

**EFFICACY OF HERBICIDES ON GROWTH, FLOWERING, QUALITY AND
YIELD OF GLADIOLUS (*Gladiolus grandiflora* L.) UNDER THE HILL ZONE
OF KARNATAKA**

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SHIVAMOGGA***

2020

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Thesis submitted to the

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**DEPARTMENT OF FLORICULTURE AND LANDSCAPE ARCHITECTURE
COLLEGE OF HORTICULTURE, MUDIGERE
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SHIVAMOGGA**

CERTIFICATE

This is to certify that the thesis entitled 'EFFICACY OF HERBICIDES ON GROWTH, FLOWERING, QUALITY AND YIELD OF GLADIOLUS (*Gladiolus grandiflora* L.) UNDER HILL ZONE OF KARNATAKA' submitted in partial fulfillment of the requirements for the award of the degree of **MASTER OF SCIENCE (HORTICULTURE)** in **FLORICULTURE AND LANDSCAPE ARCHITECTURE** to the College of Horticulture, Mudigere, University of Agricultural and Horticultural Sciences, Shivamogga is a bonafide record of research work carried out by **Mr. ANAND BURUD, ID. NO. MH2TAHO185** (anandburud2455@gmail.com) during the period of study in this university under my guidance and supervision and no part of this thesis has previously formed the basis for the award of any other degree, diploma, associateship, fellowship or any other similar titles.

Mudigere
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(Mr. Anand Burud)


**Efficacy of Herbicides on Growth, Flowering, Quality and Yield of Gladiolus
(*Gladiolus grandiflora* L.) Under Hillzone of Karnataka**


(Anand Burud)

ABSTRACT

A field experiment was conducted to evaluate the efficacy of pre-emergent herbicides in gladiolus under the hill zone of Karnataka at College of Horticulture, Mudigere, having twelve treatments replicated thrice in Randomized Complete Block Design during 2019 – 20. Among the herbicidal applications, pre-emergence application of pendimethaline at 1.0 kg *a.i./ha* recorded minimum number of grass weeds, sedge weeds, broad leaved weeds, total weed population and dry weight of weeds (3.92, 2.79, 2.57, 9.28 and 3.92 g, respectively) at 60 days after planting. This treatment also recorded significantly maximum growth and yield attributes at 60 days after planting *viz.* plant height (68.30 cm), number of leaves per plant (10.20), leaf area and leaf area index (1023.93 cm² and 1.72, respectively), total chlorophyll content in leaves (2.36 mg/g of fresh weight), weed control efficiency (49.22 %), length of spike (65.91 cm), length of rachis (38.94 cm), length of floret (10.92 cm), diameter of floret (10.21 cm), spike girth (8.73 mm), number of florets per spike (11.32), spike weight (68.87 g), vase life (10.16 days), number of spikes per plant and per hectare (1.40 and 210600.00, respectively), weight of the corms and cormels per plant (96.66 g and 28.19 g, respectively), diameter of the corms and cormels (5.10 cm and 5.18 mm, respectively), number of corms, cormels and yield of corms, cormels (1.73, 33.21, 14450 kg/ha and 912.20 kg/ha, respectively) and maximum B:C ratio (1.73). Weedy check plots recorded significantly lower growth and yield attributes. However, pre-emergence application of pendimethaline at 1.0 kg *a.i./ha*, pendimethaline at 0.75 kg *a.i./ha* was found on par with butachlor at 1.0 kg *a.i./ha* for control of total weed population at 30 days after planting.

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ಕರ್ನಾಟಕದಲ್ಲಿ ಗುಡ್‌ಗಾಡು ಪ್ರದೇಶದಲ್ಲಿ ಗ್ಲಾಡಿಯೋಲಸ್ (ಗ್ಲಾಡಿಯೋಲಸ್ ಗ್ರಾಂಡಿಪ್ಲೊಪಾ. ಎಲ್) ಬೆಳವಣಿಗೆ, ಹೂಬಿಡುವಿಕೆ, ಗುಣಮಟ್ಟ ಮತ್ತು ಇಳುವರಿ ಮೇಲೆ ಕಳೆನಾಶಕಗಳ ಪರಿಣಾಮದ ಅಧ್ಯಯನ.

(ಆನಂದ್ ಬುರುಡ್.)

ಸಾರಾಂಶ

ಕರ್ನಾಟಕದ ಗುಡ್‌ಗಾಡು ಪ್ರದೇಶದಲ್ಲಿ ಗ್ಲಾಡಿಯೋಲಸ್ (ಗ್ಲಾಡಿಯೋಲಸ್ ಗ್ರಾಂಡಿಪ್ಲೊಪಾ. ಎಲ್) ಬೆಳವಣಿಗೆ, ಹೂಬಿಡುವಿಕೆ, ಗುಣಮಟ್ಟ ಮತ್ತು ಇಳುವರಿ ಮೇಲೆ ಕಳೆನಾಶಕಗಳ ಪರಿಣಾಮದ ಅಧ್ಯಯನ ಬಗ್ಗೆ ಕ್ಷೇತ್ರ ಸಂಶೋಧನೆಯನ್ನು ತೋಟಗಾರಿಕೆ ಮಹಾವಿದ್ಯಾಲಯ, ಮೂಡಿಗೇರೆಯ ಪುಷ್ಪಕೃಷಿ ಮತ್ತು ಉದ್ಯಾನ ವಿನ್ಯಾಸ ವಿಭಾಗ ಪ್ರಯೋಗಿಕ ಬ್ಲಾಕ್‌ನಲ್ಲಿ ೨೦೧೯-೨೦ ರ ಅವಧಿಯಲ್ಲಿ ಕೈಗೊಳ್ಳಲಾಯಿತು. ಈ ಪ್ರಯೋಗವನ್ನು ಮೂರು ಬಾರಿ ಪುನರಾವರ್ತಿತಿಸಿ ಯಾದುಚ್ಚಿಕ ಸಂಪೂರ್ಣ ಬ್ಲಾಕ್ ವಿನ್ಯಾಸದಲ್ಲಿ ಸಡೆಸಲಾಯಿತು. ಈ ಪ್ರಯೋಗದಲ್ಲಿ ಮೊಳಕೆ ಪೂರ್ವ ಪೆಂಡೀಮೆಥಿಲಿನ್ ೧ ಕೆ.ಜಿ. ಎ.ಐ/ಹೆ ಸಿಂಪಟಣೆಯಿಂದ ೬೦ ದಿನಗಳ ನಂತರ ಕನಿಷ್ಠ ಕಳೆಗಳ ಸಂಖ್ಯೆ, ಸೆಡ್ಡೆ ಕಳೆಗಳು ವಿಶಾಲ ಎಲೆಗಳಿರುವ ಕಳೆ, ಅವುಗಳ ಸಂಖ್ಯೆ ಮತ್ತು ಶುಷ್ಕ ಕೂಕ (ಕ್ರಮವಾಗಿ ೩.೯೨, ೨.೭೯, ೨೫೭, ೯.೩೮, ಮತ್ತು ೩.೯೨ ಗ್ರಾಂ) ಹಾಗೂ ಗರಿಷ್ಠ ಬೆಳವಣಿಗೆ ಮತ್ತು ಇಳುವರಿಯನ್ನು ದಾಖಲಿಸಿದೆ. ಅಂದರೆ ಸಸ್ಯದ ಎತ್ತರ (೬೮.೩೦ ಸೆಂ. ಮೀ), ಪ್ರತಿ ಗಿಡಕ್ಕೆ ಎಲೆಗಳ ಸಂಖ್ಯೆ (೧೦. ೨೦), ಎಲೆಯ ವಿಸ್ತೀರ್ಣ ಮತ್ತು ಅದರ ಸೂಚ್ಯಂಕ (ಕ್ರಮವಾಗಿ ೧೦.೨೩ ಸೆಂ.ಮೀ^೨ ಮತ್ತು ೧.೭೨), ಎಲೆಯಲ್ಲಿ ಒಟ್ಟು ಕ್ಲೋರೋಫಿಲ್ ಅಂಶ (೨.೩೬ ಮಿ. ಗ್ರಾಂ/ಗ್ರಾಂ), ಕಳೆ ನಿಯಂತ್ರಣ ದಷತೆ (೪೯.೨೨%), ದೇಟಿನ ಉದ್ದ (೬೫.೯೦ ಸೆಂ.ಮೀ), ರ್ಯಾಚಿಸ್ ಉದ್ದ (೩೮.೯೪ ಸೆಂ.ಮೀ), ಹೂವಿನ ಉದ್ದ (೧೦. ೯೨ ಸೆಂ. ಮೀ), ವ್ಯಾಸ (೧೦.೩೨), ದೇಟಿನ ತೂಕ (೬೮.೩೭ ಗ್ರಾಂ), ಹೂದಾನಿ ಜೀವನ (೧೦.೧೬ ದಿನಗಳು), ಒಟ್ಟು ದೇಟಿನ ಸಂಖ್ಯೆ ಪ್ರತಿ ಗಿಡಕ್ಕೆ ಮತ್ತು ಪ್ರತಿ ಹೆಕ್ಟೇರಿಗೆ (ಕ್ರಮವಾಗಿ ೧.೪೦ ಮತ್ತು ೨,೧೦,೬೦೦.೦೦), ಪ್ರತಿ ಗಿಡಕ್ಕೆ ಗೆಡ್ಡೆಗಳ ಮತ್ತು ಮರಿಗೆಡ್ಡೆಗಳ ತೂಕ (ಕ್ರಮವಾಗಿ ೯೬.೬೬ ಗ್ರಾಂ ಮತ್ತು ೨೮. ೧೯ ಗ್ರಾಂ) ಹಾಗೂ ಅದರ ಸುತ್ತಳತೆ (ಕ್ರಮವಾಗಿ ೫.೧೦ ಸೆಂ, ಮೀ ಮತ್ತು ೫. ೧೮ ಮಿಮೀ). ಒಟ್ಟು ಗೆಡ್ಡೆಗಳು, ಮರಿಗೆಡ್ಡೆಗಳು ಹಾಗೂ ಅವರ ಇಳುವರಿ (ಕ್ರಮವಾಗಿ ೧.೭೩, ೩೩.೨೧, ೧೪೪೫೦ ಕೆಜಿ/ಹೆ ಮತ್ತು ೯೧೨.೨೦ ಕೆಜಿ/ಹೆ) ಮತ್ತು ಗರಿಷ್ಠ ನಿವ್ವಳ ಆದಾಯ ಮತ್ತು ಲಾಭ ನಷ್ಟ ಅನುಪಾತವನ್ನು (೧.೭೩) ಹೊಂದಿದೆ. ಗಮನಾರ್ಹವಾಗಿ ಕಳೆಚೆಕ್ ಪ್ರಾಟ್‌ಗಳು ಕಡಿಮೆ ಬೆಳವಣಿಗೆ ಹಾಗೂ ಇಳುವರಿಯ ಗುಣಲಕ್ಷಣಗಳನ್ನು ಹೊಂದಿದೆ ಎಂದು ಪ್ರಸ್ತುತ ಸಂಶೋಧನೆಯಿಂದ ಕಂಡುಬಂದಿದೆ.

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INTRODUCTION

I INTRODUCTION

The government of India has recognised floriculture as a potential industry due to its great role to play in the doubling farmer's income. Strengths of this sector is already well known in earning foreign exchange and shortly gained 100 per cent export-oriented status. The country has exported 16,949.37 MT of floriculture products worth of Rs. 541.61 crores in 2019 (Annon., 2019). From the day of announcement of ambitious goal of doubling farmer's income, floriculture industry considered as a significant area due to its immense potentialities and strengths in realising the goal.

Floriculture trade mainly includes cut flowers, loose flowers, pot plants, cut foliage, seeds, bulbs, tubers and rooted cuttings both in domestic as well as international market. Indian commercial floriculture scenario mainly driven by few important flower crops such as gladiolus, rose, anthurium, tuberose and carnations, marigold chrysanthemum, aster, tuberose, gerbera. In India, flower crops cultivated in 3,13,000 ha area with estimated production of 28,65,000 MT. Among them, cut flower constitutes 8,07,000 MT and loose flower of 20,59,000 MT (Annon., 2019). In Karnataka, the total area under flower crops is about 24,000 ha and the production of the cut flower is 75,000 MT and loose flower of 1,78,000 MT (Annon., 2019). The country has exported 16,949 MT of Floriculture products to the world for the worth of Rs. 541.61 crores (Annon., 2019).

Gladiolus (*Gladiolus grandiflorus*), otherwise known as "Sword Lily or Queen of the Bulbous plants" is a popular ornamental bulbous plant originated in South Africa. Taxonomically placed under monocot family Iridaceae, (Lepcha *et al.*, 2007). Iridaceae family includes perennial, rhizomatous bulbous plants distributed globally with greatest diversity in South Africa (Pragya *et al.*, 2010). The genus gladiolus is comprised of about 265 species and is one of the largest genera of family Iridaceae. The Cape of Good Hope (South Africa) is considered to be the centre of diversity for the genus Gladiolus. It is distributed throughout the region of tropical Africa, Madagascar, Arabian Peninsula, Mediterranean basin, Europe and Asia, including Iran and Afghanistan.

Gladiolus, a bulbous cut flower crop is well recognised important flower crop, contributes considerably to the floriculture trade. It is one of the choicest crops of many farmers due to its adorable ornamental value, varied uses and popularity in domestic as well as international trade which offers secured livelihood to thousands of farmers. It bears very attractive flowers with long spikes having florets of huge form, dazzling colours varying sizes and long keeping quality commercially used for cut flowers and occasionally used for landscape purposes. In India, gladiolus is being grown in an area of 11,660 ha. in the country with an estimated production of 106

crore cut flowers (Annon., 2019). Amongst the cut flowers, it occupied third position in terms of both area and production. Main gladiolus cultivating states are Karnataka, Uttar Pradesh, Uttarakhand, Himachal Pradesh, Haryana and Punjab.

