60 DAS *	75 DAS
T_1	0	100	100	9.09	34.65 AB	58.33
T_2	0	100	100	9.09	24.24 BC	67.00
T_3	0	100	100	9.09	44.50 A	78.79
T_4	0	100	100	9.09	31.42 B	72.73
T_5	0	100	100	9.09	27.17 BC	61.37
T_6	0	100	100	9.09	24.84 BC	72.73
T_7	0	100	100	9.09	19.54 C	65.15
T_8	0	100	100	9.09	42.32 A	59.09

* P = 0.05

During kharif season, downy mildew was noticed in plants of T_8 and 60 DAS all the treatments were affected by downy mildew (Table 35). The maximum disease intensity was recorded in T_8 (52.42 %) and minimum in T_5 and T_6 (35.35 %). The disease intensity was more or less same in T_1, T_2, T_3, T_4 and T_7.

During rabi symptoms of downy mildew appeared in plants of T_8 at one month after sowing and later, the disease spread to T_6 and T_4. At 60 DAS all plants in all the treatments were affected by downy mildew and the disease intensity varied significantly with treatments. Disease intensity was maximum in T_3 (44.50 %) followed by T_8 (42.32 %) and was minimum in T_7 (19.54 %). 75 DAS the percentage of disease intensity increased in all treatments and maximum disease intensity was in T_3 followed by T_4 and T_6 (72.73 %) and it was minimum in T_1 (58.33 %) (Table 36).

4.5.3 Other diseases

Leaf spot and leaf blight

During kharif season leaf spot and leaf blight diseases were also noticed. However no further spread was seen because of removal of all the disease affected leaves as and when noticed. During rabi also leaf spots were observed in some plants and were under control. During summer the leaf spot and leaf blight symptoms were not observed.

Discussion

5. DISCUSSION

Cucurbitaceous vegetables are widely grown as summer vegetables in the tropical as well as in the sub tropical regions of the world. Among them *Momordica charantia* L. known as bitter gourd is an important summer vegetable in India (Nath, 1965). The crop is valued for its fruits having high nutritive value, unique medicinal properties and consumer preference. The immature fruits as well as fully matured fruits are harvested and used for various preparations like fried and boiled items, pickles, curries, dehydrated forms etc. Compared to other cucurbitaceous vegetables, it is rich in vit C (88 mg), carbohydrate (4.2 g), protein (1.6 g), carotene (120 mg) and iron (1.8 mg per 100g) (Chauhan, 1996). The fruits contain an alkaloid momordicine which is supposed to posses cooling, stomachic carminative, antipyretic, aphrodisiac and vermifuge properties (Nadkarni, 1954).

The crop is widely grown throughout Kerala and occupies a pride of place in its production in state. It is estimated that an area of 7,000 ha is under cultivation in the state. In spite of its high cost of production; high productivity, maximum net return and constant demand makes the crop a preferred vegetable of farmers in the state. As the crop is grown through out the year with intensive packages, severe incidence of pests and diseases are causing serious threats for its successful cultivation. Adverse climatic and soil conditions coupled with excess application of fertilizer and plant protection chemicals aggravates the situation to poor productivity of the crop. Due to the succulent and fast growing nature of the crop it succumbs to diseases like mosaic, downy mildew etc. within a short span of time.

In this context, the present investigation was under taken to study the major biotic stresses like mosaic, downy mildew, jassids and fruit fly affecting the growth and productivity of bitter gourd, which was taken up at the College of Horticulture Vellanikkara during 1997-98. Data on biometric characters like length of vine, number of branches, days to first male and female flower opening, node at which first female and male flower formed, days to first harvest, days to last harvest, total yield per plot, marketable yield per plot, unmarketable yield per plot, number of harvests, length, girth and average weight of fruit and incidence of major pests and disease were recorded by raising the crop during three seasons viz. kharif, rabi and summer. The crop performance in eight treatments constituting different levels and frequencies of organic manures and inorganic fertilizers for three seasons were studied. The results obtained in the present study are briefly discussed in this chapter.

Among different pests infesting the crop, fruit fly (*Bactrocera cucurbitae*) causes damage directly to fruits. The female flies puncture the soft and tender fruits with their stout and hard ovipositor and lay eggs below the epidermis. The emerging larvae damage by tunnelling and feeding within the fruits, ultimately causing yellowing, distortion, malformation and rotting of fruits. In some cases the infested fruits fall off prematurely from plants. In the present study the crop loss due to fruit fly attack was as high as 61.81 per cent in terms of number and 59.21 per cent in terms of weight of fruits. Severe crop loss due to the infestation of fruit fly has been reported earlier by many scientists. Singh (1966) reported that more than 50 per cent of fruits are either partially or fully damaged by fruit fly. Patel (1976) recorded three to 100 per cent and Ranganath *et al.* (1997) recorded 85 per cent of crop loss due to the severe infestation of fruit fly. Fang and Chang (1984) and Doharey (1983) observed preference of bitter gourd by *B. cucurbitae*.

The days for the first incidence of fruit fly attack ranged from 45 to 55 days depending on the season and infestation became severe at 90 DAS during kharif season, 93 DAS during summer, 120 DAS during rabi. Seasonal variation on the occurrence of fruit fly was quite evident in the present study. The number of fruits damaged by fruit fly was maximum during kharif season (55.72 to 61.81 %), followed by rabi (21.02 to 31.11 %) and was minimum during summer (9.52 to 16.03 %). The crop loss in terms of weight of fruits also had the same trend. The percentage loss in weight of fruits due to fruit fly attack was 33.32 to 59.21 per cent during kharif season, 13.20 to 17.37 per cent during rabi and 4.49 to 14.71 during summer season. The variation in the severe incidence of fruit fly in different seasons may be due to variation in weather parametres. More over the bait trap used was very effective during rabi and it was not effective during kharif season. Butani and Jotwani (1984) reported a shorter period of 19 to 40 days for the completion of a single life cycle during kharif season, while it took 12 to 13 weeks during rabi. They also observed less number of fruit flies during dry weather which gradually increased with rain fall. The average weekly rain fall during the fruiting period were 124.18 mm during kharif season (Appendix I a), 24.78 mm during rabi season (Appendix I b), and 99.92 mm during summer season (Appendix I c),. The relative humidity of the atmosphere also had the same trend i.e., 85.5 per cent during kharif season, 72.69 per cent during rabi season and 79.1 per cent during summer season. Borah (1996) reported minimum fruit fly infestation (20.9 %) during rabi season in cucumber. Davis (1996) observed that April sown bitter gourd crop was highly infested by fruit fly as fruiting period coincides with heavy rain fall.

The effect of different doses and frequencies of organic manures and inorganic fertilizers on the incidence of fruit fly was not significant during any of the three seasons in the present study. However, the treatments T_8 and T_7 which had the maximum growth and fruiting was more affected by fruit fly during kharif as well as summer season. Such an observation was not noticed during rabi. Treatment T_1 which received FYM only had low incidence of fruit fly attack which decreased gradually from kharif to summer i.e., 37.07per cent during kharif season, 16.24per cent during rabi and 4.49 per cent during summer season on fruit weight basis. Same trend was observed in number of damaged fruits also.

The first report of green jassids (*Empoasca motti*) in bitter gourd from the country is by Mathew (1996 b) from KHDP (R & D unit) at Kerala Agricultural University, Vellanikkara. Both the nymphs and adults of the pest suck sap from mesophyll and cause serious damage to the foliage. The small and green coloured jassids lay eggs singly within the leaf vein, hatch in four to six days and the yellowish nymphs feeding on leaf sap from the lower leaf surface become adult within a week. The damage is caused mainly due to toxaemia of the insect saliva which is injected in to the leaf during feeding. The infested leaves slightly crinkle down ward and their edges turn pale green, yellow and finally brick red or brown, resulting in typical hopper burn symptom. Finally the leaves dry off. Severely infested plants become stunted and fail to grow and bear fruits. During the present investigation jassid infestation was observed in all the three seasons. But severe incidence was experienced during summer only. During kharif season jassids appeared very late and did not cause any damage to the foliage. During rabi also crop was not damaged even though the jassids appeared very early i.e.,15 DAS. The population of jassids during rabi and kharif season were too low to cause typical hopper burn symptom.

During summer the jassids appeared 20 DAS and infestation became serious even 35 DAS causing typical hopper burn symptoms. In order to prevent further crop loss, a protective spray with neem oil and garlic at 46 DAS, was given after which there was drastic reduction in population (1.16). Later on, malathion and garlic, neem oil and garlic were sprayed alternatively. However, 90 DAS jassid population showed a slight increase. The typical hopper burn symptom and crop damage was very conspicous during summer season. Hopper burn symptom, once appeared was not recovered later. Mathew (1996 b) also reported severe incidence of jassids in bitter gourd during summer months (January to March) at Vellanikkara. According to Lal (1951) increase in temperature have a significant role in incidence and multiplication of jassids and at 37.8^{0}C, *Empoasca motti* took 33.1 days for completion of life cycle while at 47.8^{0}C, it is took only 13.5 days. The shorter life cycle at high temperature may be one of the reason for severe incidence of jassids during summer.

The variation in the incidence of jassids due to the different sources and levels of organic and inorganic fertilizers was not significant. However, the treatment T_7 which received 20 t ha^{-1} of FYM, 2.5 t ha^{-1} of poultry manure, 2.5 t ha^{-1} of fresh cow dung slurry drenching at fortnightly interval with 70:25:50 kg ha^{-1} of NPK showed a decrease in population of jassids at 90 DAS. Reddy and Rao (1982) and Singh *et al.* (1995) reported that the plants which received more nitrogenous fertilizers became more vulnerable to sucking pests like aphids and white fly. Peter and Gopalakrishnan (1989) reported the role of potassium in pest resistance. The low incidence of jassids in the treatment T_7 may be due to the balanced availability of organic manures and inorganic fertilizers, that is 20 t ha^{-1} of FYM, 2.5 t ha^{-1} of poultry manure, 2.5 t ha^{-1} of fresh cow dung slurry drenching at fortnightly interval with 70:25: 50 kg ha^{-1} of NPK.

According to Butani and Jotwani (1984) bitter gourd is also a preferred host of epilachna beetle. *Epilachna septima* is the species feeding commonly in bitter gourd (Kapur, 1966). The grubs of the beetle are yellow, fleshy and covered with spines and hairs. They are feeding on the surface tissue of leaf causing characterisitic skeletonization of leaf lamina. Affected leaves gradually dry and droopdown. Severe infestation kills the plant outrightly if proper control measures are not taken. In the present study, epilachna beetle infestation was noticed in all the three season. However, seasonal variation was highly conspicuous and the severe infestation beyond control was observed during rabi season only

During kharif and summer season, the beetles appeared 55 and 50 DAS respectively. While during rabi the epilachna beetles were detected very early i.e., 20 DAS and has became severe at 45 DAS. During kharif and summer seasons the population of epilachna beetles were very low and were limited to a few plants irrespective of the treatment and could be controlled by handpicking and destruction.

During rabi the population of adult beetles and grubs were very high. Initially the attack was noticed in T_8 of R_2 and quickly spread to nearby plants. The pest infestation index was above 50 per cent in all the treatments by 115 DAS with a maximum index of 83.82 per cent in T_6 and 81.82 per cent in T_8. The treatments which received FYM and poultrymanure alone had recorded minimum values (51.51%). Thick growth and large leaves resulting in more leaf area in T_8 contributed by the high dose and frequent application of manures and fertilizers may be one of the reason for heavy incidence of epilachna beetle in T_8. During summer and rabi also treatment T_8 had comparatively high value of pest infestation index.