Gladiolus perpetuates through corms, which consists of one or more buds. Once planted, the buds on the corms develop into leaves and flowering spikes. At the same time as the leaves and spikes are extending, new corm forms at the base of the leaves while at the union of the parent and daughter corm, stolons grow out, terminating in cormels which are used for propagation (Kumar and Raju, 2007). In plains it blooms profusely during the spring and summer. Spikes come to harvestable stage in about 60 to 100 days after planting depending upon the cultivars and time of planting.

Successful crop cultivation essentially encompasses all the cultural operations right from the planting to harvesting. Each and every operation must be carried out at right time in a right way to produce good crop. In gladiolus, menaces of weeds are well known. Weed management, one such cultural operation in any crop production practices requires special attention. Weeds are unwanted and undesirable plants which are compete with main crop for the utilization of land and water resources. Sometimes the losses caused by weeds exceed the losses caused by any other category of agricultural pests. Of the total annual loss in agriculture produce, weeds account for 45 per cent, insects 30 per cent, diseases 20 per cent and other pests 5 per cent (<https://www.agritechnau.com>). Unnecessary interference of weeds results in several unintended consequences such as decrease in yields, increase production costs, reduction in quality, increased threat of serious insects and disease problems and many more.

Weeds remain highly competitive throughout the crop growth if left unmanaged. In gladiolus, however, the most critical period for crop weed competition is first six weeks after planting. It's already said that adverse effects caused by weeds on crop. Thus, it is crucial to initiate management practices to mitigate the initiation and further growth of the weeds. There are many weeding practices in vogue, both manual and mechanical, but, along with some inseparable consequences. Manual practices are time consuming, laborious and tedious, mechanical ones are hard to access and unaffordable to many farmers. Such unintended and indivisible outcomes necessitate search for other new better viable options for successful weed control. Considering all these factors, in the most highly mechanised era of 21st century, choosing a chemical weed control gives new hopes that it can be done efficiently with minimal cost in gladiolus.

There are more than hundred different herbicides are available in market with different chemical composition, method and time of application thus it is necessary to

have some elementary knowledge on herbicides. Classification of herbicides dealt on the basis of different aspects, such as mode of action, site of action, time of application, selectivity, translocation, *etc.* Based on the time of application, herbicides are classified as pre-emergence or post-emergence. When applied pre-emergent, they may be effective against grassy weeds or broad-leaf weeds. On the other hand, when applied post-emergent, they may be selective or non selective. At the pre-emergent stage, the herbicide may be applied to the soil or even the seeds may be treated with them. With post emergent applications, the seedlings are sprayed with specific herbicides so as to eliminate weeds. Selectivity is defined as the capacity of a herbicide to kill a target plant without harming or killing the non target plants. Selective herbicides are highly specific and are best suited for the control of a specific weed associated with a specific crop, most of the herbicides used in agriculture and related industries are highly selective. Upon contact, they act by getting absorbed and translocated into the xylem or the phloem of the weeds, by inhibiting or disrupting the metabolic machinery or other biosynthetic pathways and by injuring or killing the weeds. On the other hand, non-selective herbicides have a limited use in agriculture and other related industries but they are effective in land-reclamation projects where the land needs to be cleared of all vegetation or where the weeds may be localized away from the plants of interest with having established all the relevant information sufficiently, fact that limited work done on gladiolus, present study was designed and carried out with the following objectives on chemical weed management in gladiolus.

1. To study the effect of herbicides on growth and flowering of gladiolus
2. To study the effect of herbicides on yield and quality of cut flowers and corms in gladiolus and
3. To work out the economics of gladiolus

REVIEW OF LITERATURE

II REVIEW OF LITERATURE

Gladiolus even though a hardy crop, the degree of damage caused by weeds is related to type, species and density of weeds growing in a crop community. Weed species are known to vary with the season and type of cultivation. Persistence of weeds in a location is largely influenced by climatic, edaphic and biotic factors, which affect their occurrence, abundance, range and distribution.

Weeds bring about heavy damages to flower crops by competing with them for water, nutrients, light and space besides acting as alternate host to a number of pests and diseases. Out several factors affecting growth and production of flower crop, weeds are the most important ones. Reduction in crop yield has direct correlation with weed competition. Proper control of weeds is very essential in obtaining optimum plant growth, higher yield and quality flowers. The literature cited on weed control aspects in gladiolus and other related flower crops aspects is reviewed with the following headings;

2.1 To study the effect of herbicides on growth and flowering of gladiolus and other flower crops

It is evident that weeds are adapted to rapid dissemination, faster growth and multiplication enabling them to compete at every stage of crop growth for nutrients, moisture, light, space and this reduce the yield and quality of flower. Besides harboring many pests and diseases, the loss in flower yield depends upon the type of weed flora and intensity of weed competition infestation.

Metazachlor at 1.5 kg / ha, pendimethaline 1.32 kg / ha and pendimethaline 1.32 kg + metamitron 2.1 kg / ha chemicals well tolerated to weeds when applied after sowing gladiolus cv. Eurovision (Mynett and Jagusz, 1990).

Yield reduction was as high as 61 per cent in tuberose (Anandamurthy and Narayanagowda, 1992) and 70 per cent in china aster was noticed due to weed competition (Basavaraju *et al.*, 1992).

Arora *et al.* (1992) studied the effect of three pre-plant herbicides *viz.*, alachlor (50) @ 1.5, 2.0 & 2.5 kg *a.i* / ha, fluchloralin (46%) @ 2, 2.5 & 3.0 kg *a.i* / ha and atrazine @ 1.5, 2.0 11 & 2.5 kg *a.i*/ha in relation to hand weeding (control) in gladiolus cultivar '*Sylvia*'. Four days prior to corms planting, the experimental plots were drenched with above herbicides. The fluchloralin at 3.0 kg *a.i* / ha proved to be the most effective herbicide in controlling the weed population.

Murthy and Gowda (1994) found that pendimethaline 1.0 and 1.25 kg / ha was very effective in controlling weeds and decreasing the dry matter production of weeds in tuberose.

Chahal *et al.* (1994) carried out field studies to evaluate different weed management practices including hand weeding, mulching and 13 combinations of two pre-emergence herbicides (atrazine and pendimethaline), three post-emergence herbicides (paraquat, glyphosate and isoproturon), in gladiolus cv. *Psittacinus* hybrid. Out of a total 25 weed species observed, *Galinsoga parviflora*, *Cyperus rotundus*, *Echinochloa colonum*, *E. crus-galli* and *Digitaria sanguinalis* were the prominent ones. All treatments were effective in reducing the total weed population during earlier stages, however, atrazine (1-2 kg / ha) was more effective than pendimethaline (1-2 kg / ha) during the first period (*i.e.* up to 95 days after planting).

Application of 1.0 kg / ha butachlor and 2.0 kg / ha metolachlor recorded an increase in fresh weight of spikes for the first 3 days after picking, but fresh weight declined thereafter. Plants grown on the weed free site had the greatest spike weight and there was no significant difference in spike weight among the herbicide treatments (Murthy and Gowda, 1994).

Lasker and Jana (1995) tested the influence of five herbicides namely atrazine at 2 and 4 kg *a.i.*/ ha, simazine at 2 and 4 kg *a.i.* / ha, oxyflurofen at 1 and 2 kg *a.i.* / ha, fluchloralin at 2 and 4 kg *a.i.*/ ha and Diuron at 2 and 4 kg *a.i.* /ha as pre-emergence (5 days before planting of corms) and manual weeding (3 times at 20 days interval after planting) in gladiolus crop. Considering the overall performance, oxyflurofen at lower concentration (1 kg *a.i.* / ha) was supreme among the herbicides used. Manual weeding however, resulted in highest favourable response in all respects.

Kwon, O.D *et al.* (1996) in his studies to determine the major weed species and to evaluate herbicides for weed control in gladiolus fields during 1993 to 1994 under two cropping patterns and found sixteen species of weeds in gladiolus fields. The dominant weeds were *Digitaria sanguinalis* and *Portulaca oleracea*. The most effective herbicides for controlling grass weeds were alachlor, simazine, napropamide, linuron and pendimethaline. These herbicides gave excellent weed control with very slight injury at the early stage of gladiolus growth but no injury to flowers.

Kwon, O.D *et al.* (1996) recommend that the most effective herbicides for controlling grass weeds were alachlor, simazine, napropamide, linuron and pendemethaline. These herbicides gave excellent weed control in gladiolus field.

Yaduraju *et al.* (1997) reported lowest weed biomass in rose with application of atrazine @ 2 kg *a.i.*/ ha treatment. Fresh weight of weeds after herbicide treatments was reduced in gladiolus.

Singh *et al.* (2000) conducted a field experiment to determine the effect of different herbicide treatments on the growth and flowering of *G. grandiflorus* cv.

Friendship, in Varanasi, Uttar Pradesh, India, and found that the plant height, number of leaves, earliness to flowering, spike length, number and size of florets significantly increased compared to the control (unweeded) during both years. Among the treatments, pendimethalin (1.5 kg / ha) + 2, 4-D (2 kg / ha) was the most effective during both years.

Gupta and Singh (2001) observed that the total count, fresh weight and dry weight of monocot and dicot weeds in gladiolus were significantly reduced in the plot which received pre-emergence pendimethaline at 1.5 kg *a.i./ha*+ post- emergence 2, 4-D at 2.0 kg *a.i./ ha* and recorded the best weed control efficiency of 81.69 per cent.

The pendimethalin and trifluralin at 0.50 and 0.75 kg *a.i./ ha* gave an effective control of weeds in gladiolus crop and they significantly improved spike length and number of florets per spike (Arora *et al.*, 2002).

Dhiman (2003) recorded maximum plant height with pendimethaline at 0.2 per cent while it was minimum with 0.5 per cent. These results are similar with the findings of Arora *et al.* (2002), who also found similar trend for spike length of gladiolus with increase in pendimethaline concentration.

Kori and Patil (2003) recorded the least number of days were taken for first flower appearance, higher spike length, early to reach 50 per cent flowering, maximum number of florets per spike in weed free treatment which was non-significant with paddy straw mulch and pendimethaline 1.00 kg *a.i./ ha*. Similar results were also reported by Basavaraju (1989) on china aster and Koutepas (1982) in gladiolus.

Shalini and Patil (2004) concluded that the number of leaves per plant differed significantly at all the stages of crop growth and highest plant height was recorded in weed free treatment followed by pendimethaline @ 1.0 *a.i./ ha* at the time of harvesting in gerbera. Similar results were also reported by Koutepas (1982) in gladiolus, Pal and Das (1990) in tuberose and Basavaraju *et al.* (1992) in china aster and increased leaf area was obtained by Pitt *et al.* (1981) in gladiolus and Murthy and Gowda (1994) in tuberose.

Manuja *et al.* (2005) studied the effects of various pre and post emergence herbicides on weed infestation and on corm and cormel production in three gladiolus (*Gladiolus spp.*) cultivars during 1997-2000. The main weeds infesting the experimental farm were *Ageratum conyzoides*, *Gnaphalium peregrinum*, *Plantago lanceolata*, *Cynodon dactylon*, *Amaranthus viridis*, *Paspalum dilatatum*, *Portulaca oleracea*, *Euphorbia hirta*, *Oxalis corniculata*, *Trifolium repens*, *Imperata cylindrica* and *Digitaria adscendence*.

Singh (2005) was conducted an experiment during 2000-01 to evaluate the efficacy of different management practices against weeds and their effect on the growth, flowering, yield and leaf nutrient status of rose and he found that the field was invaded by non-grasses, grasses and sedges .He found that all treatments significantly reduced the populations of broadleaves (non grasses) and grasses as well as total dry weed biomass compared with the weedy control.

Singh and karki (2005) found maximum diameter of basal shoot and number of basal shoots per plant was significantly increased in rose with weed free treatment which was non-significant with rice straw mulch and metribuzin @ 2.0 kg *a.i./* ha. Kamboj *et al.* (2005) also recorded maximum plant height in weed check and maximum number of branches with treatment pendimethalin at 0.50 kg *a.i./* ha.

A study on weed flora of gladiolus fields was done by Riaz *et al.* (2007) They observed frequently occurring and densely populated weeds like *Poa annua*, *Coronopus didymus*, *Convolvulus arvensis*, *Euphorbia prostrate*, *Melilotus parviflora*, *Cynodon dactylon*, *Mazus goodenifolia* and *Verbena agrestis* with AF ranging from 51–69 per cent and AD from 0.75– 1.05. Less frequently occurring weeds with AF between 21 to 49 per cent were *Amaranthus viridis*, *Cirsium arvense*, *Eclipta alba*, *Stellaria media*, *Chenopodium murale*, *C. album*, *Medicago denticulata*, *Fumaria indica*, *Malva parviflora*, *Oxalis corniculata*, *Imperata cylindrica*, *Ranunculus muricatus*, *R. scleratus*, *Solanum nigrum*. *Parthenium hysterophorus*, *Sonchus asper*, *Xanthium stramonium*, *Euphorbia heleoscapia*, *Lathyrus aphca*, and *Solanum nigrum* were found least frequently occurring species with AF 20 per cent and below and AD of 0.10 to 0.38.

Frequent hand weedings at every 4 weeks and pendimethalin + glyphosate remarkably produced the highest number of flowers per spike, improved the vegetative growth, number of basal leaves, diameter, weight, spike length, high flowering index and cut flower yield of tuberose, Nevertheless, it conversely recorded the lowest percentages of N, P and K contents, in comparison to the unweeded controls (Naggar and Byari, 2009).

Marinangeli *et al.* (2010) conducted green house and field studies to evaluate the phytotoxic effect and weed control herbicides applied pre and post in lily bulb production. In green house studies bromoxynil (415 g *a.i./* ha), fluroxypyr (200 g *a.i./* ha), metsulfuron (3 g *a.i. /* ha), iodosulfuron-methyl sodium (3 g *a.i./*ha) + metsulfuron, oxyfluofen (3 g *a.i/* ha), ioxynil (529 g *a.i /*ha) and linuron (750 g *a.i /* ha) produced severe phytotoxicity or death of bulbs but, glyphosate (720 g *a.i./* ha) and aclonifen (720 g *a.i /* ha) produced little to no symptoms and were considered safe to apply to lilies. In filed pre herbicides metachlor (960) + atrazine (1500) and metachlor (960) + flumetsulam (80) provided good weed control but were phytotoxic

and observed chlorosis symptoms. Metolachlor + linuron resulted in little or no symptoms of injury and no reduction in bulb yield.

Vinay Kumar and Gowada (2011) observed that hand weedings thrice at 30, 60 and 90 DAP were more effective to control the annual grasses and broad leaves weeds in china aster flower cultivation during *kharif* season. The present investigation was taken up to know the effect of different weed management practices on quality of china aster flower. Hand weeding thrice took less number of days for 50 per cent of flowering besides increasing the stalk length, diameter of flower and fresh weight of flower, which was at par with oxyfluorfen 0.1 kg *a.i.*/ ha followed by earthing up at 35 DAT. Unweeded control showed poor performance in all the flower quality parameters mentioned above. Besides controlling weeds effectively and increasing the yields, the herbicides also increased the quality of china aster flower.

Kumar *et al.* (2012) resulted that enhancement in spike yield with 2 hand weeding at 20 and 40 days after planting (6.05 t / ha) and pendimethaline 2 kg / ha + one hand weeding (5.79 t /ha), both superior to weedy check (3.25 t / ha). The highest weed control efficiency (78.2 %) was also achieved with two hand weeding, followed by pendimethaline + hand weeding 76.9 %) in gladiolus.

Bhat *et al.* (2012) evaluated four herbicides i.e. atrazine, metribuzine, butachlor and pendimethaline each with two concentrations in gladiolus. The better growth and flowering characters were achieved with pendimethaline @1.0 kg *a.i.*/ ha and pendimethaline @0.75 kg *a.i.* / ha which were followed by butachlor and weed free treatments. Similarly, weed density, fresh and dry weight as well as weed control efficiency was recorded lowest in pendimethaline @ 0.75 kg *a.i.*/ha treatments which were followed by atrazine and metribuzine treatments, while the unweeded treatment recorded highest values of these parameters.

Sharma *et al.* (2014) reported that average flower weight, number of flowers per plant, flower diameter and earliest days to first bud appearance was obtained with pendimethalin (37.8 %) @ 0.64 kg *a.i.* / ha + one hand weeding @ 40 DAT + pendimethalin (37.8 %) @ 0.64 kg / ha @ 45 DAT which was having same effect as with pendimethalin @ 1.0 kg/ ha + one hand weeding @ 40 DAT in chrysanthemum.

Sharma *et al.* (2014) conducted to an experiment evaluate the effect of weed management practices on the growth and flowering of chrysanthemum. The experiment consisted of eleven treatments comprising of hand weeding, mulching, herbicides and unweeded check replicated three times in randomized block design. Maximum plant height, plant spread and number of branches plant⁻¹ were recorded on application of pendimethaline (extra) @ 0.64 kg /ha +one hand weeding at 40 DAT + pendimethaline (extra) @ 0.64 kg / ha at 45 DAT followed by pendimethaline @ 1.0 kg / ha +one hand weeding at 40 DAT which had at par effect. Highest average

flower weight, number of flowers plant⁻¹, flower diameter and earliest days to first bud appearance was obtained with pendimethaline (extra) @ 0.64 kg / ha + one hand weeding at 40 DAT + pendimethaline (extra) @ 0.64 kg / ha at 45 DAT which was having same effect as with pendimethaline @ 1.0 kg / ha + one hand weeding at 40 DAT. Application of pendimethaline (extra) @ 0.64 kg / ha + one hand weeding at 40 DAT + pendimethaline (extra) @ 0.64 kg / ha at 45 DAT was found superior for parameters under observations, but it was found to have at par effect with pendimethaline @ 1.0 kg / ha + one hand weeding at 40 DAT.

Swaroop *et al.* (2014) stated that the most critical period for gladiolus weed competition is first six weeks after planting of crop. During this critical period, weeding is essentially required by chemical, nonchemical means or in integrated manner. Therefore, timely weed control at early stage is imperative for realizing desirable level of productivity. The use of herbicides offers selective and economic control of weeds right from the beginning, giving crop an advantage of good start and competitive superiority. Pre and post-emergence herbicides may also be viable option to control the weeds. Manual weed control is effective.

A study was undertaken during winter season to evaluate the effect of weed management practices on the growth and flowering of chrysanthemum. The experiment consisted of eleven treatments comprising of hand weeding, mulching, herbicides and un-weeded check. Maximum plant height, plant spread and number of branches plant⁻¹, highest average flower weight, number of flowers plant⁻¹, flower diameter and earliest days to first bud appearance were recorded on application of pendimethalin @ 0.64 kg / ha +one hand weeding at 40 DAT + pendimethalin @ 0.64 kg / ha at 45 DAT. The minimum dry matter and nitrogen uptake was noted under pendimethalin @ 0.64 kg / ha + one hand weeding at 40 DAT + pendimethalin @ 0.64 kg / ha at 45 DAT. Application of pendimethalin @ 0.64 kg / ha + one hand weeding at 40 DAT + pendimethalin @ 0.64 kg / ha at 45 DAT was found superior for parameters under observations, but it was found to have at par effect with pendimethalin @ 1.0 kg / ha +one hand weeding at 40 DAT (Sharma *et al.*, 2014).

An experiment was carried out to evaluate the effect of different herbicides on weed control and growth and development of gladiolus (*Gladiolus toun L.*) cv. White Prosperity. Significantly low weed count, fresh weight and dry weight were recorded in the pre-emergence application of atrazine @ 1.0 and 1.5 kg *a.i.* /ha. The maximum weed control efficiency (WCE) was recorded in atrazine @ 1.5 kg *a.i.*/ ha (82.2). However, pre-emergence application of pendimethalin 1.0 and 0.75 kg *a.i.*/ ha had superior effect on the plant height, spike length, rachis length and number of florets. The number of corms/plant, fresh weight of corms and diameter of corms were maximum with application of atrazine @ 1.0 and 1.5 kg *a.i.*/ ha however, number of

cormels were found maximum (28.6) in pendimethalin @ 1.0 kg *a.i.*/ ha and lowest (2.4) in atrazine @ 1.0 kg *a.i.*/ ha (Kadam *et al.*, 2014).

A study conducted by Bhat and Sheikh (2015) to evaluate different herbicides in gladiolus. The experiment consisted of eight different herbicides, cultural practices as weed control treatment and unweeded control. Among four herbicides namely atrazine, metribuzin, butachlor and pendimethalin each with two concentrations, the better growth and flowering characters were achieved with pendimethalin @ 1.0 kg *a.i.* / ha and pendimethalin @ 0.75 kg *a.i.*/ha which were followed by butachlor and weed free treatments. Similarly, weed density, fresh and dry weight as well as weed control efficiency was recorded lowest in pendimethalin @ 0.75 kg *a.i.* / ha treatments which were followed by atrazine and metribuzin treatments, while the unweeded treatment recorded highest values of these parameters.

Tripathy *et al.* (2015) reported that pendimethalin @ 1.00 kg *a.i.*/ ha was found to be most effective in controlling weed growth in chrysanthemum as compared to other treatments and was at par with pendimethalin @ 0.75 kg *a.i.*/ha. The growth parameters i.e., plant height, plant spread, number of sprays per plant, weight of flowers per plant, number of flowers per plant did not vary significantly with the treatments which suggest that the herbicides have no negative effect on the plants and can be used for controlling weeds in spray chrysanthemum.

Studies were conducted to identify the important weeds infesting *Gladiolus grandiflora* L. and to investigate the effects of various mulches and herbicide as a check. Control (weedy check) was also included for comparison. The fields were observed densely populated (7/15 weeds) with monocotyledonous belonging to family Poaceae. Among various mulching treatments, plastic mulch proved to be the most effective for inhibiting weed germination (10 weeds m⁻²). Application of pine wood chips promoted plant height of *G. grandiflora* to almost double (283 cm) as compared to weedy check (143 cm). Numerically, higher values of corm size (6 cm), corm weight (40 g), cormel size (2.3 cm), cormel weight (1.4 g) and cormel yield (102.3 cormels m⁻²) were observed in pine wood chips. The herbicide Gezapex Combi used as a standard, injured crop by stunting and chlorosis (Khan *et al.*, 2015).

An experiment conducted by Kumar and Singh (2015) effect of different weed control methods *viz.*, chemical, physical and cultural on weed management and growth rate of damask rose (*Rosa damascena* Mill.) nursery. Atrazine @ 1.0 and 2.0 kg / ha and metribuzin @ 0.75 and 1.50 kg / ha were applied as pre emergence in combination with one hand weeding at 4 months after planting. Both the herbicides were effective in reducing the weed population and biomass. Black polythene mulch was quite effective in controlling weeds, improving establishment and growth of

nursery plants. Higher weed control efficiency (97.6 %) next to weed free treatment was recorded in black polythene mulch as compared to other treatments.

An experiment undertaken by Kumar *et al.* (2017) to ascertain the influence of integrated weed management practices on weed growth suppression, vegetative growth and flowering attributes of chrysanthemum variety Thai Chen Queen. Among the various weed control practices, number of total weeds count/m² (20.00), fresh (41.05 g/m²) and dry weight of weeds (14.13 g / m²) were recorded minimum with butachlor @ 1.00 kg *a.i* per ha at 25 days after transplanting. Whereas, at later stages, butachlor application @ 1.50 kg *a.i.* per weight was very effective on minimum weed count (41.66 / m²), fresh (76.93 g / m²) and dry weight (28.88 g / m²) of weeds. Various vegetative and flowering attributes like number of weight branches per plant (17.66), plant spread (21.99 cm), days to full bloom stage (31.11), duration of flowering (34.13 days) and days to flower withering (16.11 days) were observed appreciable with butachlor @ 1.50 kg *a.i.*/ha. However, number of flowers/plant (26.78), flower diameter (9.25 cm), weight of flowers/plant (244.23 g), weight of flowers/plot (2.19 kg) and weight of flower/ha (219.81 q) were found maximum with the treatment weed free check.

Aravind and Venugopal (2017) was studied, weed management in tuberose cv. Prajwal by chemicals was undertaken. Higher leaf area was recorded in weed free check treatment (64.99 cm²), followed by pendimethaline 30 EC @ 1kg *a.i.*/ ha (63.59 cm²) and alachlor 50 EC @ 1.5 kg *a.i.*/ha (61.69 cm²). The least number of days (94.00) were taken for first flowering under the weed free check treatment followed by pendimethaline 30 EC @ 1 kg *a.i.*/ha (97.66 days) and alachlor 50 EC @ 1.5 kg *a.i.*/ ha (101.33 days). Among the different weed control treatments, under weed free check, maximum spike length of 84.18 cm was recorded which was statistically superior over rest of the treatments. Pendimethaline 30 EC @ 1 kg *a.i.*/ ha and alachlor 50 EC @ 1.5 kg *a.i.*/ ha were the next best which recorded the spike length of 81.22 and 80.85 cm, respectively. The flower yield varied significantly (2.91 to 4.18 t / ha) among different treatments. The maximum flower yield was recorded in treatment weed free check (4.18 t / ha, followed by pendimethaline 30 EC @ 1 kg *a.i.*/ ha (3.67 t / ha) and alachlor 50 EC @ 1.5 kg *a.i.*/ha (3.54 t /ha).

2.2 To study the effect of herbicides on quality and yield of cut flowers and corms in gladiolus and other flower crops

There are various methods to control weeds in gladiolus, but none can be said as best because each has its own merits and de merits. The final choice of any weed control or herbicide will depend on effectiveness on the crop growth, yield and quality.

Pal and Das (1990) a field trials were conducted with 3 to 4 kg / ha saturn 3 to 4 litres / ha gramoxone and basagran and 2-3 litres Glycel applied 7 days prior to planting or 3 times (at intervals of 40 days) after planting tuberose [*Polianthes tuberosa*] cv. *Single*. The following tuberose growth parameters were increased by herbicide treatments: height (from 27.5 to 27.5-41 cm), the number of leaves/plant (from 6.5-7 to 6.7-13), number of bulbs/plant (from 12 to 19), the wt. of bulbs (from 100-105 to 102-180 g), duration of flowering (from 14-15 to 14-19 days), length of flower spikes (from 72-73 to 73-94 cm) number of flower spikes/ plot (from 90-95 to 100-180) and the flower yield/plot (from 1-1.2 to 1.3-4.2 kg). Gramoxone at 4 litres resulted in the largest increments in each case, whereas 3 kg Saturn and 2 liters glycel generally had the least effect.

Anadamurthy and Narayanagowda (1992) reported higher flower yield, the highest return in tuberose and lower weed population with the pre-emergent application of alachlor or metalachlor at 2.0 kg *a.i.* / ha and pendimethaline at 1.25 kg *a.i.*/ ha.

Widaryanto *et al.* (1995) conducted a field experiment in gladiolus to study the effectiveness of weed control by oxyfluron, mulching and weeding. Mulching and herbicides were effective in suppressing weed growth for the first 30 DAP, especially that of broad leaved species. Mulching and weeding suppressed weed growth for the first 60 DAP. All methods of weed control affected *G. hybridus* growth to a lesser or greater extent.