Dhingra *et al.* (1985) observed that during July to November, epilachna beetle completed as high as six generations. Davis (1996) also observed severe epilachna infestation on bitter gourd plants which were sown in October. Sreekala (1997) who studied the epilachna beetles of vegetables; found that multiplication of *E. septima* was high when the temperature is 27.6 ± 1.5^0C and relative humidity 89.5 ± 3 per cent. It took only 21.59 days for completion of one life cycle and during september males lived for 18.6 days and females for 22.4 days.

Mosaic disease has been major limiting factor for the successful cultivation of bitter gourd in majority of districts in Kerala (Mathew, 1996 a). Symptoms first appear as pale chlorotic patches in young leaves which is followed by typical curling, crinkling and mottling of leaves, and shortening of internodes. The early infection of mosaic results in distortion and severe stunting of plants. The fruits become undersized, malformed and yield also drastically reduced. Pillai (1971), Joseph and Menon (1981), Raghunadhan (1989), Vasudeva and Lal (1943), Singh and Dey (1976) and Singh (1989) reported the symptoms of mosaic from different parts of the country.

During the present study severe incidence of mosaic was noticed. Seasonal variation was also evident on the occurrence of mosaic. During the kharif season mosaic disease appeared as early as 25 DAS and became severe at 35 DAS. It was further delayed by five days to appear the mosaic during rabi. During summer the symptoms appeared late i.e., 50 DAS and it took another 20 days for the disease to become severe. According to Kassanis (1957) most of the plant viruses multiply less rapidly as the temperature rose from 30^{0}C and some ceased to multiply at temperature around 36^{0}C. Late occurrence of mosaic incidence during summer may be due to the high temperature of around 37.5^{0}C in the early stages of summer crop (Appendix I c).

During kharif season the mosaic incidence was zero to 24.99 per cent at 30 DAS which was increased to 61.11 to 86.11per cent at 60 DAS. Disease incidence during rabi was more than in kharif season i.e., 44.45 per cent at 30 DAS, 100 per cent at 60 DAS and 120 DAS. During summer, even though none of the plants were affected by mosaic at 30 DAS, all the plants succumbed to mosaic at 60 DAS; Latha (1992), Davis (1996) and Mathew (1996 a) also reported more incidence of mosaic during summer months than kharif season. Mosaic incidence was negatively correlated with rainfall and relative humidity and was positively correlated with temperature. According to Latha (1992) the heavy incidence of mosaic in pumpkin during dry months may be due to quick multiplicatuion of white fly which is a vector of mosaic disease.

Disease intensity also varied depending on the stage of crop and season. During kharif season the maximum intensity recorded was 51.52per cent at 30 DAS, 41.82 per cent at 60 DAS and 83.46 per cent at 120 DAS. During rabi it was 22.73 per cent at 30 DAS, 60.61 per cent at 60 DAS and 75.76 per cent at 120 DAS. It was 53.03 per cent at 50 DAS and 76.16 per cent at 120 DAS during summer. Reduction of disease intensity in certain treatments at 60 DAS than at 30 DAS may be due to uprooting and destruction of earlier infected plants during kharif season. The masking of mosaic symptom at 18.3^{0}C has been reported by Kassanis (1957) in muskmelon. The disease incidence and disease intensity did not have any relationship with each other.

The treatments with various levels and frequencies of organic manures and inorganic fertilizers did not affect the mosaic except at 30 DAS. The intensity was maximum in T_1 (33.33%) which received FYM at the rate of 25 t ha^{-1} alone and there was no disease in T_8 which received maximum N and K as 20 t ha^{-1} of FYM, 2.5 t ha^{-1} of poultry manure, 2.5 t ha^{-1} of fresh cow dung slurry drenching with 70:25:75 kg ha^{-1} of NPK. However such a relationship was not noticed in later stages of growth.

Downy mildew of cucurbits is widespread in tropical regions all over the world (Palti, 1974). The symptoms appear on the upper surface of leaves as angular yellow spots. During favourable condition under surface of the spots are covered with a greyish mouldy growth. As the spots enlarge, general yellowing of leaves occur resulting in death of tissue and withering and drying of leaves. As in other pests and diseases, the incidence and intensity of downy mildew were also influenced by weather conditions. During kharif season downy mildew appeared 50 DAS and the entire crop was infected within ten days. During rabi the disease appeared earlier i.e., 30 DAS and became severe after another 20 days. During summer the crop was not at all affected by downy mildew.

During rabi symptoms appeared early and entire crop was infected even at 30 DAS. During kharif season disease intensity ranged from 35.35 to 52. 42 per cent at 60 DAS. Palti and Rotem (1971) reported the effect of rainfall on the incidence of downy mildew. Royle (1976) found that *Pseudoperenospora* require wet plant surface for conidial germination. During the early stages of kharif season crop which was planted on May 30, there was no rain fall and the mean temperature ranged from 24.22 to 29.45^{0}C. Humidity was also less compared to later part of this crop. The rabi crop received a uniformly distributed rain fall during its early stage with humidity ranging from 72.5 to 86.5 per cent. The dry condition during the early stages of kharif season crop may be responsible for the late occurrence of downy mildew in the kharif season crop and the climatic condition in the later part of kharif season crop and the entire rabi season was highly conducive for development of the *Pseudoperenospora cubensis*. The high temperature, low humidity and absence of rain fall may be the reason for the absence of downy mildew during summer months. As in the case of mosaic disease, the incidence and intensity of downy mildew was also not affected by various treatments except at 30 DAS during rabi. The disease intensity was minimum in T_7 (19.54) which received 20 t ha^{-1} of FYM, 2.5 t ha^{-1} of poultry manure, 2.5 t ha^{-1} of fresh cow dung slurry drenching with 70:25:50 kg ha^{-1} of NPK and T_3 recorded maximum intensity of downy mildew. However in the later stages such a trend was not observed and all the treatments were equally affected by downy mildew.

Bitter gourd plants are characterised by indeterminate growth habit. Initially the seedlings grow up as a single vine supported by its unique tendrils. Before attaining reproductive phase, plants develop a number of lateral branches which also having apical dominance. In the later part of the growth phase, vegetative as well as the reproductive phases, are synchronised resulting in continuous vegetative growth and fruiting.