Sudhakar *et al.*, (2001) reported that glyphosate at 1.0 kg *a.i.* / ha gave excellent control of weeds and in turn influenced on flower yield in rose.

Arora *et al.* (2002) reported that the application of pendimethaline, linuron and trifluralin at 0.50 and 0.75 kg / ha gave an effective control of weeds. Pendimethaline and linuron significantly improved spike length, number of florets per spike, corm weight and number of cormels per corm in gladiolus.

Dhiman (2003) studied the effects of 0.1, 0.2, 0.3, 0.4 and 0.5 *per cent* pendimethaline on the germination and growth of gladiolus cv. Mayur treatment with 0.1 *per cent* pendimethalin resulted in the highest seed germination (28.7 %) and number of leaves per plant (3.56). differences in the number of days before seed germination, plant height and number of cormels per plant and corm diameter were not significant.

Manuja *et al.* (2005) reported that application of pendimethaline 1.0 kg *a.i.* . / ha reduced the germination of the cormels to a lesser extent. Pre-emergence application of oxyfluorfen 0.25 kg *a.i.*/ ha gave the lowest weed count and weed dry matter accumulation, comparable with weed free treatment, at 90 days after

planting (DAP). The corm and cormel production was significantly higher in oxyfluorfen treatment. The results indicate that application of oxyfluorfen as pre-emergence herbicide followed by application of glyphosate at 90 DAP could be an effective treatment for weed control in gladiolus cormels.

Nagar and Byari (2009) observed that incorporating pre and post-emergence herbicides (pendimethaline + glyphosate) improved tuberose cut flower yield, lengthened the blooming period, enlarged the clump masses, and increased the water use efficiencies. Using pendimethaline + glyphosate, at any level of hand weeding subjected to frequent irrigation every 2 and /or 4 days, markedly improved tuberose flowering stalk yield and clump development. It also maximized gross returns, net profit and other economic feasibility parameters.

Bhat *et al.* (2012) studied the treatment oxyfluorfen @ 0.75 and 0.50 l / ha significantly controlled weeds and reduced their dry weight and indicated maximum growth, flowering and yield in marigold. Weed control efficiency (WCE) and herbicidal efficiency index (HEI) was also found more in the similar treatment. Bhat and Sheiakh (2015) reported that better growth and flowering characters in gladiolus were achieved with pendimethline @ 1.0 kg *a.i./ha* and pendimethline @ 0.75 kg *a.i./ ha* which were followed by butachlor and weed free treatments. Similarly, weed density, fresh and dry weight as well as weed control efficiency was recorded lowest in pendimethaline @ 0.75 kg *a.i./ ha* treatments which were followed by atrazine and metribuzine treatments, while the unweeded treatment recorded highest values of these parameters.

Kumar *et al.* (2012) resulted that enhancement in spike yield with 2 hand weeding at 20 and 40 days after planting (6.05 t / ha) and pendimethaline 2 kg / ha + one hand weeding (5.79 t / ha), both superior to weedy check (3.25 t/ha). The highest weed control efficiency (78.2 %) was also achieved with two hand weeding, followed by pendimethaline + hand weeding 76.9 %) in gladiolus.

Bhat *et al.* (2013) observed that treatments, weed free and pendimethaline 1.5 kg *a.i./ ha* showed better results with vegetative, reproductive and yield parameters in gladiolus. The most effective herbicides for controlling grass weeds were alachlor, simazine, napropamide, linuron and pendimethaline. These herbicides gave excellent weed control with very slight injury at the early stage of gladiolus growth but no injury to flowers.

Chahal *et al.* (2013) reported that application of atrazine @ 3 kg / ha was observed comparatively more efficient in controlling weeds; but caused phytotoxicity to gladiolus plants.

Kadam *et al.* (2014) reported that pre-emergence application of pendimethaline (1.0 and 0.75 kg / ha) had superior effect on the plant height, spike length, rachis length and number of florets in gladiolus. The number of corms/plant, fresh weight of corms and diameter of corms were maximum with application of atrazine (@ 1.0 and 1.5 kg / ha) and number of cormels were found maximum (28.6) in pendimethaline @ 1.0 kg / ha and lowest (2.4) in atrazine @ 1.0 kg / ha.

Application of atrazine 1.0 kg / ha pre-emergence followed by rice residue @ 5 tonnes / ha at 2 days after atrazine application caused greatest reduction in density and dry weight of weeds in gladiolus. The tank-mix pre-emergence application of pendimethaline 0.75 kg / ha + metribuzine 0.3 kg / ha resulted in significantly greater two-year mean gladiolus plant height (116 cm), cut-flower yield (1,72,500 spikes / ha), corm yield (3.82 tonnes / ha) and net returns (Rs. 2,43,100 / ha) compared to weedy check and most other treatments, and was most remunerative (Swaroop *et al.*, 2014).

Tripathy *et al.* (2015) reported that pendimethaline @ 1.00 kg *a.i.*/ ha was found to be most effective in controlling weed growth in spray chrysanthemum as compared to other treatments and was at par with pendimethaline @ 0.75 kg *a.i.*/ ha. The growth parameters i.e., plant height, plant spread, number of sprays per plant, weight of flowers per plant, number of flowers per plant did not vary significantly with the treatments which suggest that the herbicides have no negative effect on the plants and can be used for controlling weeds in spray chrysanthemum.

2.3 Economics of usage of herbicides in gladiolus

The final choice of any weed control method depends to a greater extent on the cost of herbicides and their relative efficiency. Although chemical weed control seems to be cheaper and effective, the overall economics of this practice does not justify its general adoption by grasses except in cereal where the labor is costly and scarce during the peak periods of farm operations.

Yadav and Bose (1987) indicated that usage of atrazine at 2.0 and 3.0 kg *a.i.*/ha and oxyfluorfen at 0.5 kg *a.i.*/ ha gave the additional income of Rs 2102, Rs. 13792 and Rs. 1589, respectively per hectare over the weeded control on tuberose and gladiolus.

Application of atrazine at the rate of 3.0 kg *a.i.*/ha showed maximum reduction of weed population and produced highest flower yield of tuberose (Pal and Das, 1990).

Murthy and Gowda (1994) found pre-emergence application of pendimethaline at 1.25 kg / ha is effective in control of weed population and increased

flower yield in tuberose. Similar results were reported in gladiolus by Wilfreet and Burgis (1977), Yadav and Bose (1987) in tuberose and gladiolus.

After glyphosate and oxyflourfen next best treatment producing higher flower yield in roses was atrazine followed by pendimethaline observed by Sudakar *et al.* (2002).

Kori and Patil (2003) recorded the highest flower yield in gladiolus in weed free treatment followed by pendimethaline 1.00 kg *a.i./ ha* and paddy's straw mulch.

According to Shalini and Patil (2006) highest net returns were obtained in weed free check (Rs.5,70,590 / ha), followed by pendimethaline @ 1.0 kg *a.i./ ha* (Rs. 4, 16,162/ ha), alachlor @1.50 kg *a.i./ha* (Rs. 3,39,070/ha) and organic mulch (Rs. 2,92,650 / ha) in gerbera.

Application of atrazine 1.0 kg / ha pre-emergence followed by rice residue @ 5 tonnes/ha at 2 days after atrazine application caused greatest reduction in density and dry weight of weeds in gladiolus. The tank-mix pre-emergence application of pendimethaline 0.75 kg / ha +metribuzin 0.3 kg / ha resulted in significantly greater two-year mean gladiolus plant height (116 cm), cut-flower yield (1,72,500 spikes/ha), corm yield (3.82 tonnes/ha) and net returns (Rs. 2,43,100/ha) compared to weedy check and most other treatments, and was most remunerative (Swaroop *et al.* 2014).

Majid *et.al.* (2019) carried out an experiment to evaluate different herbicide treatments to control of the noxious weed, *Gladiolus segetum*, commonly found in wheat in northwest of Iran. The objective was to evaluate potential control possibilities with commercial herbicides containing sulfosulfuron, mesosulfuron + idosulfuron, mesosulfuron-methyl + idosulfuron-methyl-sodium + diflufenican, metsulfuron-methyl + sulfosulfuron, clodinafop-propargyl, and glyphosate. Results revealed that higher rates of glyphosate resulted in higher biomass reduction of *G. segetum* in both years. But the application rates of glyphosate were remarkably higher compared to sulfosulfuron and mesosulfuron + idosulfuron. The ED 50 values of glyphosate were 1751.99 and 1919.93 g *a.i. / ha*, and the ED 90 values were 6349.96 and 7031.84 g *a.i./ ha*, in 2014 and 2015, respectively.

MATERIAL AND METHODS

III MATERIAL AND METHODS

The present investigation entitled ‘Efficacy of herbicides on growth, flowering, quality and yield of gladiolus (*Gladiolus grandiflora* L.) under hill zone of Karnataka’, is carried out in the experimental block of Department of Floriculture and Landscape Architecture, College of Horticulture, Mudigere, during 2019-20. The details of materials, techniques, methodologies used and statistical method adopted for conducting the experiment are described in this chapter.

3.1 Geographical location and weather conditions of the experimental site

The experiment is carried out at research block of Department of Floriculture and Landscape Architecture, College of Horticulture, Mudigere. It is situated in the Western Ghats and represents the typical hill zone (Zone-9 and Region- V) of Karnataka and lies at 13°25’ North latitude and 75°25’ East longitude with an altitude of 980 m above MSL.

3.2 Climatic conditions of the experimental site

The mean monthly weather data during crop growth period for the year 2019-20 are collected from the meteorological observation, Zonal Agricultural and Horticultural Research Station (ZAHRS), Mudigere are presented in Appendix I. Climate in the region is cool and pleasant throughout the year with total annual rainfall of 287.13 mm, mainly distributed between June to June. The mean maximum temperature is 28.24 °C and mean minimum temperature is 19.13 °C and the relative humidity ranges from 71.60 to 80.53 per cent.

3.3 Soil and its characteristics

The experimental site is sandy loam soil with adequate drainage. The soil sample from a depth of 0-15 cm was collected at random spots a day before layout of experiment. The collected sample is mixed thoroughly and composite soil was analyzed to determine the physico-chemical composition of the soil. The experiment is conducted in red sandy loam soil. The physical and chemical characteristics of soil is presented in appendix-II.

3.4 Experimental details

Statistical design	Randomized Complete Block Design
Number of replications	03
Number of treatments	12
Spacing	30 x 20 cm
Planting method	Flat bed method
Plot size	2 x 1 m
Cultivar	Summer Sunshine
Mode of weedicide application	Soil surface spray @ 2 days after planting
Date of planting	28-10-2019

3.4.1 Treatment details:

Details of herbicides used for the experiment

Treatment number	Treatment details
T ₁	Atrazine @ 1.0 kg <i>a.i.</i> / ha
T ₂	Atrazine @ 1.5 kg <i>a.i.</i> / ha
T ₃	Metribuzin @ 0.25 kg <i>a.i.</i> / ha
T ₄	Metribuzin @ 0.5 kg <i>a.i.</i> / ha
T ₅	Butachlor @ 1.0 kg <i>a.i.</i> / ha
T ₆	Butachlor @ 1.5 kg <i>a.i.</i> / ha
T ₇	Pendimethalin @ 0.75 kg <i>a.i.</i> / ha
T ₈	Pendimethalin @ 1.0 kg <i>a.i.</i> / ha
T ₉	Oxyfluorfen @ 0.5 kg <i>a.i.</i> / ha
T ₁₀	Oxyfluorfen @ 1.0 kg <i>a.i.</i> / ha
T ₁₁	Weedy check
T ₁₂	Weed free

3.4.2 Design and layout of the experimental plot

The experiment was laid out in Randomized Complete Block Design (RCBD) with 12 treatments and three replications. The treatments in each replication are allotted using random number table. The plan of layout of the experiment is given in figure-1 and Plate. 5, 6.

Information on herbicides under the study

Sl. No.	Active ingredient (s)	Chemical family or class	Trade name and formulation	Mode of action*
1	Atrazine	Triazine	Atratop - 50% WP	It functions by binding to plastoquinone binding protein in photosystem-II. Results in death from starvation and oxidative damage caused by breakdown in electron transport process.

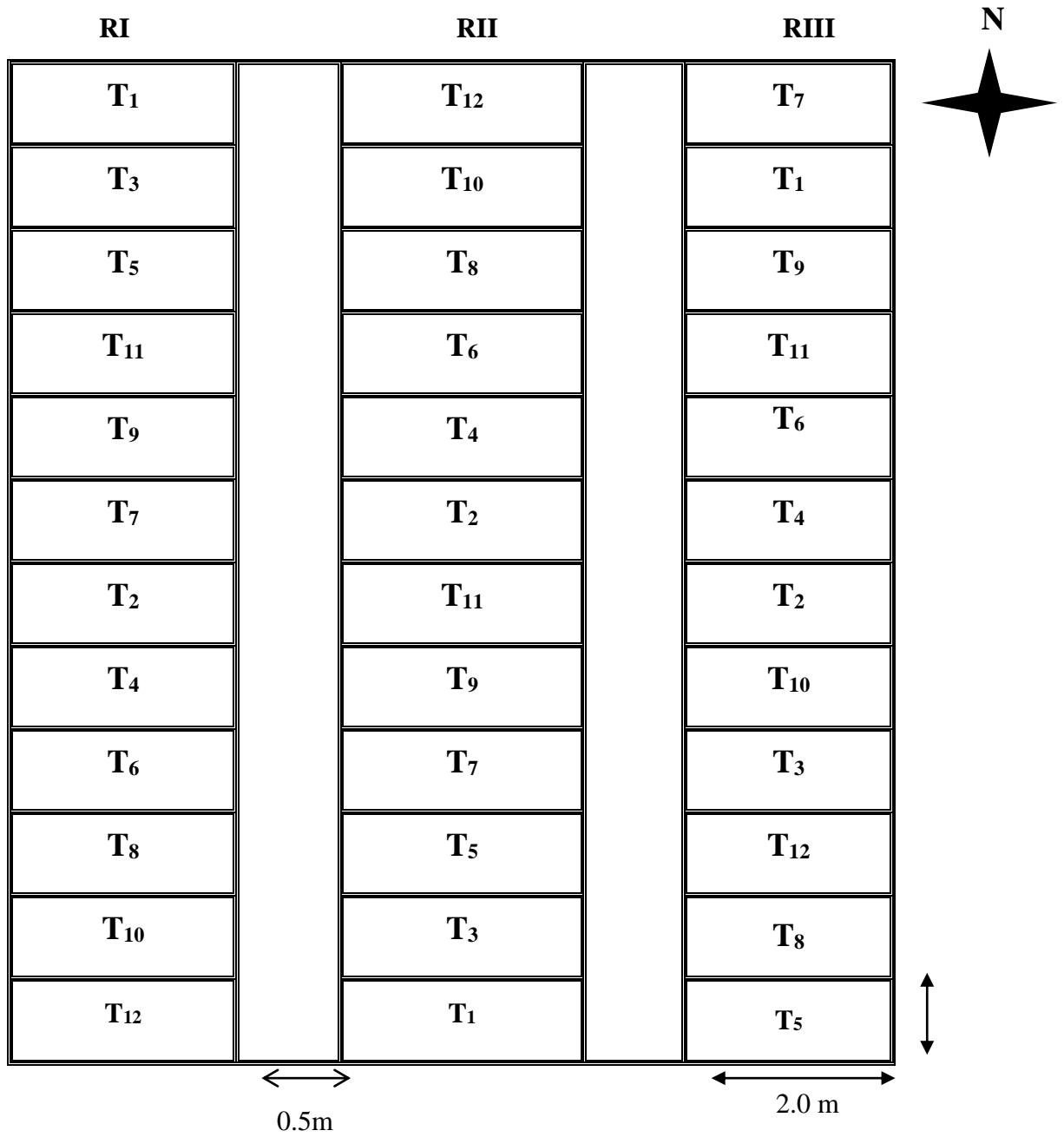


Fig.1. Plan of layout of the experiment



Plate. 5. General view of experimental plot at early vegetative stage



Plate. 6. General view of experimental plot at flowering stage

2	Metribuzin	Triazinone	Lexine - 70% WP	It acts by inhibiting photosystem-II of photosynthesis by disrupting electron transfer, this results in death due to starvation in the target plant
3	Butachlor	Acetanilide	Weedar - 50% EW	It inhibits cell division by blocking protein synthesis.
4	Pendimethalin	Dinitroaniline	Stomp - 30% EC	It inhibits root and shoot growth. It primarily prevents the plant cell division and elongation in a susceptible species.
5	Oxyfluorfen	Diphenylether	Goal – 23.5% EC	It inhibits photoporphyrinogen oxidase, leading to irreversible cell membrane damage

*(Annon., 2018)

3.5 Preparatory operations

3.5.1 Source of planting material

The planting material for the experiment comprising of gladiolus cultivar “Summer Sunshine” was procured from Department of Floriculture and Landscape Architecture, College of Horticulture Mudigere, Karnataka.

3.6 Cultural operation

3.6.1 Preparation of experimental site

All the weeds, stubbles, stones are removed then well-decomposed farmyard manure at 25 t/ha and lime is applied to maintain the soil pH and mixed well. The leveled experimental area is divided into equal plots of size 2 m × 1 m of flat beds. A spacing of 0.5 m is provided between replications and 0.2 m between treatments.

3.6.2 Planting

Healthy and uniform corms measuring about 3-4 cm are selected for planting. Before planting corms are treated with thiourea at 1000 ppm (Plate. 1) for half an hour and they are planted at a spacing of 30 cm x 20 cm (Plate. 2) on flat beds and light irrigation was given immediately after planting followed by spraying of herbicides two days after planting (Plate. 4). The crop is raised and maintained by following the standard cultural practices of University of Horticultural Sciences, Bagalkot (Anon, 2013).

3.6.3 Irrigation

Initially plants are irrigated weekly twice. Later irrigation is given depending upon soil moisture and weather conditions, the beds are irrigated regularly to keep soil moderately moist.

3.6.4 Fertilizers

The crop was fertilized with recommended dose of fertilizers, *i.e.*, N, P and K @ 100:60:60 kg per ha in the form of urea, SSP and MOP are applied as per the recommendations from the package of practices, UHS, Bagalkot (Anon, 2013). Fifty per cent of nitrogen and the full dose of phosphorus and potash are used as basal dose and the remaining fifty per cent of nitrogen is applied at 45 days after planting.

3.6.5 Intercultural operation

Intercultural operation like earthing up are done at 60 days after planting to cover up the exposed corms and also to prevent the crop from lodging. Weeds are allowed to grow naturally in order to know the effect of weeds on main crop except in weed free treatment.

3.6.6 Plant protection

To control the pests and diseases, necessary plant protection measures were taken up as per recommended package of practice.

3.6.7 Harvesting

The flowering spikes are harvested when one or two basal florets showed color in a spike and used for recording the different parameters. After three months of flowering when the foliage turned to yellow, the corm and cormels are lifted carefully from the ground. The harvested corms and cormels are further used for recording different parameters. Simultaneously weeds are also harvested, dried and its parameters are recorded.

3.7 Observations recorded

3.7.1. Observation on weeds

3.7.1.1 Weed population

The total number of different weeds present in experimental plots were counted with a help of quadrates of 0.5 m² and weed population is recorded. All the weeds present in the experimental plots were classified under three major group (i) grasses (ii) sedges and (iii) broad leaved weeds. The numbers of weeds were counted at 30, 45 and 60 DAP and the average is worked out.



Plate. 1. Thiourea treatment (1000 ppm) of the corms before planting



Plate. 2. Planting of gladiolus corms



Plate. 3. Spraying of herbicides at 2 DAP



Plate.4. Sprouting of gladiolus corms

3.7.1.2 Dry weight of weeds (g)

After collecting the weeds from individual treatments at a specific day, weed samples were kept for shade drying for 72 hours. After complete drying the dry weight of the weeds were recorded for different treatments.

3.7.1.3 Weed control efficiency (WCE)

The weed control efficiency indicates the percentage reduction in weed population or dry weight of weeds under treated plot (herbicide) in comparison to untreated plot (weedy check) and calculated on the basis of reduction in dry weight in the treated plot in comparison with weedy check and expressed in percentage.

$$WCE = \frac{DWC - DWT}{DWC} \times 100$$

Where,

WCE = Weed control efficiency

DWC = Dry weight of the weed in weedy check plot

DWT = Dry weight of the weeds in treated plot

3.7.1.4 Weed Index (WI)

It is defined as the magnitude of yield reduction due to the presence of weeds in comparison to weed free plot, weed index is calculated by using the formula, given by Gill and Vijay kumar (1969).

$$\text{Weed index (\%)} = \frac{X - Y}{X} \times 100$$

Where,

X = Flower yield of the weed free check

Y = Flower yield from the treatment for which weed index has to be calculated

3.7.1.5 Grass weed population

The number of grass weeds were taken 30, 45 and 60 DAP from one place in each plot using 0.5 m² quadrat and average value were taken as number of grass weeds.

3.7.1.6 Sedge weed population

Number of sedge weeds were taken at 30, 45 and 60 DAP from one place in each plot using 0.5 m² quadrat and average value were taken as number of sedge weeds.

3.7.1.7 Broad leaved weed population

Number of broad leaved weeds were taken at 30, 45 and 60 DAP from one place in each plot using 0.5 m² quadrat and average value were taken as number of broad leaved weeds.

3.7.2 Vegetative parameters of gladiolus

The observations on vegetative parameters are recorded at 30, 45 and 60 days after planting.

3.7.2.1. Days taken for sprouting (at once)

The number of days taken for sprouting at once is the average of total corms get sprouted and it was taken 15 at days after planting

3.7.2.2. Sprouting per cent

Sprouting percentage was the natural process by which corms germinate and put out shoots (Plate. 3).

$$SP = \frac{\text{Corns germinated}}{\text{Total corms}} \times 100$$

3.7.2.3. Number of shoots per corm

Five randomly plants were selected and the number of shoots counted and average was worked out at 30 DAP.

3.7.2.4 Plant height (cm)

The height of the five randomly selected plants were measured from the base of the plant to the tip of the longest leaf at 30, 45 and 60 DAP and average was expressed in centimetre.

3.7.2.5 Number of leaves per plant

The number of leaves produced from the five randomly selected plants were recorded by counting the number of leaves at 30, 45 and 60 days after planting and average was worked out.

3.7.2.6 Leaf area per plant (cm²)

The leaf area was estimated by using the leaf parameters like leaf length and width of the leaf, number of leaves per plant and the factor 0.471. It is expressed in cm² per plant.

$$\text{Leaf area} = \text{Length of the leaves} \times \text{Width of the leaves} \times \text{factor (K)}$$

3.7.2.7 Leaf area index (LAI)

The leaf area index was calculated by dividing the leaf area per plant and the land area occupied by the plant Sestak *et al.*, 1971.

$$\text{LAI} = \frac{\text{Leaf area (cm}^2\text{/plant)}}{\text{Land area (cm}^2\text{/plant)}}$$

3.7.3 Observations on flowering parameters

3.7.3.1 Days taken for initiation of inflorescence

The number of days taken for initiation of inflorescence from the date of planting in the five randomly selected plants were counted and an average was worked out and expressed in days.

3.7.3.2 Days taken for first floret opening

The number of days taken from the date of planting to the first floret opening stage was recorded in five randomly selected plants and the average was worked out and expressed in days.

3.7.3.3 Days taken for 50 per cent flowering

The number of days taken for 50 *per cent* of the plants to flower opening was recorded in each treatment by counting days from the date of planting and average was worked out and expressed in days.

3.7.3.4 Duration of flowering (days)

Days taken from the first flower opening to the last flower opening in a spike was recorded in five randomly selected plants and the average was worked out and expressed in days.

3.7.4 Observations on flower quality parameters

3.7.4.1 Spike length (cm)

Length of the spike was measured in the cut flowers obtained from five randomly selected plants from the base of the stem up to the tip of the inflorescence and an average was worked out and expressed in centimetres.

3.7.4.2 Length of the rachis (cm)

Length of the rachis was measured in centimetres from basal floret to the top of the floret in the cut spike obtained from five randomly selected plants and average was worked out and expressed in centimetres.

3.7.4.3 Number of florets per spike

The number of florets produced per each spike was recorded from the five randomly selected plants and the average number of florets produced per spike was worked out.

3.7.4.4 Girth of the spike (mm)

The girth of the spike was measured at the point just below the basal floret with the help of the vernier calipers from the five randomly selected plants and the average was worked out and expressed in millimetres.

3.7.4.5 Floret diameter (cm)

The diameter of the floret was measured by using the scale and average floret diameter was expressed in centimetres.

3.7.4.6 Length of the floret (cm)

Length of the floret was measured with the help of scale from five randomly selected plants and the average was worked out and expressed in centimetres.

3.7.4.7 Weight of the spike (g)

Spike weight was recorded by weighing the spikes after harvesting from five randomly selected plants and average was worked out and expressed in grams.

3.7.4.8 Vase life (days)

Spikes were harvested at color showing stage and they were kept in the conical flask containing 250 ml of plain water at room temperature for the study. The number of days was counted until the florets lost their marketable visual value.

3.7.5 Flower yield parameters

3.7.5.1 Spike yield per plant (No's.)

The number of spikes produced per plant was recorded from the five randomly selected plants and the average number of spikes produced per plant was worked out.

3.7.5.2 Spike yield per plot (No's.)

The number of spikes produced per plot was worked out from the data of spikes yield per plant.

3.7.5.3 Spike yield per hectare (No's.)

The number of spikes produced per hectare was calculated from the data of spike yield per plot.

3.7.6 Corm and cormel parameters

3.7.6.1 Number of corms per plant

The number of corms produced per plant was recorded from the five randomly selected plants and their average was worked out.

3.7.6.2 Number of cormels per plant

Cormels produced per plant were counted from the five randomly selected plants and average was worked out.

3.7.6.3 Number of corms and cormels per plot

The number of corms and cormels produced per plot was recorded from the data of corms and cormels yield per plant.

3.7.6.4 Weight of corms and cormels (g/plant)

The harvested corms and cormels from the five randomly selected plants were weighed individually and an average weight of corms and cormels produced by plants was worked out and expressed in grams per plant.

3.7.6.5 Weight of corms and cormels (g/plot)

The weight of corms and cormels produced per plot was recorded from the data of weight of corms and cormels yield per plant and expressed in grams per plot.

3.7.6.6 Diameter of corm (cm)

The diameter of corm was measured from one end to the other end of the corm from five randomly selected plants by using vernier caliper and average was worked out and expressed in centimeters.

3.7.6.7 Diameter of cormels (mm)

The diameter of cormels from five randomly selected plants were measured by using vernier caliper and average was worked out and expressed in millimeter.

3.7.6.8 Corms yield (kg/ha)

The yield of corms per hectare was worked out by weight of corms obtained from each net plot and expressed in kilogram per hectare.

3.7.6.9 Cormels yield (kg/ha)

The yield of cormels per hectare was worked out by weight of cormels obtained from each net plot and expressed in kilogram per hectare.