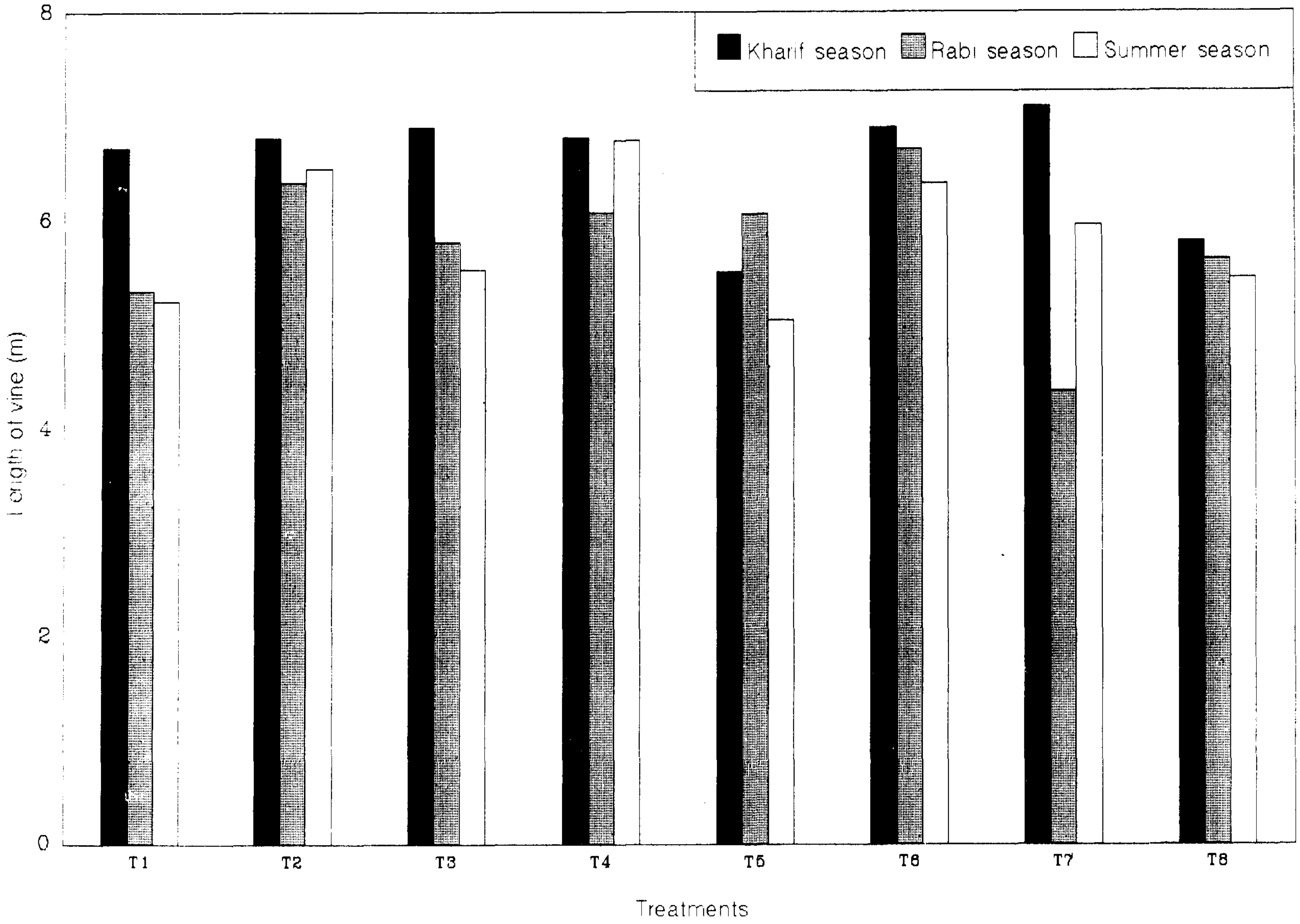

Fig.2 Length of vine with seasons in different treatments

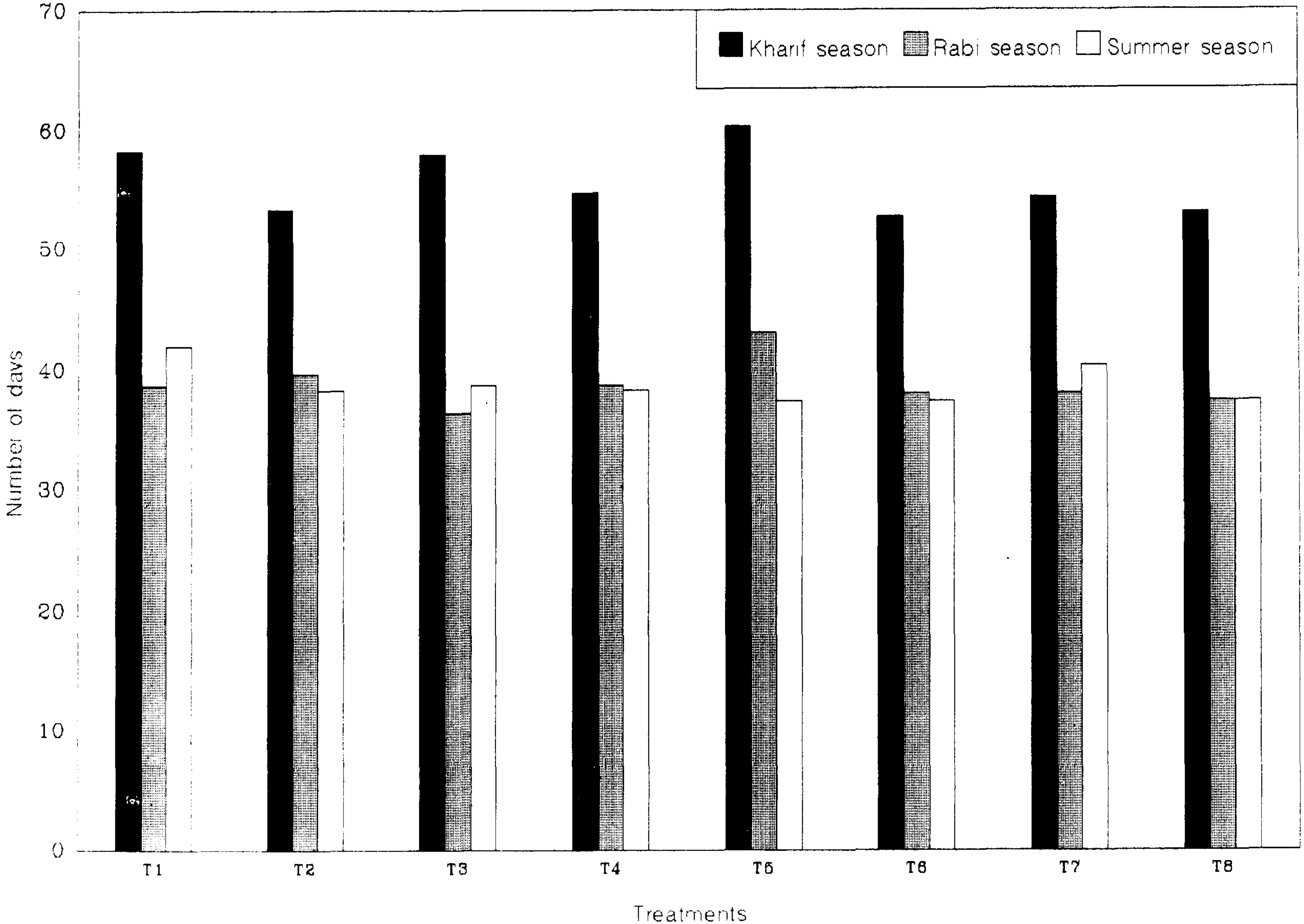

Fig.3 Days taken for the first female flower anthesis in different treatments over seasons

Table 37. Means of economic characters during kharif, rabi and summer seasons

Characters	Kharif (S_1)	Rabi (S_2)	Summer (S_3)
Length of vine (m)	6.60	5.80	5.90
Number of branches	14.50	19.63	14.96
Days to first male flower anthesis	46.67	35.76	33.92
Node at which the first male flower is formed	11.75	11.92	11.13
Days to first female flower anthesis	55.50	38.71	38.71
Node at which the first female flower is formed	22.25	17.92	15.42
Days to first harvest	67.54	52.09	48.79
Fruiting period	59.79	65.50	56.21
Marketable yield (kg per $16m^2$)	11.35	16.46	12.05
Unmarketable yield (kg per $16m^2$)	6.89	3.07	4.40
Total yield (kg per 16 m^2)	17.81	19.36	13.75
Number of marketable fruits per plot (16 m^2)	102.25	178.67	176.75
Number of unmarketable fruits per plot (16 m^2)	138.38	62.33	26.71
Total number of fruits per plot (16 m^2)	244.38	241.00	203.54
Number of harvests	8.29	10.50	10.33
Length of fruit (cm)	24.00	23.61	19.83
Girth of fruit (cm)	17.00	17.13	15.67
Average fruit weight (g)	228.63	247.58	192.96

In the present study vegetative characters like length of vine and number of branches didn't show significant variation with different seasons. However vine length was maximum during kharif season (6.6 m) and during rabi and summer seasons it was almost equal (5.8 to 5.9 m) (Fig. 2). The number of branches were maximum during rabi (19.63). Incidence of pests and diseases especially jassids and mosaic has influenced growth of plants. Though not significant, the increase in vine length during kharif season may be due to low and late incidence of mosaic. Jayasree (1984), Pandey and Joshi (1989) observed a reduction in length of vine due to mosaic. Bose and Som (1986) also observed increase in vine length and plant spread during kharif season compared to summer.

Variation in length of vine and the number of branches, due to different sources and levels of nutrients were significant during kharif season only. The non significance of the above characters due to different treatments during rabi and summer seasons may be due to the severe incidence of mosaic. In both the seasons mosaic incidence at the peak fruiting stage was almost complete. In the kharif season maximum vine length was in T_7 (7.10m) which received 20 t ha^{-1} of FYM, 2.5 t ha^{-1} of poultry manure, 2.5 t ha^{-1} of fresh cow dung slurry drenching at fort nightly interval with 70:25:50 kg ha^{-1} of NPK. The treatment T_5, which recorded minimum vine length (5.8 m) had maximum number of branches, indicating a negative association of both the characters. According to Pandey and Joshi (1989) early infection of mosaic virus in bitter gourd significantly decreased the thickness and length of vine and productivity.

Earliness, duration of fruiting and frequency of harvests are important economic characters in bitter gourd. Vegetables reaching early in the market fetches

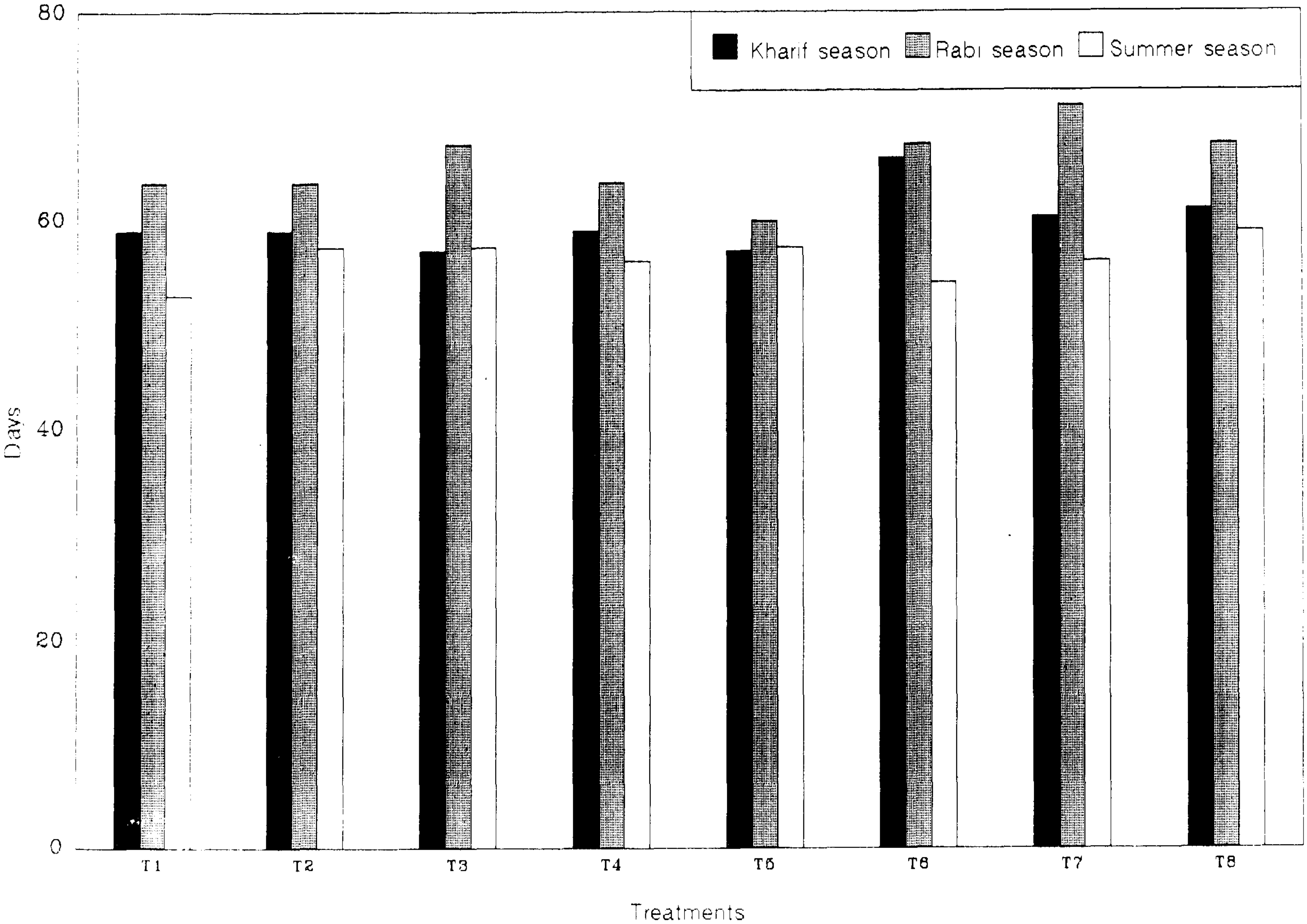

Fig.4 Seasonal variation for fruiting period with different treatments

premium price. Days taken for the first male and female flower opening, days to first and last harvest varied significantly with seasons. Days to first male flower opening was minimum during summer (33.92 days). While it was maximum during kharif season (46.67 days). Days to first female flower opening (Fig. 3) and days to first harvest also recorded same trend; and early crop was harvested during summer. The summer and rabi crops recorded almost equal values for all the above characters. However, duration of fruiting period was minimum (56.21 days) during summer (Fig. 4). During kharif season the plants flowered very late and the total number of harvests was minimum. Duration of fruiting period and number of harvests were maximum during rabi (65.50 and 10.50 respectively). Maximum growth and fruiting during rabi may be due to the ideal temperature (26.1 to 28.2^{0}C), optimum rain fall and humidity during the cropping period. Nath *et al.* (1987) also reported maximum growth and fruiting at an optimum temperature of 24 to 27^{0}C in bitter gourd.

Pooled analysis of the data revealed significant variation due to different treatments for the days to first female flower anthesis. The treatment T_8 which received 20 t ha^{-1} of FYM, 2.5 t ha^{-1} of poultry manure, 2.5 t ha^{-1} of fresh cow dung slurry drenching at fortnightly interval with 70:25:75 kg ha^{-1} of NPK produced female flowers earlier and it was on par with T_6, T_4 and T_7. During kharif season female flowers were first born in T_6 (52.67 days) followed by T_8 (53 days). During rabi female flower emergence was much earlier and all the treatments except T_5 produced female flowers within a range of 36 to 39 days. Earliness in flowering and fruiting and less duration during summer in the present study may be due to the high temperature (25.7 to 31.7^{0}C). Lyutova and Kamontseva (1992) also observed earlier yield when