3.7.7 Bio chemical parameters

3.7.7.1 Estimation of chlorophyll content (mg/g fresh weight)

Chlorophyll content of leaf was analyzed by collecting the healthy and fully matured second leaf from the center portion of the plant at peak vegetative growth stage. The chlorophyll-a, chlorophyll-b and total chlorophyll contents of leaf tissue were determined by using dimethyl sulfoxide (DMSO) method as suggested by Shoaf and Lium (1976).

Chlorophyll estimation procedure

Fresh and fully matured leaves from the plant were brought to laboratory in ice box from the research field and the known weight of the fresh leaf sample (100 mg) were cut into small pieces and was incubated in 7.0 ml of dimethyl sulfoxide at 65 °C for 120 minutes. After the incubation period the supernatant was collected by decanting and leaf tissue was discarded, then the volume of the supernatant was made up to 10 ml using DMSO. The absorbance of the extract was measured at 645 nm and 663 nm using dimethyl sulfoxide as blank in the spectrophotometer (VISISCAN 167). The chlorophyll-a, chlorophyll-b and total chlorophyll content were calculated by using the following formulae, the chlorophyll content was estimated in leaves at 60 DAP and expressed in mg per gram from weight.

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

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

$$\text{Total Chlorophyll} = 20.2 (A_{645}) + 8.028 (A_{663}) \times \frac{V}{1000 \times W \times a}$$

Where,

A = Absorbance at specific wave length (645 nm and 663 nm)

V = Volume of the extract (10 ml)

W = Fresh weight of the sample (100 mg)

a = Path length of light in the cuvette (1 cm)

3.7.8 Economics

3.7.8.1 Cost of cultivation

The prices of all inputs prevailing at the time of their use, the laborer's cost were considered to work out the cost of cultivation (Appendix-III and IV).

3.7.8.2 Gross income (Rs.)

The gross income was worked out based on the prevailing market price of gladiolus spikes, corms and cormels.

Gross yield = Sum of spike yield + Corm yield + Cormels yield.

3.7.8.3 Net income (Rs.)

The net income per hectare was calculated by using the following formula.

$$NI = \text{Gross income} - \text{Cost of cultivation}$$

3.7.8.4 Benefit-cost ratio (BCR)

The cost-benefit ratio for different treatments was worked out based on the price of inputs used for cultivation and price of marketable produce in the local market by using formula and expressed in the ratio.

$$\text{Benefit : Cost ratio} = \frac{\text{Net income}}{\text{Cost of cultivation}}$$

3.8 Statistical analysis

3.8.1 ANOVA

Observations were recorded from five randomly selected plants of each treatment and replication. The data comprising the calculated average values of each observation treatment wise and replication wise are subjected to computerized statistical analysis using a method suggested by Sundaraj *et al.* (1972). Significant differences are plotted by comparing the calculated 'F' value and Table 'F' value and the level of significance used in 'F' test was P = 0.05. Critical difference is calculated whenever the 'F' test is found significant.

3.8.2 Standard error of mean (S. Em)

The values for S.Em (Standard error of mean) was calculated by the following formula

$$S. Em \pm = \sqrt{EMS - r}$$

Where,

EMS= Error mean sum of square

r =Number of replication

3.8.3 Critical difference (CD)

Critical difference was calculated whenever the 'F' test is found significant. By using the formula.

CD = SEd x 't' value at error degrees of freedom.

t = Tabulated 't' value at 5 per cent probability level.

$$S. Ed = \sqrt{2EMS/r}$$

Where,

S. Ed = Standard error of difference between two treatment means

EMS = Error mean sum of square

r = Number of replication

EXPERIMENTAL RESULTS

IV EXPERIMENTAL RESULTS

The results obtained from the present investigation entitled “Efficacy of herbicides on growth, flowering, quality and yield of gladiolus (*Gladiolus grandiflora* L.) under the hill zone of Karnataka” was conducted during the year 2019-20 at the College of Horticulture, Mudigere. The results with respect to the effect herbicides on growth, flowering, quality and yield of gladiolus obtained during the course of investigation are presented in this chapter under the following headings.

4.1 Effect of different herbicides on growth parameters in gladiolus

4.1.1 Days taken for sprouting (at once)

Effect of various treatments on number of days taken for sprouting presented in the Table 1. Among the treatments, T₁₂-weed free recorded minimum number of days for sprouting (12.00) at 30 days after planting, followed by T₂-atrazine @ 1.5 kg *a.i./ha* and T₇-pendimethalin @ 0.75 kg *a.i./ha* had taken 12.15 and 12.26 days, respectively. Whereas, maximum number of days taken for sprouting was observed in treatment T₁₁-weedy check (14.37).

4.1.2 Sprouting per cent (%)

Data on sprouting percentage presented in the Table 1. Among the treatments, T₁₂-weed free recorded maximum sprouting percentage (100.00) at 30 days after planting, followed by treatments T₈-pendimethalin @ 1.0 kg *a.i./ha* and T₇- pendimethalin @ 0.75 kg *a.i./ha* which had recorded 98.88 and 97.77 %, respectively. Whereas, minimum sprouting percentage was observed in treatment T₁₁-weedy check (90.89 %).

4.1.3 Shoots per corm (No 's)

The values relating to this finding were subjected for statistical calculation. Among the treatments, T₁₂-weed free recorded significantly maximum shoots per corm (1.83) at 30 days after planting, followed by T₈-pendimethalin @ 1.0 kg *a.i./ha* (1.76) and T₇-pendimethalin @ 0.75 kg *a.i./ha* (1.64). Whereas, significantly minimum shoots per corm were recorded in T₁₁-weedy check (1.26).

4.2 Effect of different herbicides on growth parameters at various stages of growth in gladiolus

4.2.1 Plant height (cm)

The data recorded on the plant height at 30, 45 and 60 days after planting (Table 2) revealed that there were significant differences among herbicides treatments.

Table 1. Effect of different herbicides on growth parameters in gladiolus

Treatment	Days taken for sprouting	Sprouting per cent	Shoots per corm (No's)
T ₁ - Atrazine @ 1.0 kg <i>a.i./ha</i>	12.73	96.66	1.51
T ₂ - Atrazine @ 1.5 kg <i>a.i./ha</i>	12.15	95.55	1.42
T ₃ - Metribuzin @ 0.25 kg <i>a.i./ha</i>	13.85	92.22	1.39
T ₄ - Metribuzin @ 0.5 kg <i>a.i./ha</i>	12.65	93.33	1.46
T ₅ - Butachlor @ 1.0 kg <i>a.i./ha</i>	13.97	96.66	1.33
T ₆ - Butachlor @ 1.5 kg <i>a.i./ha</i>	13.87	92.77	1.31
T ₇ - Pendimethalin @ 0.75 kg <i>a.i./ha</i>	12.26	97.77	1.64
T ₈ - Pendimethalin @ 1.0 kg <i>a.i./ha</i>	12.37	98.88	1.76
T ₉ - Oxyfluorfen @ 0.5 kg <i>a.i./ha</i>	13.56	90.89	1.41
T ₁₀ - Oxyfluorfen @ 1.0 kg <i>a.i./ha</i>	13.39	94.44	1.58
T ₁₁ -Weedy check	14.37	90.89	1.26
T ₁₂ -Weed free	12.00	100.00	1.83
S.Em ±	0.52	3.13	0.07
CD @ 5%	1.53	9.17	0.20

Table 2. Effect of different herbicides on plant height at various stages of growth in gladiolus

Treatment	Plant height (cm)		
	Days after planting		
	30	45	60
T ₁ - Atrazine @ 1.0 kg <i>a.i./ha</i>	33.40	49.94	60.50
T ₂ - Atrazine @ 1.5 kg <i>a.i./ha</i>	35.10	52.40	63.20
T ₃ - Metribuzin @ 0.25 kg <i>a.i./ha</i>	33.80	46.30	57.10
T ₄ - Metribuzin @ 0.5 kg <i>a.i./ha</i>	31.70	43.40	55.20
T ₅ - Butachlor @ 1.0 kg <i>a.i./ha</i>	32.40	48.71	55.00
T ₆ - Butachlor @ 1.5 kg <i>a.i./ha</i>	31.30	42.23	53.70
T ₇ - Pendimethalin @ 0.75 kg <i>a.i./ha</i>	36.20	53.20	65.40
T ₈ - Pendimethalin @ 1.0 kg <i>a.i./ha</i>	37.40	57.40	68.30
T ₉ - Oxyfluorfen @ 0.5 kg <i>a.i./ha</i>	34.22	49.40	58.30
T ₁₀ - Oxyfluorfen @ 1.0 kg <i>a.i./ha</i>	32.49	47.90	58.70
T ₁₁ -Weedy check	26.90	40.30	51.20
T ₁₂ -Weed free	38.10	59.40	70.50
S.Em ±	1.45	1.97	1.95
CD @ 5%	4.25	5.78	5.72

At 30 DAP, T₁₂ -weed free recorded significantly maximum plant height (38.10 cm), which was on par with T₈-pendimethalin @ 1.0 kg *a.i./* ha (37.40 cm), T₇- pendimethalin @ 0.75 kg *a.i./*ha (36.20 cm) and T₂-atrazine @ 1.5 Kg *a.i/* ha (35.10 cm). Whereas, significantly minimum plant height was recorded in T₁₁-weedy check (26.90 cm).

At 45 DAP, T₁₂-weed free recorded significantly maximum plant height (59.40 cm), which was on par with T₈-pendimethalin @ 1.0 kg *a.i./*ha (57.40 cm) and T₇- pendimethalin @ 0.75 kg *a.i./* ha (53.20 cm). Whereas, significantly minimum plant height was recorded in T₁₁-weedy check (40.30 cm).

At 60 DAP, T₁₂-weed free recorded significantly maximum plant height (70.50 cm), which was on par with T₈-pendimethalin @ 1.0 kg *a.i./*ha (68.30) and T₇- pendimethalin @ 0.75 kg *a.i./* ha (65.40 cm). Whereas, significantly minimum plant height was recorded in T₁₁-weedy check (51.20 cm).

4.2.2 Number of leaves per plant

The data pertaining to the influence of various weed control treatments on number of leaves per plant at different crop growth stages are presented in the Table 3. The different weed control treatments significantly differed with respect to number of leaves per plant.

At 30 DAP, T₈-pendimethalin @ 1.0 kg *a.i./* ha recorded significantly maximum number of leaves per plant (5.30) which was on par with T₇-pendimethalin @ 0.75 kg *a.i./* ha (5.20) and T₃-metribuzin @ 0.25 kg *a.i./* ha (4.80). Whereas, significantly minimum number of leaves was recorded in T₁₁-weedy check (2.70).

At 45 DAP, T₈-pendimethalin @ 1.0 kg *a.i./*ha recorded significantly maximum number of leaves per plant (7.80) which was on par with T₇-pendimethalin @ 0.75 kg *a.i./* ha (7.10). Whereas, significantly minimum number of leaves was recorded in T₁₁-weedy check (4.10).

At 60 DAP, T₈-pendimethalin @ 1.0 kg *a.i./*ha recorded significantly maximum number of leaves per plant (10.20) which was on par with T₇- pendimethalin @ 0.75 kg *a.i./*ha (9.0). Whereas, significantly minimum number of leaves was recorded in T₁₁-weedy check (5.70).

4.2.3 Leaf area per plant (cm²)

The data pertaining to the influence of various weed control treatments on leaf area per plant at different crop growth stages are presented in the Table 4. The different weed control treatments significantly differed with respect to leaf area per plant.

Table 3. Effect of different herbicides on number of leaves at various stages of growth in gladiolus

Treatment	Number of leaves		
	Days after planting		
	30	45	60
T ₁ - Atrazine @ 1.0 kg <i>a.i./ha</i>	3.50	4.90	6.30
T ₂ - Atrazine @ 1.5 kg <i>a.i./ha</i>	3.10	4.80	6.20
T ₃ - Metribuzin @ 0.25 kg <i>a.i./ha</i>	4.80	6.60	8.20
T ₄ - Metribuzin @ 0.5 kg <i>a.i./ha</i>	3.80	5.70	7.40
T ₅ - Butachlor @ 1.0 kg <i>a.i./ha</i>	3.70	5.50	7.30
T ₆ - Butachlor @ 1.5 kg <i>a.i./ha</i>	3.40	5.10	6.80
T ₇ - Pendimethalin @ 0.75 kg <i>a.i./ha</i>	5.20	7.10	9.00
T ₈ - Pendimethalin @ 1.0 kg <i>a.i./ha</i>	5.30	7.80	10.20
T ₉ - Oxyfluorfen @ 0.5 kg <i>a.i./ha</i>	3.90	5.60	7.10
T ₁₀ - Oxyfluorfen @ 1.0 kg <i>a.i./ha</i>	3.70	5.40	7.00
T ₁₁ -Weedy check	2.70	4.10	5.70
T ₁₂ -Weed free	3.60	5.40	7.20
S.Em ±	0.22	0.33	0.45
CD @ 5%	0.66	0.97	1.32

Table 4. Effect of different herbicides on leaf area at various stages of growth in gladiolus

Treatments	Leaf area (cm ²)		
	Days after planting		
	30	45	60
T ₁ - Atrazine @ 1.0 kg <i>a.i./ha</i>	118.57	322.69	422.87
T ₂ - Atrazine @ 1.5 kg <i>a.i./ha</i>	134.39	341.11	483.32
T ₃ - Metribuzin @ 0.25 kg <i>a.i./ha</i>	271.22	672.38	815.90
T ₄ - Metribuzin @ 0.5 kg <i>a.i./ha</i>	333.49	698.65	856.42
T ₅ - Butachlor @ 1.0 kg <i>a.i./ha</i>	152.09	464.39	521.38
T ₆ - Butachlor @ 1.5 kg <i>a.i./ha</i>	173.91	487.29	575.01
T ₇ - Pendimethalin @ 0.75 kg <i>a.i./ha</i>	381.77	782.26	941.56
T ₈ - Pendimethalin @ 1.0 kg <i>a.i./ha</i>	421.45	811.31	1023.93
T ₉ - Oxyfluorfen @ 0.5 kg <i>a.i./ha</i>	194.98	503.91	621.04
T ₁₀ - Oxyfluorfen @ 1.0 kg <i>a.i./ha</i>	229.86	521.20	684.23
T ₁₁ -Weedy check	106.36	321.31	403.99
T ₁₂ -Weed free	360.41	663.18	852.37
S.Em ±	8.60	17.02	22.25
CD @ 5%	25.22	49.91	65.25

At 30 DAP, T₈-pendimethalin @ 1.0 kg *a.i./ha*, recorded significantly maximum leaf area (421.45 cm²) which was on par with T₇-pendimethalin @ 0.75 kg *a.i./ha* (381.77 cm²). Whereas, significantly minimum number of leaf area was recorded in T₁₁-weedy check (106.36 cm²).