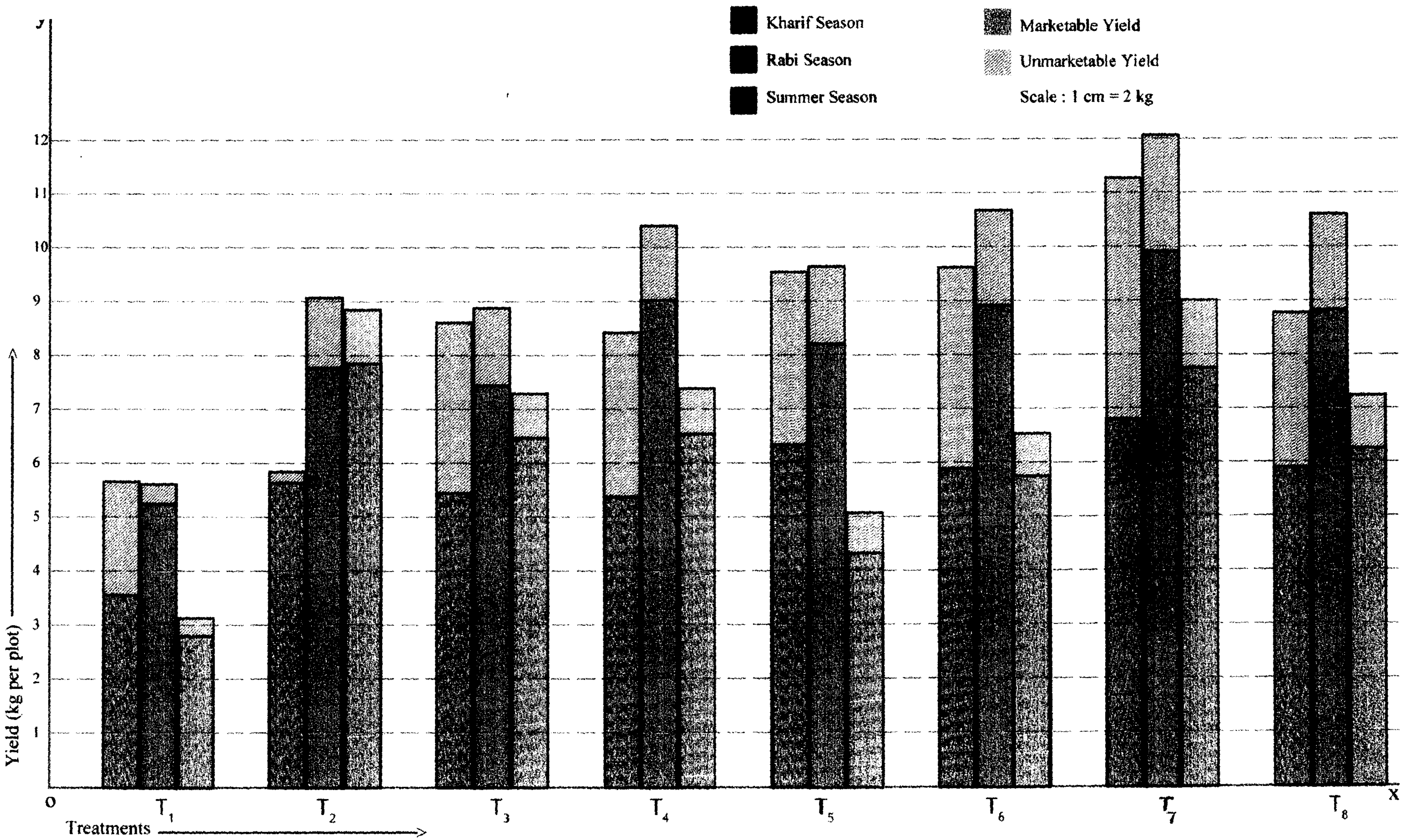

Fig. 5. Variation in total marketable and unmarketable yield (kg. per 16m²) with seasons in different treatments.

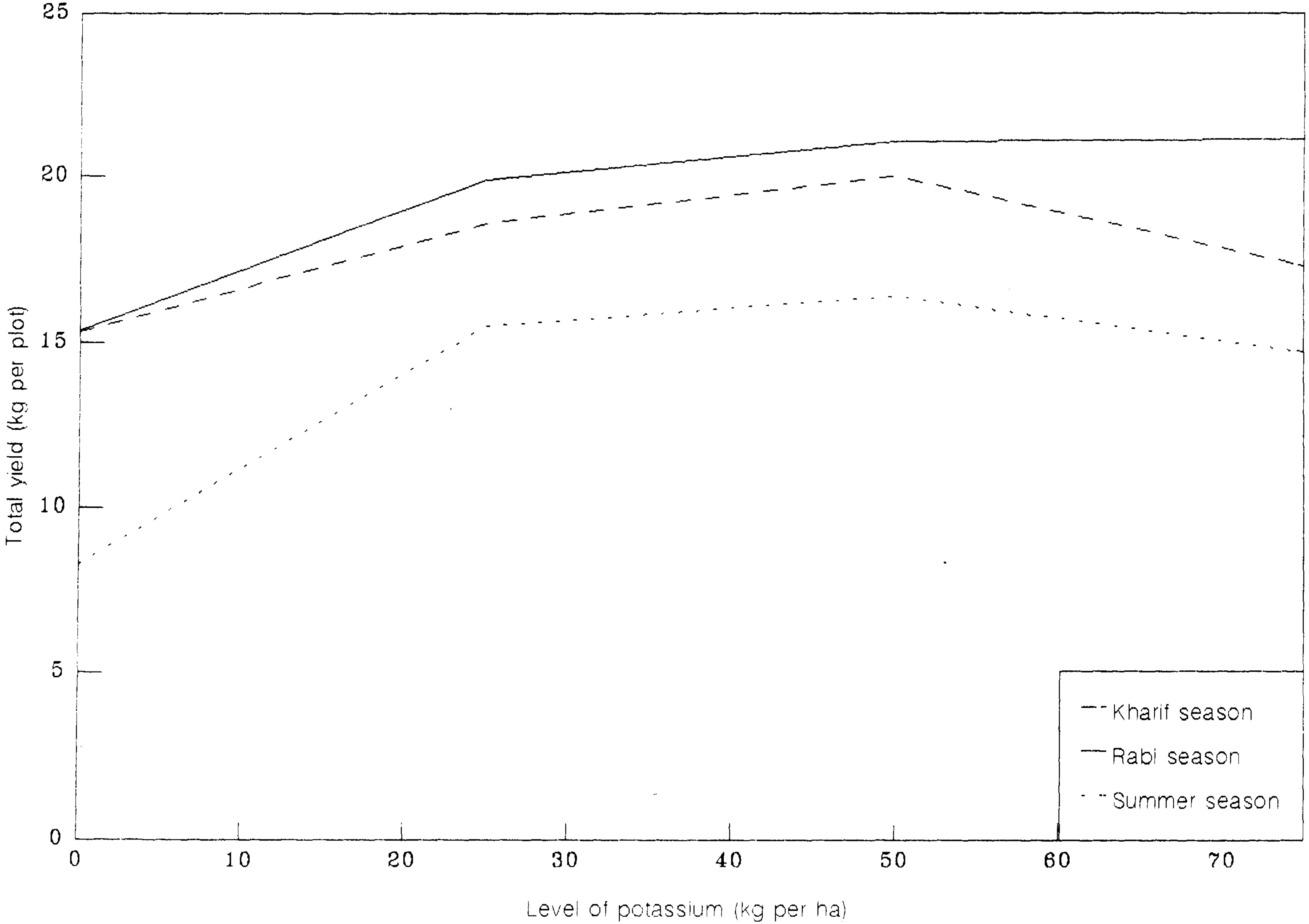

Fig. 6 Response curve of potassium for total yield

cucumber was sown in January. Davis (1996) also found earlier female flower emergence in February sown crop.

The days taken for the first female flower opening varied significantly with different sources and levels of nutrients at different seasons (Fig. 3). T_5 took maximum days for opening of first female flower (46.89), followed by T_1 (46.11) which received organic manures only. The treatment T_8 which received maximum organic and inorganic nutrients showed earlier flowering. Significant variation due to treatment was observed in the days taken for the first female flower opening during kharif and rabi seasons. Late flowering was observed in T_5 in both kharif and summer (60.33 and 43 days respectively) which received 20 t ha^{-1} of FYM, 2.5 t ha^{-1} of poultry manure and 2.5 t ha^{-1} of fresh cow dung slurry drenching at fortnightly interval. Even though the variation due to treatment was not significant during summer, the treatment T_1 which received organic manure alone as 25 t ha^{-1} of FYM recorded maximum number of days (42) for the opening of first female flower.

Productivity of a crop is the result of a conglomeration of factors including its genetic potential, climatic and soil conditions in which it is grown and the management practices followed. This is true in bitter gourd where different varieties or cultivars are grown in the state under different climate and soil conditions, following different management practices depending on the local situations. The crop is highly responsive to manures and fertilizer application and the intake of nutrients depends on the quantity as well as frequency of application.

In the present study, total yield varied significantly with seasons (Fig. 5). Significant seasonal variation was also observed in the marketable yield per plot, total number of fruits per plot (Fig. 7), number of harvests, length of fruit (Fig. 9) and girth of fruit (Fig. 11). The maximum yield was recorded from rabi season (19.36 kg per 16 m^2) followed by kharif season (17.8 kg per 16 m^2) and it was minimum in summer (13.75 kg. per 16 m^2) (Table 37). According to Matsuo (1968) seasonal variation in the yield of cucurbits was due to difference in temperature and photoperiod. The seasonal influence on yield may be through different ways such as the influence on sex differentiation, pollination, germination, fruit set etc. Bose and Ghosh (1970) reported that short days help in increasing female flower production in bitter gourd. According to Nath *et al.* (1987) the optimum temperature for fruiting in bitter gourd is 24 to 27^{0}C. In the present study the optimum temperature was attained in rabi (26.1 to 28.2^{0}C) and in kharif season (24.2 to 29.5^{0}C).

Maximum yield during rabi was due to extended fruiting period, maximum number of harvests and due to increase in the fruit size as evidenced by maximum length (23.61 cm), girth (17.13 cm) and average weight (247.58 g) of fruit. Marketable yield (fruits without any pest and disease) was also maximum during rabi. It is due to the low infestation by fruit fly during rabi compared to other seasons. Davis (1996) also observed highest yield in bitter gourd in October sown crop.

Even though the kharif season crop ranked second in total yield, marketable yield was very low(Fig. 5). This was due to maximum incidence of fruit fly during kharif season. The loss due to fruit fly attack was as high as 39.56 per cent on weight basis and 57.67 per cent on number basis. The number and weight of unmarketable fruits during kharif season was 138.38 and 6.89 kg per 16 m^2 respectively compared to 62.33 and 3.07 kg during rabi. This is in accordance with Davis (1996) who observed severe incidence of fruit fly in April sown bitter gourd crop and minimum incidence in September sown crop

Table 38. Overall treatment means for vegetative and productive characters

Treatments	Length of vine (m)	Number of branches	Days to first male flower anthesis	Node at which the first male flower is formed	Days to first female flower anthesis	Node at which first female flower is formed	Days to first harvest	Fruiting period	Marketable yield (kg per 16 m^2)	Unmarketable yield (kg per 16 m^2)	Total yield (kg per 16 m^2)	Number of marketable fruits per plot (16 m^2)	Number of unmarketable fruits per plot (16 m^2)	Total number of fruits per plot (16 m^2)	Number of harvests	Length of fruit (cm)	Girth of fruit (cm)	Average fruit weight(g)
T_1	5.63	15.44	39.00	12.56	46.11	18.56	57.89	58.44	7.85	2.18	9.72	102.78	50.67	153.44	9.22	20.49	15.07	188.50
T_2	6.45	17.33	39.00	12.78	43.78	17.44	57.11	60.00	14.29	3.67	17.96	165.78	82.33	248.11	9.78	23.00	17.27	221.77
T_3	6.04	18.11	38.56	9.67	44.33	16.67	55.78	60.56	13.02	3.62	16.64	156.33	70.89	227.44	9.78	23.50	16.51	230.23
T_4	6.50	17.89	37.89	11.67	43.89	21.89	56.78	59.56	14.08	3.51	17.59	158.67	68.43	227.11	9.56	22.41	16.48	221.03
T_5	5.70	16.44	41.56	12.22	46.89	18.33	58.67	58.11	12.71	3.59	16.30	150.11	64.67	224.78	9.44	22.08	16.23	237.90
T_6	6.64	15.11	38.89	11.11	42.67	18.11	53.89	62.44	13.83	4.18	18.01	153.22	84.99	238.22	9.89	22.54	17.17	228.20
T_7	5.81	15.22	37.89	11.13	44.22	19.07	55.11	62.44	16.43	5.28	21.68	174.33	95.45	270.00	9.87	23.47	17.80	224.30
T_8	5.63	15.33	37.11	11.44	42.55	17.56	53.89	62.44	14.10	4.92	17.86	159.00	89.01	248.00	10.11	22.30	16.27	212.53

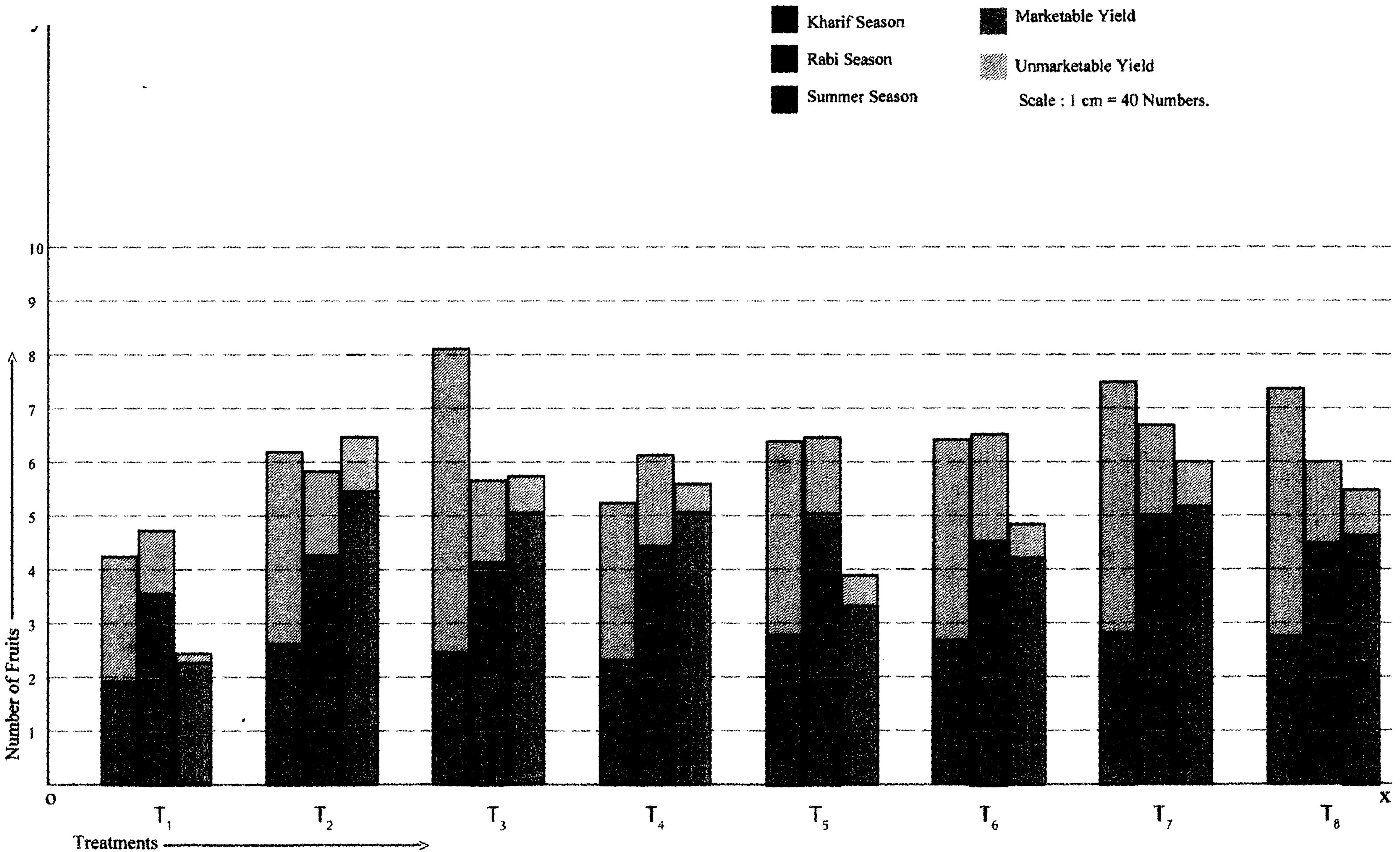

Fig. 7. Seasonal variation in the total number of fruits, number of marketable and unmarketable fruits with different treatments

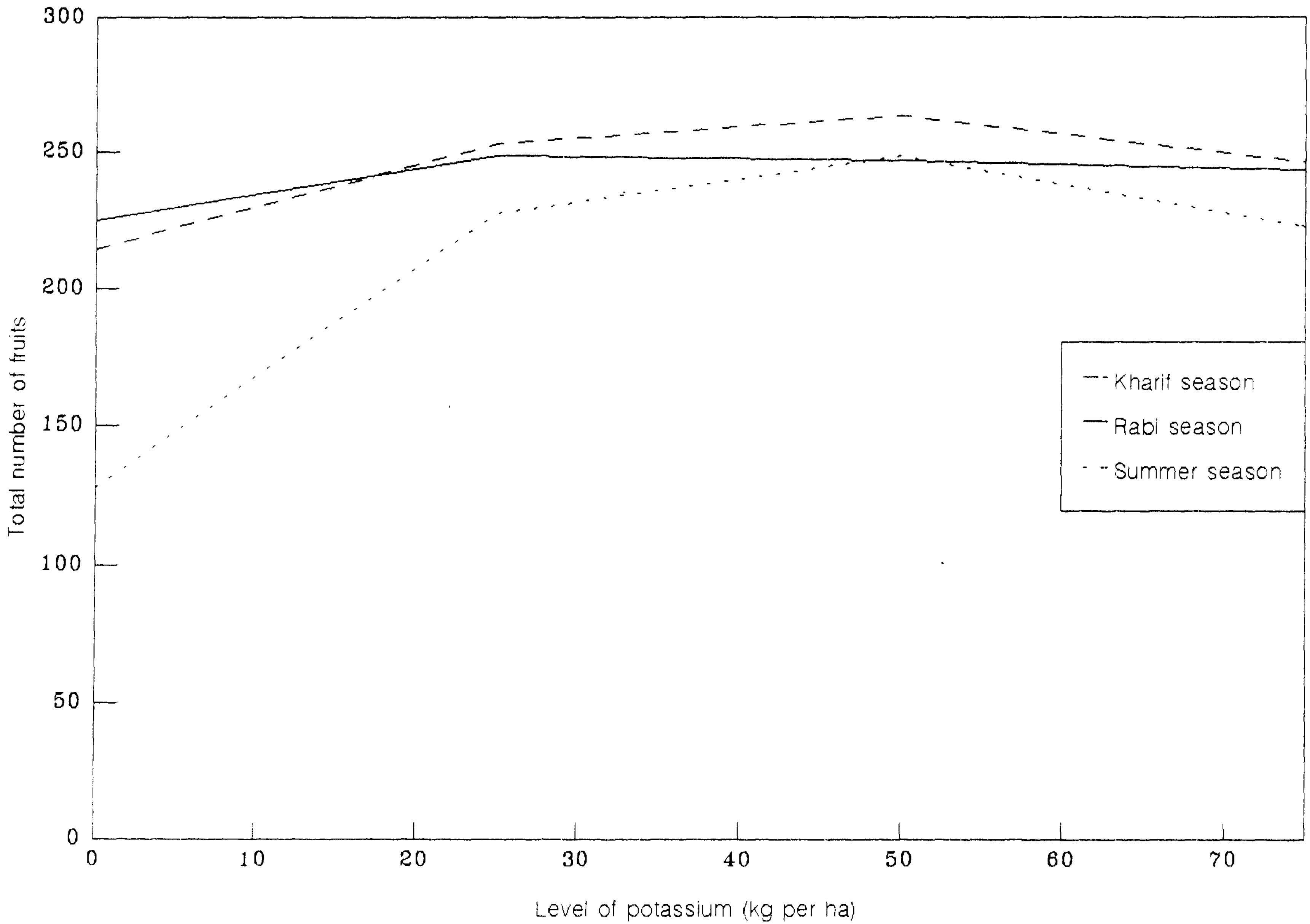

Fig. 8 Response curve of potassium for total number of fruits

In spite of maximum number of harvests (10.33) and minimum loss of fruits due to infestation of fruit fly (4.40 kg per plot or 26.71 numbers of fruits), the total yield during summer season was very low. It was due to reduction in size of fruits as evidenced by the minimum length (19.83 cm), girth (15.67 cm) and average fruit weight (192.96 g) (Fig. 13). Low yield during summer may also be due to the high mean temperature (25.7 to 31.7^{0}C) than the optimum (24 to 27^{0}C) which made a congenial condition for out break of mosaic incidence and jassid infestation, ultimately reducing the yield. Even after a regular spray of organic pesticides, the jassid infestation could not be controlled and the summer crop showed severe hopper burn symptom.

Significant variation was observed due to the different sources and levels of organic and inorganic nutrients on total yield (Fig. 6), marketable yield, total number of fruits (Fig. 8), average fruit weight (Fig. 14), length of fruit (Fig. 10), girth of fruit (Fig. 12) and number of harvests. The treatment T_7 recorded maximum total yield (21.68 kg per 16 m^2), total number of fruits (270.0), marketable yield (16.43 kg per 16 m^2), number of marketable fruits (174.33) and girth of fruit (17.80 cm). The length of fruit was maximum in T_3 (23.50 cm) which was on par with T_7 (23.47 cm). The treatment T_7 also had a fruit weight of 224.30 g which is on par with T_5 (237.90 g). The number of harvests was maximum in T_8 (10.11) closely followed by T_7 (9.81) (Table 38). Srivastava and Srivastava (1976) and Ramachandran (1978) reported a positive correlation for yield with number of female flowers, number of fruits and lateral branches, fruit weight and length in bitter gourd.

According to Nath *et al.* (1994) all gourds, cucumber and pumpkin respond well to manuring and fertilizer application, revealing the increase in yield of cucurbits.