At 45 DAP, T₈-pendimethalin @ 1.0 kg *a.i./ha*, recorded significantly maximum leaf area (811.31cm²) which was on par with T₇-pendimethalin @ 0.75 kg *a.i./ha* (782.26 cm²). Whereas, significantly minimum number of leaf area was recorded in T₁₁-weedy check (321.31 cm²).

At 60 DAP, T₈-pendimethalin @ 1.0 kg *a.i./ha*, recorded significantly maximum leaf area (1023.93 cm²) which was on par with T₇-pendimethalin @ 0.75 kg *a.i./ha* (941.56 cm²). Whereas, significantly minimum number of leaf area was recorded in T₁₁-weedy check (403.99 cm²).

4.2.4 Leaf area index (LAI)

The data pertaining to the influence of various weed control treatments on leaf area index per plant at different crop growth stages are presented in the Table 5. The different weed control treatments significantly differed with respect to leaf area index per plant.

At 30 DAP, T₈-pendimethalin @ 1.0 kg *a.i./ha* recorded significantly maximum leaf area index per plant (0.51) which was on par with T₇-pendimethalin @ 0.75 kg *a.i./ha* (0.48). Whereas, significantly minimum number of leaf area index was recorded in T₁₁-weedy check (0.16).

At 45 DAP, T₈-pendimethalin @ 1.0 kg *a.i./ha* recorded significantly maximum leaf area index per plant (1.05) which was on par with T₇-pendimethalin @ 0.75 kg *a.i./ha* (1.01). Whereas, significantly minimum number of leaf area index was recorded in T₁₁-weedy check (0.48).

At 60 DAP, T₈-pendimethalin @ 1.0 kg *a.i./ha* recorded significantly maximum leaf area index per plant (1.72), which was on par with T₇-pendimethalin @ 0.75 kg *a.i./ha* (1.69). Whereas, significantly minimum number of leaf area index was recorded in T₁₁-weedy check (0.71)

4.3 Effect of different herbicides on chlorophyll content at peak vegetative stage in gladiolus

Significant differences were observed among the plants, different concentrations of herbicide application with respect to the leaf chlorophyll content (Table-6).

Table 5. Effect of different herbicides on leaf area index at various stages of growth in gladiolus

Treatment	Leaf area index (LAI)		
	Days after planting		
	30	45	60
T ₁ - Atrazine @ 1.0 kg <i>a.i./ha</i>	0.21	0.52	0.87
T ₂ - Atrazine @ 1.5 kg <i>a.i./ha</i>	0.28	0.61	1.03
T ₃ - Metribuzin @ 0.25 kg <i>a.i./ha</i>	0.30	0.87	1.43
T ₄ - Metribuzin @ 0.5 kg <i>a.i./ha</i>	0.39	0.95	1.57
T ₅ - Butachlor @ 1.0 kg <i>a.i./ha</i>	0.33	0.79	1.21
T ₆ - Butachlor @ 1.5 kg <i>a.i./ha</i>	0.35	0.81	1.38
T ₇ - Pendimethalin @ 0.75 kg <i>a.i./ha</i>	0.48	1.01	1.69
T ₈ - Pendimethalin @ 1.0 kg <i>a.i./ha</i>	0.51	1.05	1.72
T ₉ - Oxyfluorfen @ 0.5 kg <i>a.i./ha</i>	0.32	0.79	1.32
T ₁₀ - Oxyfluorfen @ 1.0 kg <i>a.i./ha</i>	0.42	0.85	1.37
T ₁₁ -Weedy check	0.16	0.48	0.71
T ₁₂ -Weed free	0.45	0.93	1.45
S.Em ±	0.02	0.03	0.05
CD @ 5%	0.05	0.08	0.14

Table 6. Effect of different herbicides on chlorophyll content at peak vegetative stage in gladiolus

Treatment	Chlorophyll - a (mg/g of fresh weight)	Chlorophyll – b (mg/g of fresh weight)	Total chlorophyll (mg/g of fresh weight)
T ₁ - Atrazine @ 1.0 kg <i>a.i./ha</i>	0.97	0.35	1.32
T ₂ - Atrazine @ 1.5 kg <i>a.i./ha</i>	0.89	0.38	1.27
T ₃ - Metribuzin @ 0.25 kg <i>a.i./ha</i>	1.49	0.45	1.97
T ₄ - Metribuzin @ 0.5 kg <i>a.i./ha</i>	1.41	0.44	1.85
T ₅ - Butachlor @ 1.0 kg <i>a.i./ha</i>	1.37	0.37	1.74
T ₆ - Butachlor @ 1.5 kg <i>a.i./ha</i>	1.02	0.41	1.43
T ₇ - Pendimethalin @ 0.75 kg <i>a.i./ha</i>	1.52	0.70	2.19
T ₈ - Pendimethalin @ 1.0 kg <i>a.i./ha</i>	1.57	0.79	2.36
T ₉ - Oxyfluorfen @ 0.5 kg <i>a.i./ha</i>	1.21	0.40	1.61
T ₁₀ - Oxyfluorfen @ 1.0 kg <i>a.i./ha</i>	1.09	0.43	1.52
T ₁₁ -Weedy check	0.82	0.28	1.10
T ₁₂ -Weed free	1.42	0.70	2.12
S.Em ±	0.05	0.03	0.07
CD @ 5%	0.14	0.10	0.20

4.3.1 Chlorophyll 'a'

Treatments varied significantly with respect to chlorophyll 'a' content. T₈-Pendimethalin @ 1.0 kg *a.i./* ha recorded significantly maximum chlorophyll 'a' content (1.57 mg/g of fresh weight) and it was statistically on par with T₇-pendimethalin @ 0.75 kg *a.i./*ha (1.52 mg/g of fresh weight) and T₃-metribuzin @ 0.25 kg *a.i./*ha (1.49 mg/g). Whereas, significantly minimum chlorophyll 'a' content was recorded in T₁₁-weedy check (0.82 mg/g of fresh weight).

4.3.2 Chlorophyll 'b'

Significant difference was observed for chlorophyll 'b' content among the treatments. Chlorophyll 'b' content recorded significantly maximum in T₈-pendimethalin @ 1.0 kg *a.i./* ha (0.79 mg / g of fresh weight) and it was statistically on par with T₇- pendimethalin @ 0.75 kg *a.i./* ha (0.70 mg / g of fresh weight). Whereas, significantly minimum chlorophyll 'b' was recorded in T₁₁-weedy check (0.28 mg/g of fresh weight).

4.3.3 Total chlorophyll content

Total chlorophyll content of the leaf also varied significantly among the treatments. T₈-pendimethalin @ 1.0 kg *a.i./* ha recorded significantly maximum total chlorophyll content (2.36 mg/g of fresh weight) and it was statistically on par with T₇-pendimethalin @ 0.75 kg *a.i./* ha (2.19 mg / g of fresh weight). Whereas, significantly minimum total chlorophyll content was recorded in T₁₁-weedy check (1.10 mg / g of fresh weight).

4.4 Effect of different herbicides on weed flora at various stages of growth in gladiolus

4.4.1 Grass weed population (No's)

The experimental data on population of grasses, sedges, broad leaved weeds and total weed population as influenced by different weed control treatments recorded at 30,45 and 60 days after planting.

Grass weed population as influenced by different weed control treatments differed significantly at all stages of crop growth (Table 7).

At 30 DAP, among the treatments, T₁₂-weed free recorded significantly the minimum number of grass weed population (1.38), which was on par with T₈-pendimethalin @ 1.0 kg *a.i./*ha (2.04), and T₇-pendimethalin @ 0.75 kg *a.i./*ha (2.84), Whereas, significantly maximum number of grass weed population was recorded in T₁₁-weedy check (11.93).

Table 7. Effect of different herbicides on grass weed population at various stages of growth in gladiolus

Treatment	Grass weed population (per m ²)		
	Days after planting		
	30	45	60
T ₁ - Atrazine @ 1.0 kg <i>a.i./ha</i>	3.82	5.82	7.29
T ₂ - Atrazine @ 1.5 kg <i>a.i./ha</i>	5.89	8.25	10.09
T ₃ - Metribuzin @ 0.25 kg <i>a.i./ha</i>	5.25	8.89	12.49
T ₄ - Metribuzin @ 0.5 kg <i>a.i./ha</i>	4.02	7.51	11.24
T ₅ - Butachlor @ 1.0 kg <i>a.i./ha</i>	3.41	5.17	6.92
T ₆ - Butachlor @ 1.5 kg <i>a.i./ha</i>	5.97	8.37	11.56
T ₇ - Pendimethalin @ 0.75 kg <i>a.i./ha</i>	2.84	4.29	5.49
T ₈ - Pendimethalin @ 1.0 kg <i>a.i./ha</i>	2.04	3.01	3.92
T ₉ - Oxyfluorfen @ 0.5 kg <i>a.i./ha</i>	5.51	8.41	13.11
T ₁₀ - Oxyfluorfen @ 1.0 kg <i>a.i./ha</i>	5.22	8.02	12.52
T ₁₁ -Weedy check	11.93	17.22	24.52
T ₁₂ -Weed free	1.38	2.87	3.41
S.Em ±	0.25	0.50	0.55
CD @ 5%	0.75	1.46	1.61

At 45 DAP, among the treatments, T₁₂-weed free recorded significantly the minimum number of grass weed population (2.87), which was on par with T₈-pendimethalin @ 1.0 kg *a.i./ha* (3.01) and T₇-pendimethalin @ 0.75 kg *a.i./ha* (4.29), Whereas, significantly maximum number of grass weed population was recorded in T₁₁-weedy check (17.22).

At 60 DAP, among the treatments, T₁₂-weed free recorded significantly the minimum number of grass weed population (3.41), which was on par with T₈-pendimethalin @ 1.0 kg *a.i./ha* (3.92) and T₇-pendimethalin @ 0.75 kg *a.i./ha* (5.49), Whereas, significantly maximum number of grass weed population was recorded in T₁₁-weedy check (24.52).

4.4.2 Sedge weed population (No's)

Sedge weed population as influenced by different weed control treatments differed significantly at all stages of crop growth (Table 8).

At 30 DAP, among the treatments, T₁₂-weed free recorded significantly the minimum number of sedge weed population (0.83), which was on par with T₈-pendimethalin @ 1.0 kg *a.i./ha* (1.12) and T₇-pendimethalin @ 0.75 kg *a.i./ha* (1.15). Whereas, significantly maximum number of sedge weed population was recorded in T₁₁-weedy check (4.25).

At 45 DAP, among the treatments, T₁₂-weed free recorded significantly the minimum number of sedge weed population (1.97), which was on par with T₈-pendimethalin @ 1.0 kg *a.i./ha* (2.02) and T₇-pendimethalin @ 0.75 kg *a.i./ha* (2.12). Whereas, significantly maximum number of sedge weed population was recorded in T₁₁-weedy check (8.45).

At 60 DAP, among the treatments, T₁₂-weed free recorded significantly the minimum number of sedge weed population (2.42), which was on par with T₈-pendimethalin @ 1.0 kg *a.i./ha* (2.79). Whereas, significantly maximum number of sedge weed population was recorded in T₁₁-weedy check (11.91).

4.4.3 Broad leaved weed population (No's)

Broad leaved weed population as influenced by different weed control treatments differed significantly at all stages of crop growth (Table 8).

At 30 DAP, among the treatments, T₁₂-weed free recorded significantly the minimum number of broad leaved weed population (1.21), which was on par with T₈-pendimethalin @ 1.0 kg *a.i./ha* (1.24) and T₇-pendimethalin @ 0.75 kg *a.i./ha* (1.37). Whereas, significantly maximum number of broad leaved weed population was recorded in T₁₁-weedy check (6.41).