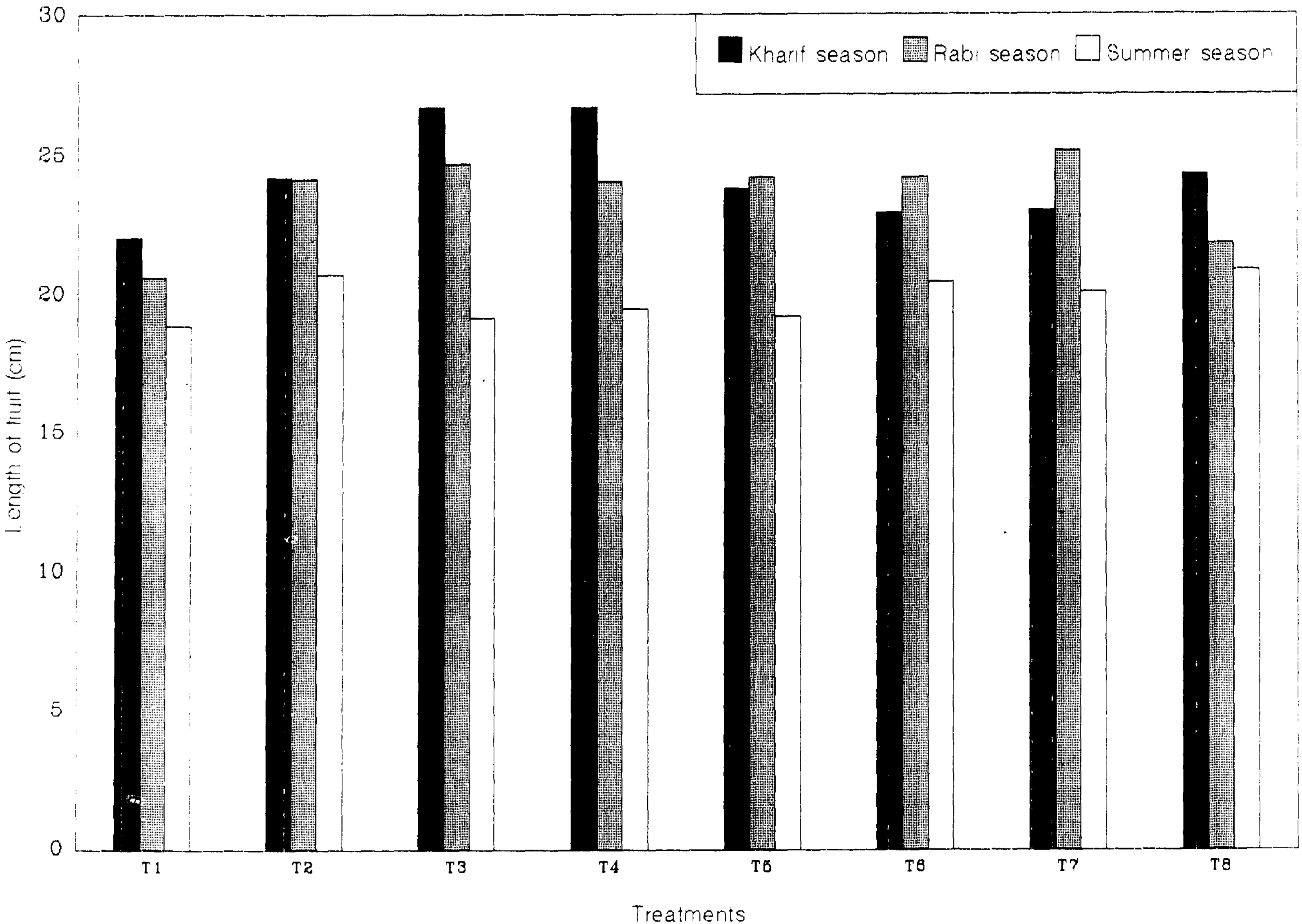

Fig. 9 Length of fruit with different treatments over seasons

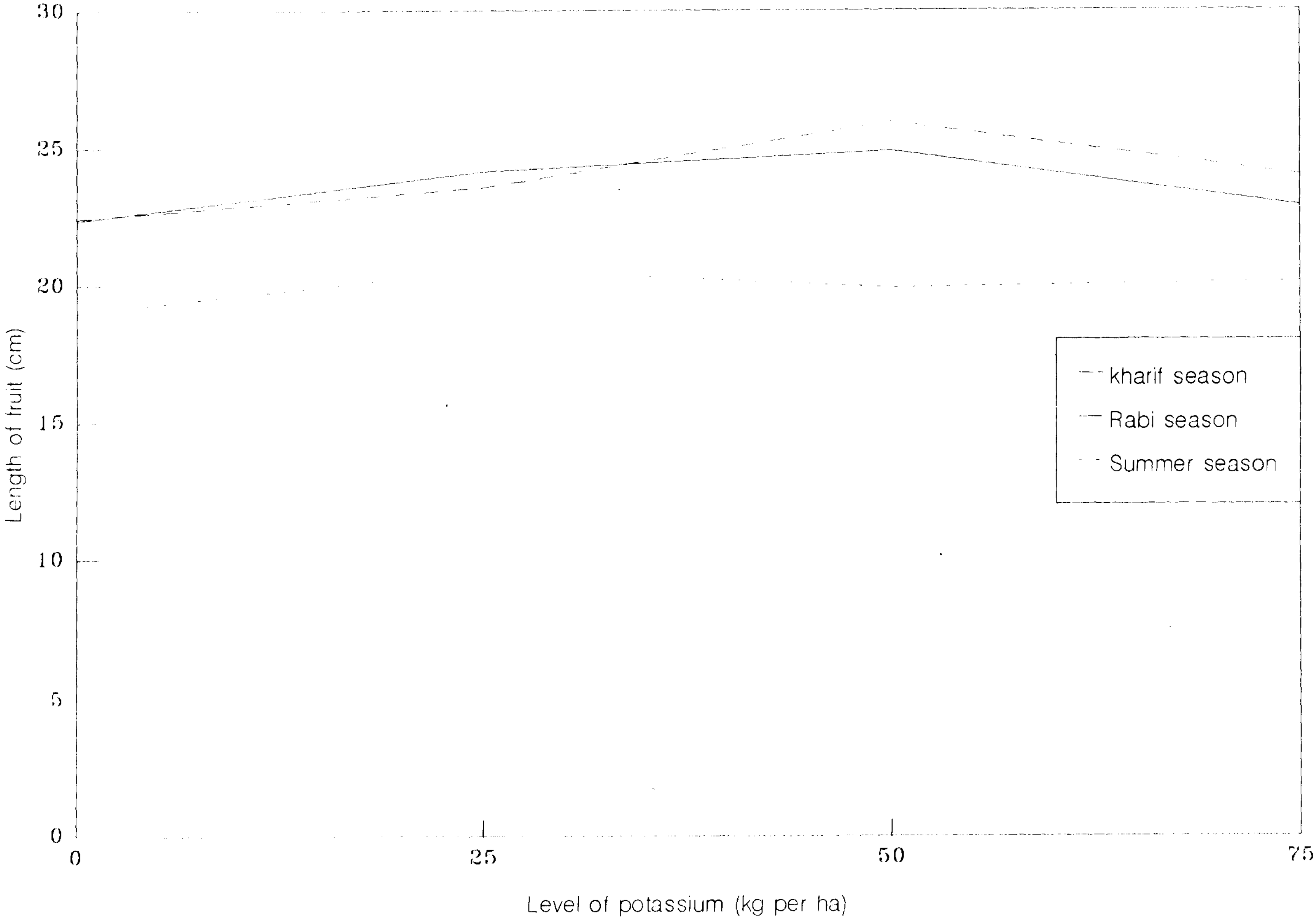

Fig.10 Response curve of potassium for length of fruit

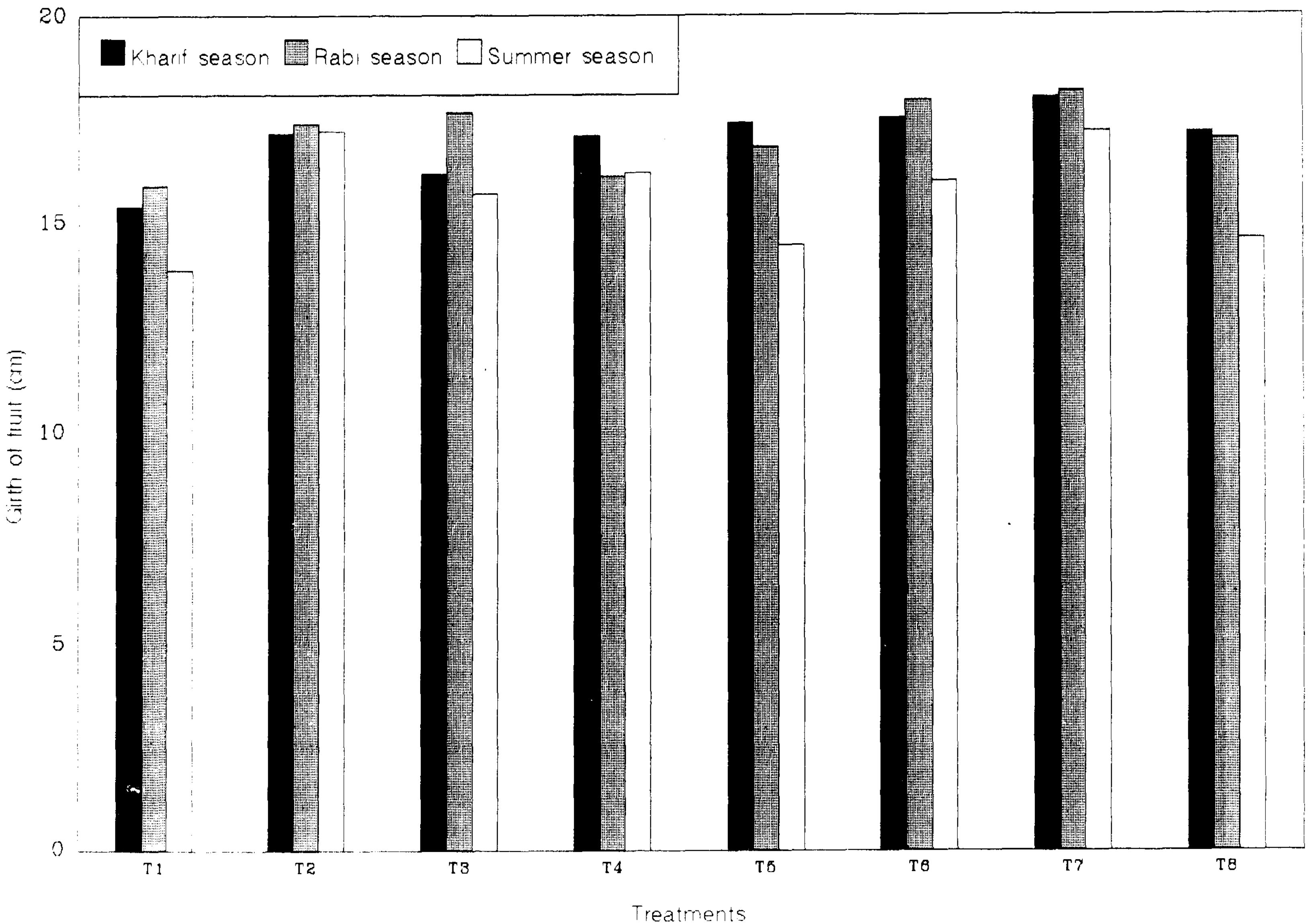

Fig. 11 Seasonal variation for girth of fruit with different treatments

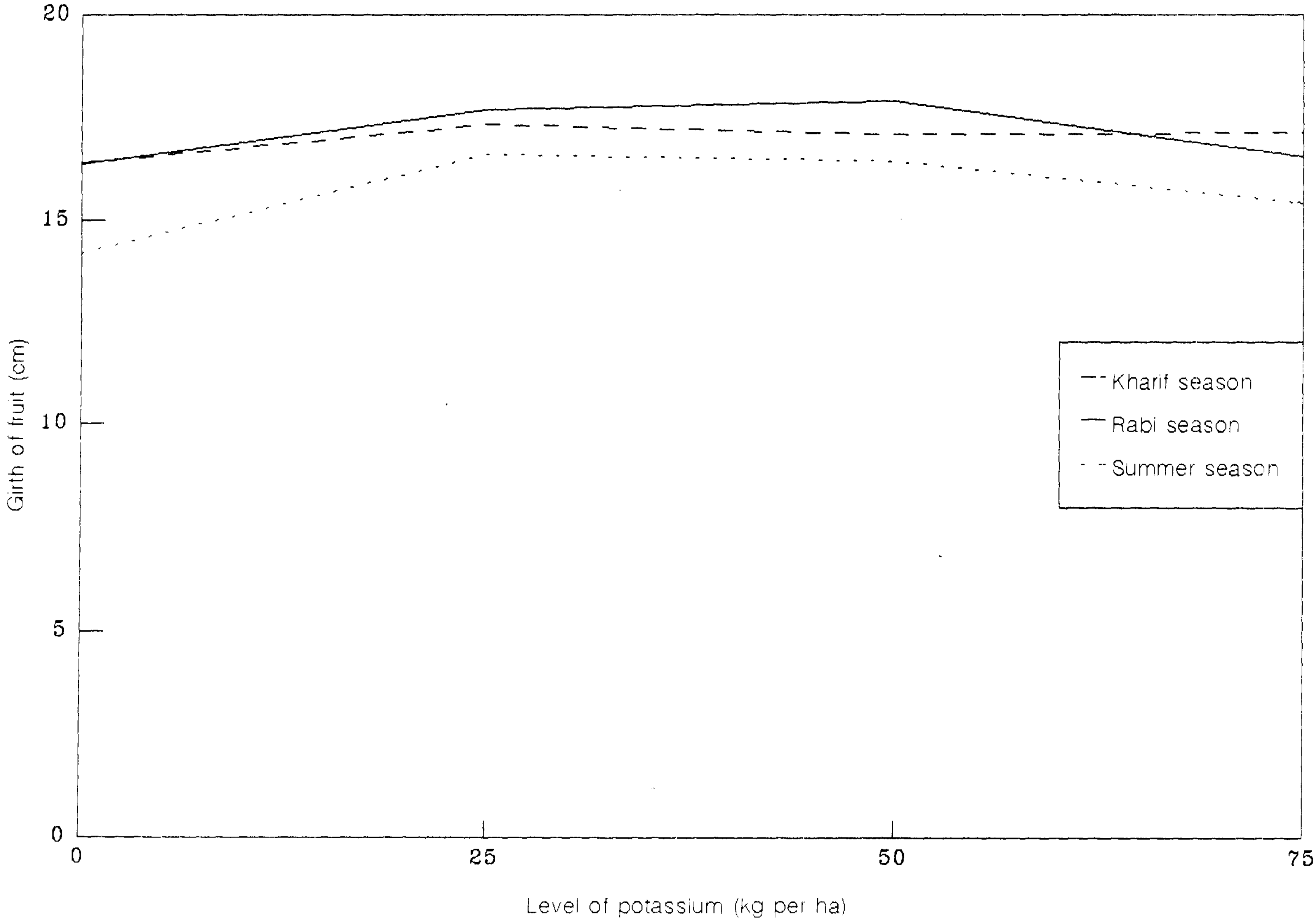

Fig. 12 Response curve of potassium for girth of fruit

During the present study all the economic characters were more in T_5 than that of T_1. This reveals the possibility of getting a medium yield by use of organic manures and organic concentrates. Basal dose of 20 t ha^{-1} dried cow dung with application of sufficient quantity of poultry manure and fresh cow dung slurry has yielded just double than the yield from 25 t ha^{-1} of dried cow dung alone and all the economic characters were better expressed in T_5 than in T_1. This clearly indicates the need of organic manures like poultry manure or cowdung slurry as top dressing. Das *et al.* (1987) reported that higher rates of nitrogen application always showed a positive effect on growth and development in pointed gourd. Sharma and Shukla (1972) observed a significant increase in yield of pumpkin with increased level of nitrogen. Bishop *et al.* (1969) showed that phosphorus was of greater importance in yield response than nitrogen or potassium. The plants receiving minimum potassium (25 kg ha^{-1}) and the plants receiving maximum potassium (75 kg ha^{-1}) recorded almost equal values for all the economic characters indicating that there is no beneficial effect by applying a very high dose of potassium. In the present study maximum yield was from 50 kg ha^{-1} of potassium than 25 kg ha^{-1} and 75 kg ha^{-1}. Penny *et al.* (1976) observed a markedly poor growth of cucumber in potassium deficient soil. According to Srinivas and Doijode (1984) application of potassium fertilizer increased the percentage of perfect flowers in muskmelon.

During the present study T_1 recorded minimum values for yield (9.72 kg per 16 m^2), total number of fruits (153.44), marketable yield (7.85 kg per 16 m^2) number of marketable fruits (102.78), average fruit weight (188.5 g), length (20.49 cm) and girth (15.07 cm.) of fruit and vegetative characters. It may be due to the lack of optimum nutrients for the growth and development of plants. An earlier experiment

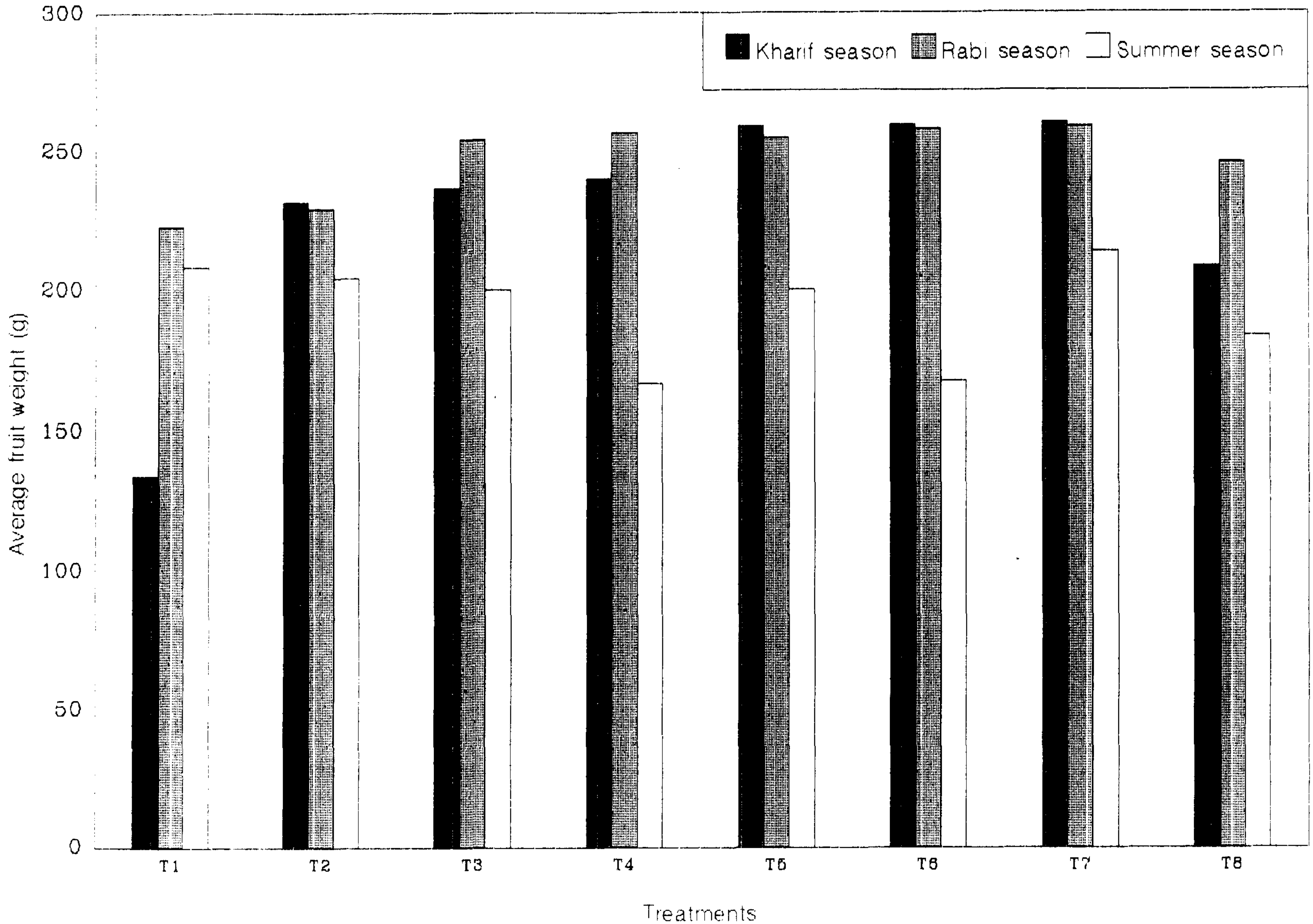

Fig. 13 Average fruit weight with seasons in different treatments

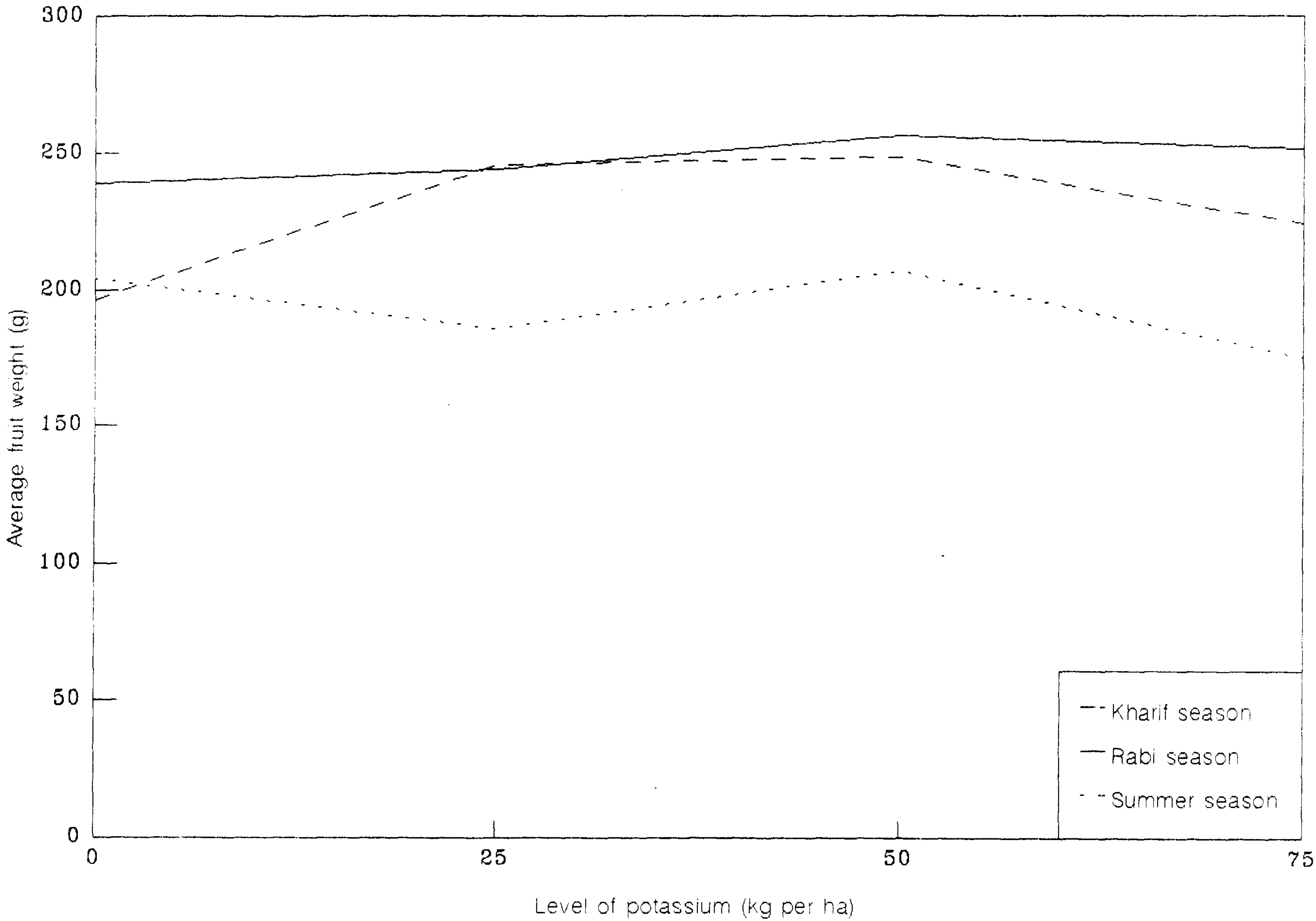

Fig. 14 Response curve of potassium for average fruit weight

conducted at the College of Horticultre, Vellanikkara also revealed poor fruit set at a very low dose of nitrogen and phosphorus (KAU.,1983).

Mahakal *et al.* (1977) reported that an optimum dose of N, P and K at 75:50:100 kg ha^{-1} for *Citrullus vulgaris* var. *fistulosus*. But the highest fertilizer dose, 75:100:150 kg ha^{-1} of NPK gave only a slight increase in yield. A study based on the effect of graded doses of N, P, and K on growth and yield of bitter gourd has also revealed that maximum yield was recorded when nutrients were given at the rate of 50:25:50 kg ha^{-1} (KAU., 1981). Ravikrishnan (1989) reported maximum yield of bitter gourd which received 90:25:50 kg ha^{-1} of NPK. The study conducted by Thomas (1984) based on the response of bitter gourd to different fertility levels revealed maximum yield from plants receiving 60:30:60 kg ha^{-1} of NPK. From the above findings it is evident that the maximum yield of bitter gourd was obtained from plants receiving P and K in the ratio 1:2, Therefore in the present investigation, maximum productivity of bitter gourd plants in the treatment T_7 may also be due to availability of optimum levels of P and K in the ratio 1:2. The treatment T_7 received 20 t ha^{-1} of FYM as basal, 2.5 t ha^{-1} of poultry manure at the vining stage and fresh cow dung slurry drenching at fortnightly interval with 70:25:50 kg ha^{-1} of NPK @ 50 per cent of N, full P and 50 per cent of K as basal, remaining 50 per cent of N in five equal splits at fortnightly interval and K in two equal splits at 30 and 45 days after sowing.

Summary

6. SUMMARY

The investigation on "Nutritional management of bitter gourd (*Momordica charantia* L.) in relation to pest and disease incidence" was conducted during three seasons viz. kharif (May to October 1997), rabi (September 1997 to January 1998) and summer (January to May 1998) in the Department of Olericulture, College of Horticulture, Vellanikkara in the variety Preethi. The experiment was laid out in completely randomised block design with eight treatments and three replications. Different sources, levels and frequencies of application of organic manures and inorganic fertilizers constituted the eight treatments. Results of the present investigation are summarised below:

The major pests and diseases affecting bitter gourd in different seasons at Vellanikkara were fruit fly, (*Bactrocera* cucurbitae), jassids (*Empoasca motti*), epilachna beetle (*Henosepilachna septima*), downy mildew (*Pseudoperenospora cubensis*) and mosaic. None of the treatments comprising of different sources, levels and frequencies of application of organic manures and inorganic fertilizers were effective for the control or management of pests and diseases.

Occurrence of fruit fly infestation started with the emergence of female flowers and it varied with season. Loss due to fruit fly infestation was maximum during kharif season (57.67%) and minimum during summer (12.63%) on fruit number basis. Same trend was observed in fruit weight also. Infestation started at 45 DAS, became severe at 90 DAS during kharif season and at 93 DAS during summer. Fruit fly infestation was late during rabi (120 DAS).

The incidence and intensity of jassid infestation was maximum during summer and infestation started as early as 20 DAS causing severe hopper burn symptom, stunting and crop loss. Eventhough jassid population was recorded typical yellowing and hopper burn symptom were not noticed during kharif and rabi season.

Even though grubs and adults of epilachna beetle were observed during all the three seasons, the infestation became severe only during rabi season. The beetles were noticed at 20 DAS during rabi and attained maximum infestation (83.82%) at 115 DAS. The population of epilachna beetle during kharif and summer season were under control by the use of organic insecticides.

Mosaic incidence was minimum during kharif season and maximum (100%) during summer and rabi. Intensity of mosaic and crop loss was also maximum during summer months. Variation in mosaic incidence due to different sources, levels and frequency of application of nutrients were significant at 30 DAS during rabi. However, during later stages all the treatments were totally affected by mosaic.

Downy mildew was maximum during rabi followed by kharif season. As the kharif season crop was planted in the later part of summer, the days for the first incidence of downy mildew was delayed up to 50 days while it took only 30 days during rabi. The summer crop was completely free from downy mildew. Disease intensity varied significantly with different sources and levels of nutrients at 30 DAS during rabi and maximum disease intensity was in T_3(44.50%) and minimum in T_7 (19.54%). However, during the later stages treatments did not have any effect on the incidence and intensity of downy mildew.

Seasonal variation was significant for the expression of the economic characters like days taken for first male and female flower opening, days taken for first and last harvest, total yield, total number of fruits, marketable yield, length, girth and average weight of fruits.

Due to the mild climate and less incidence of jassids and mosaic disease, the total productivity was maximum during rabi season (19.36 kg per 16 m^2) followed by kharif season crop (17.18 kg per 16 m^2). Due to severe incidence of mosaic and jassids, the summer crop recorded minimum yield (13.75 kg per 16 m^2). Even though the kharif season crop ranked second in productivity the marketable yield was minimum mainly due to great loss by fruit fly infestation. Average size of fruit in terms of weight (247.58 g), length (23.61 cm) and girth (17.13 cm) was maximum during rabi season.

Pooled analysis revealed significant variation with different sources and levels of organic and inorganic nutrients for seven characters viz. days to first female flower opening, total yield, total number of fruits, marketable yield, length, girth and average weight of fruit.

The treatment T_7 which received 20 t ha^{-1} of FYM, 2.5 t ha^{-1} of poultry manure, 2.5 t ha^{-1} of fresh cowdung slurry drenching with NPK @ 70:25:50 kg ha^{-1} had maximum productivity during all the three seasons.

Average fruit weight, length of fruit, girth of fruit and length of main vine were maximum in the treatment T_7 during kharif and rabi seasons.

Yield in T_5 which received 20 t ha^{-1} of FYM as basal and 2.5 t ha^{-1} of poulty manure at vining stage and 2.5 t ha^{-1} of fresh cowdung slurry drenching at fortnightly interval was double than that of T_1 which received 25 t ha^{-1} of FYM only.

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* Originals not seen

APPENDIX I a

Weather parameters during kharif season

Weeks	Period	Maximum Temperature (^0C)	Minimum Temperature (^0C)	Mean Temperature (^0C)	Humidity (%)	Total rainfall (mm)
1	28 May to 3 June	34	24.9	29.45	73.0	a
2	4 to 10	33.7	23.2	28.45	74.0	a
3	11 to 17	31.1	23.2	27.15	80.0	a
4	18 to 24	31.3	23.2	27.25	85.0	a
5	25 June to 1 July	26.6	21.8	24.20	95.0	a
6	2 to 8	27.7	22.1	24.90	88.0	239.5
7	9 to 15	28.8	22.3	24.20	93.0	192.5
8	16 to 22	29.8	22.8	26.30	86.0	207.0
9	23 to 29	29.0	22.7	25.85	91.5	252.1
10	30 July to 5 August	29.1	23.3	26.20	86.5	143.6
11	6 to 12	27.7	21.9	24.80	89.0	280.5
12	13 to 19	29.6	23.1	26.40	83.5	24.3
13	20 to 26	29.6	22.9	26.30	87.0	151.8
14	27 August to 2 September	28.9	23.4	26.20	84.5	71.2
15	3 to 9	30.4	23.0	26.70	83.0	5.4
16	10 to 16	31.4	23.1	27.30	79.0	55.2
17	17 to 23	29.5	22.7	26.10	86.5	76.1
18	24 to 30	30.8	24.3	27.60	81.5	26.1
19	1 to 7 October	31.7	24.7	28.20	78.5	13.2

a - absent

(Date of sowing 28 May 1997)

APPENDIX I b

Weather parameters during rabi season

Weeks	Period	Maximum Temperature (°C)	Minimum Temperature (°C)	Mean Temperature (°C)	Humidity (%)	Total rainfall (mm)
1	17 to 23 September 1997	29.5	22.7	26.10	86.5	76.1
2	24 to 30	30.8	24.3	27.60	81.5	26.1
3	1 to 7 October	31.7	24.7	28.20	78.5	13.2
4	8 to 14	33.3	23.1	28.20	72.5	84.3
5	15 to 21	32.4	23.6	28.00	74.0	53.1
6	22 to 28	31.7	23.5	27.60	78.0	28.9
7	29 October to 4 November	31.7	23.1	27.40	78.0	45.5
8	5 to 11	31.6	24.2	27.30	78.0	74.6
9	12 to 18	32.0	23.3	27.60	77.5	30.4
10	19 to 25	33.7	22.1	27.90	79.5	74.4
11	26 November to 1 December	34.2	24.3	27.80	75.5	1.6
12	2 to 8	34.6	24.3	27.30	73.5	23.1
13	9 to 15	34.8	23.3	28.00	74.0	43.6
14	16 to 22	34.4	23.4	28.10	74.0	a
15	23 to 31	33.4	23.6	27.40	67.0	a
16	1 to 7 January 1998	35.3	24.3	27.90	59.5	a
17	8 to 14	35.9	23.6	27.70	61.0	a
18	15 to 21	35.5	23.8	27.90	69.5	a

a - absent

(Date of sowing 17 September 1997)

APPENDIX I c

Weather parameters during summer season

Weeks	Period	Maximum Temperature (°C)	Minimum Temperature (°C)	Mean Temperature (°C)	Humidity (%)	Total rainfall (mm)
1	15 to 21 January 1998	35.5	23.8	29.70	64.5	a
2	22 to 28	37.5	23.7	30.60	64.0	a
3	29 January to 4 February	36.2	22.9	29.60	69.0	11
4	5 to 11	37.5	25.1	31.30	61.5	a
5	12 to 18	36.4	26.1	31.30	69.0	a
6	19 to 25	36.6	26.8	31.70	69.0	4.2
7	26 February to 4 March	35.9	24.6	30.30	71.5	57.2
8	5 to 11	35.2	25.5	30.40	75.0	4.8
9	12 to 18	35.5	25.3	30.40	73.5	80.4
10	19 to 25	32.4	24.1	28.30	82.5	107.4
11	26 March to 1 April	33.6	25.7	29.70	76.5	11.0
12	2 to 8	34.4	25.2	29.80	74.5	24.4
13	9 to 15	32.0	23.9	27.50	81.5	65.7
14	16 to 22	30.0	23.1	26.60	87.5	118.0
15	23 to 29	29.0	22.4	25.70	87.5	257.3
16	30 April to 6 May	27.8	23.8	25.80	92.0	368.7

a - absent

(Date of sowing 15 January 1998)

NUTRITIONAL MANAGEMENT OF BITTER GOURD (*Momordica charantia* L.) IN RELATION TO PEST AND DISEASE INCIDENCE

BY

C. R. REKHA

ABSTRACT OF THE THESIS

Submitted in partial fulfilment of the

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COLLEGE OF HORTICULTURE

VELLANIKKARA, THRISSUR

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ABSTRACT

Investigation on "Nutritional management of bitter gourd (*Momordica charantia* L.) in relation to pest and disease incidence" was conducted at the College of Horticulture, Kerala Agricultural University, Vellanikkara, Thrissur during kharif (May to October 1997), rabi (September 1997 to January 1998) and Summer (January to May 1998) seasons, by using the variety Preethi. The different sources levels and frequencies of application of organic manures and inorganic fertilizers, constituting eight treatments did not effect significantly on the occurrence of pests like fruit fly (*Bactrocera cucurbitae*), jassids (*Empoasca motti*), epilachna beetle (*Henosepilachna septima*) and diseases like mosaic and downy mildew (*Pseudoperenospora cubensis*). Seasonal influence was observed on the occurrence of above pests and diseases. Among the pests and diseases affecting the crop, mosaic disease and jassids caused drastic reduction in the crop growth and productivity. Fruit fly infestation was at its peak during rainy season while epilachna beetle and downy mildew during rabi season. Incidence of jassids and intensity of mosaic was maximum during summer season. Productivity of the crop (12.1 t ha^{-1}) and size of fruits in terms of weight (247.58 g) length (23.61 cm) and girth (17.13 cm) was maximum during rabi season. The treatment T_7 which received 20 t ha^{-1} of FYM, 2.5 t ha^{-1} of poultry manure, 2.5 t ha^{-1} of fresh cowdung slurry drenching with NPK @ 70:25:50 kg ha^{-1} had maximum productivity with maximum fruit size in all the three seasons. Yield in T_5 which received 20 t ha^{-1} of FYM as basal and 2.5 t ha^{-1} of poultry manure at vining stage and 2.5 t ha^{-1} cowdung slurry drenching at fortnightly interval was double than that in T_1 which received 25 t ha^{-1} of FYM only.