Table 8. Effect of different herbicides on sedge weed population at various stages of growth in gladiolus

Treatment	Sedge weed population (per m ²)		
	Days after planting		
	30	45	60
T ₁ - Atrazine @ 1.0 kg <i>a.i./ha</i>	2.71	3.92	4.71
T ₂ - Atrazine @ 1.5 kg <i>a.i./ha</i>	2.32	3.31	4.18
T ₃ - Metribuzin @ 0.25 kg <i>a.i./ha</i>	1.98	3.22	3.97
T ₄ - Metribuzin @ 0.5 kg <i>a.i./ha</i>	2.55	3.42	4.34
T ₅ - Butachlor @ 1.0 kg <i>a.i./ha</i>	2.62	3.48	4.66
T ₆ - Butachlor @ 1.5 kg <i>a.i./ha</i>	2.54	3.33	4.52
T ₇ - Pendimethalin @ 0.75 kg <i>a.i./ha</i>	1.15	2.12	3.41
T ₈ - Pendimethalin @ 1.0 kg <i>a.i./ha</i>	1.12	2.02	2.79
T ₉ - Oxyfluorfen @ 0.5 kg <i>a.i./ha</i>	2.96	4.92	6.22
T ₁₀ - Oxyfluorfen @ 1.0 kg <i>a.i./ha</i>	3.14	5.84	6.11
T ₁₁ -Weedy check	4.25	8.45	11.91
T ₁₂ -Weed free	0.83	1.97	2.42
S.Em ±	0.14	0.22	0.21
CD @ 5%	0.41	0.66	0.62

Table 9. Effect of different herbicides on broad leaved weed population at various stages of growth in gladiolus

Treatment	Broad leaved weed population (per m ²)		
	Days after planting		
	30	45	60
T ₁ - Atrazine @ 1.0 kg <i>a.i./ha</i>	2.31	4.53	5.22
T ₂ - Atrazine @ 1.5 kg <i>a.i./ha</i>	2.29	4.72	6.39
T ₃ - Metribuzin @ 0.25 kg <i>a.i./ha</i>	3.41	5.82	8.33
T ₄ - Metribuzin @ 0.5 kg <i>a.i./ha</i>	3.02	5.14	7.87
T ₅ - Butachlor @ 1.0 kg <i>a.i./ha</i>	1.82	3.71	4.78
T ₆ - Butachlor @ 1.5 kg <i>a.i./ha</i>	2.12	4.98	7.14
T ₇ - Pendimethalin @ 0.75 kg <i>a.i./ha</i>	1.37	3.84	3.02
T ₈ - Pendimethalin @ 1.0 kg <i>a.i./ha</i>	1.24	2.02	2.57
T ₉ - Oxyfluorfen @ 0.5 kg <i>a.i./ha</i>	4.02	6.49	9.74
T ₁₀ - Oxyfluorfen @ 1.0 kg <i>a.i./ha</i>	4.24	6.30	9.37
T ₁₁ -Weedy check	6.41	10.22	18.09
T ₁₂ -Weed free	1.21	1.94	2.34
S.Em ±	0.17	0.33	0.51
CD @ 5%	0.49	0.97	1.49

At 45 DAP, among the treatments, T₁₂-weed free recorded significantly the minimum number of broad leaved weed population (1.94), which was on par with T₈- pendimethalin @ 1.0 kg *a.i./* ha (2.02) and T₇-pendimethalin @ 0.75 kg *a.i./* ha (3.84). Whereas, significantly maximum number of broad leaved weed population was recorded in T₁₁-weedy check (10.22).

At 60 DAP, among the treatments, T₁₂-weed free recorded significantly the minimum number of broad leaved weed population (2.34), which was on par with T₈- pendimethalin @ 1.0 kg *a.i./* ha (2.57) and T₇-pendimethalin @ 0.75 kg *a.i./*ha (3.02). Whereas, significantly maximum number of broad leaved weed population was recorded in T₁₁-weedy check (18.09).

4.4.4 Total weed population

Total weed population as influenced by different weed control treatments differed significantly at all stages of crop growth (Table 10).

At 30 DAP, among the treatments, T₁₂-weed free recorded significantly the minimum number of total weed population (3.42), which was on par with T₈-pendimethalin @ 1.0 kg *a.i./* ha (4.53) and T₇-pendimethalin @ 0.75 kg *a.i./* ha (5.23). Whereas, significantly maximum number of total weed population was recorded in T₁₁-weedy check (22.53).

At 45 DAP, among the treatments, T₁₂-weed free recorded significantly the minimum number of total weed population (6.78), which was on par with T₈-pendimethalin @ 1.0 kg *a.i./*ha (7.05) and T₇-pendimethalin @ 0.75 kg *a.i./* ha (10.04). Whereas, significantly maximum number of total weed population was recorded in T₁₁-weedy check (35.89).

At 60 DAP, among the treatments, T₁₂-weed free recorded significantly the minimum number of total weed population (8.17), which was on par with T₈-pendimethalin @ 1.0 kg *a.i./* ha (9.28) and T₇-pendimethalin @ 0.75 kg *a.i./* ha (11.92). Whereas, significantly maximum number of total weed population was recorded in T₁₁-weedy check (53.71).

4.4.5 Dry weight of weeds (g)

Dry weight of weeds as influenced by different weed control treatments differed significantly at all stages of crop growth (Table 11).

At 30DAP, among the treatments, T₁₂-weed free recorded significantly the minimum number of dry weight of weeds (0.94 g/m²), which was on par with T₈-pendimethalin @ 1.0 kg *a.i./*ha (1.05 g/m²) and T₇-pendimethalin @ 0.75 kg *a.i./*ha (1.09 g/m²). Whereas, significantly maximum dry weight of weeds was recorded in T₁₁-weedy check (2.24 g/m²).

Table 10. Effect of different herbicides on total weed population at various stages of growth in gladiolus

Treatment	Total weed population (per m ²)		
	Days after planting		
	30	45	60
T ₁ - Atrazine @ 1.0 kg <i>a.i./ha</i>	8.83	14.27	17.07
T ₂ - Atrazine @ 1.5 kg <i>a.i./ha</i>	10.50	16.28	20.66
T ₃ - Metribuzin @ 0.25 kg <i>a.i./ha</i>	10.64	17.93	24.77
T ₄ - Metribuzin @ 0.5 kg <i>a.i./ha</i>	9.59	16.28	21.94
T ₅ - Butachlor @ 1.0 kg <i>a.i./ha</i>	7.85	13.20	17.69
T ₆ - Butachlor @ 1.5 kg <i>a.i./ha</i>	10.62	16.68	23.07
T ₇ - Pendimethalin @ 0.75 kg <i>a.i./ha</i>	5.23	10.04	11.92
T ₈ - Pendimethalin @ 1.0 kg <i>a.i./ha</i>	4.53	7.05	9.28
T ₉ - Oxyfluorfen @ 0.5 kg <i>a.i./ha</i>	12.51	19.52	28.86
T ₁₀ - Oxyfluorfen @ 1.0 kg <i>a.i./ha</i>	12.60	19.79	28.00
T ₁₁ -Weedy check	22.53	35.89	53.71
T ₁₂ -Weed free	3.42	6.78	8.17
S.Em ±	0.51	0.67	1.09
CD @ 5%	1.50	1.97	3.19

Table 11. Effect of different herbicides on dry weight of weeds at various stages of growth in gladiolus

Treatment	Dry weight of weeds (g/ m ²)		
	Days after planting		
	30	45	60
T ₁ - Atrazine @ 1.0 kg <i>a.i./ha</i>	1.24	2.30	4.78
T ₂ - Atrazine @ 1.5 kg <i>a.i./ha</i>	1.29	2.37	5.04
T ₃ - Metribuzin @ 0.25 kg <i>a.i./ha</i>	1.39	2.50	5.48
T ₄ - Metribuzin @ 0.5 kg <i>a.i./ha</i>	1.32	2.41	5.22
T ₅ - Butachlor @ 1.0 kg <i>a.i./ha</i>	1.18	2.19	4.52
T ₆ - Butachlor @ 1.5 kg <i>a.i./ha</i>	1.41	2.53	5.44
T ₇ - Pendimethalin @ 0.75 kg <i>a.i./ha</i>	1.09	2.02	4.10
T ₈ - Pendimethalin @ 1.0 kg <i>a.i./ha</i>	1.05	1.98	3.92
T ₉ - Oxyfluorfen @ 0.5 kg <i>a.i./ha</i>	1.53	2.92	5.98
T ₁₀ - Oxyfluorfen @ 1.0 kg <i>a.i./ha</i>	1.48	2.58	5.59
T ₁₁ -Weedy check	2.24	4.48	7.72
T ₁₂ -Weed free	0.94	1.82	3.71
S.Em ±	0.07	0.12	0.33
CD @ 5%	0.21	0.37	0.98

At 45 DAP, among the treatments, T₁₂-weed free recorded significantly the minimum number of dry weight of weeds (1.82 g / m²), which was on par with T₈-pendimethalin @ 1.0 kg *a.i.*/ ha (1.98 g / m²) and T₇-pendimethalin @ 0.75 kg *a.i.*/ ha (2.02 g/m²). Whereas, significantly maximum dry weight of weeds was recorded in T₁₁-weedy check (4.48 g/m²).

At 60 DAP, among the treatments, T₁₂-weed free recorded significantly the minimum number of dry weight of weeds (3.71 g / m²), followed by T₈-pendimethalin @ 1.0 kg *a.i.*/ ha (3.92 g / m²) and T₇-pendimethalin @ 0.75 kg *a.i.*/ ha (4.10 g / m²). Whereas, significantly maximum dry weight of weeds was recorded in T₁₁-weedy check (7.72 g / m²).

4.4.6 Weed control efficiency (WCE)

Weed control efficiency (WCE) as influenced by different weed control treatments differed significantly at all stages of crop growth (Table 12).

At 30 DAP, among the treatments, T₁₂-weed free recorded significantly maximum weed control efficiency (55.14 %), which was on par with T₈-pendimethalin @ 1.0 kg *a.i.*/ ha (53.12%) and T₇-pendimethalin @ 0.75 kg *a.i.*/ ha (51.33 %). Whereas, significantly minimum weed control efficiency was recorded in T₁₁-weedy check (0 %).

At 45 DAP, among the treatments, T₁₂-weed free recorded significantly maximum weed control efficiency (59.37 %), which was on par with T₈-pendimethalin @ 1.0 kg *a.i.*/ ha (55.80 %) and T₇-pendimethalin @ 0.75 kg *a.i.*/ ha (54.91 %). Whereas, significantly minimum weed control efficiency was recorded in T₁₁-weedy check (0 %).

At 60 DAP, among the treatments, T₁₂-weed free recorded significantly maximum weed control efficiency (51.94 %), which was on par with T₈-pendimethalin @ 1.0 kg *a.i.*/ ha (49.22 %) and T₇-pendimethalin @ 0.75 kg *a.i.*/ ha (46.89 %). Whereas, significantly minimum weed control efficiency was recorded in T₁₁-weedy check (0 %).

4.4.7 Weed Index (WI)

Weed index (WI) as influenced by different weed control treatments differed significantly at all stages of crop growth (Table 12).

The data pertaining to weed index Table 12 indicated that weed free recorded significantly no yield reduction which was on par with T₈-pendimethalin @ 1.0 kg *a.i.*/ ha (4.53 %) and T₇-pendimethalin @ 0.75 kg *a.i.*/ ha (5.08 %), Whereas maximum weed index was recorded in T₁₁-weedy check (37.82 %).

Table 12. Effect of different herbicides on weed control efficiency and weed index at various stages of growth in gladiolus

Treatment	Weed control efficiency (%)			Weed index (%)
	Days after planting			
	30	45	60	
T ₁ - Atrazine @ 1.0 kg <i>a.i./ha</i>	44.19	48.88	38.13	8.50
T ₂ - Atrazine @ 1.5 kg <i>a.i./ha</i>	42.41	47.09	33.38	18.94
T ₃ - Metribuzin @ 0.25 kg <i>a.i./ha</i>	38.25	44.17	29.01	21.22
T ₄ - Metribuzin @ 0.5 kg <i>a.i./ha</i>	41.07	46.20	32.38	30.60
T ₅ - Butachlor @ 1.0 kg <i>a.i./ha</i>	47.19	50.95	41.20	9.28
T ₆ - Butachlor @ 1.5 kg <i>a.i./ha</i>	37.07	43.75	29.53	13.12
T ₇ - Pendimethalin @ 0.75 kg <i>a.i./ha</i>	51.33	54.91	46.89	5.08
T ₈ - Pendimethalin @ 1.0 kg <i>a.i./ha</i>	53.12	55.80	49.22	4.53
T ₉ - Oxyfluorfen @ 0.5 kg <i>a.i./ha</i>	31.94	34.78	22.53	26.61
T ₁₀ - Oxyfluorfen @ 1.0 kg <i>a.i./ha</i>	33.74	42.41	27.59	27.70
T ₁₁ -Weedy check	0.00	0.00	0.00	37.82
T ₁₂ -Weed free	55.14	59.37	51.94	0.00
S.Em ±	1.62	1.93	1.73	0.73
CD @ 5%	4.75	5.67	5.08	2.14

4.5 Effect of different herbicides on flowering parameters in gladiolus

4.5.1 Days taken for initiation of inflorescence

The data on the number of days taken for initiation of inflorescence as influenced by different concentration of herbicides on gladiolus are presented in the Table 13. There were significant differences among all the treatments regarding the days taken for initiation of inflorescence, which was ranged from 74.00 to 90.00 days.

The data presented in the Table 13 indicated that T₁₂-weed free recorded significantly minimum number of days taken for initiation of inflorescence (74.00). followed by T₈-pendimethalin @ 1.0 kg *a.i./* ha (78.00 days). Whereas, T₁₁-weedy check recorded significantly maximum number of days taken for initiation of inflorescence (90.00).

4.5.2 Days taken for first floret opening

The data on the number of days taken for first floret opening as influenced by different concentration of herbicides on gladiolus are presented in the Table 13. There were significant differences among all the treatments regarding the days taken for first floret opening, which was ranged from 79.00 to 98.00 days.

The data presented in the Table 13 indicated that T₁₂-weed free recorded significantly minimum number of days taken for first floret opening (79.00), which was on par with T₈-pendimethalin @ 1.0 kg *a.i./*ha (82.00). Whereas, T₁₁-weedy check recorded significantly maximum number of days taken for first floret opening (98.00).

4.5.3 Days taken for 50 per cent flowering

The data on the number of days taken for 50 per cent flowering as influenced by different concentration of herbicides on gladiolus are presented in the Table 13. There were significant differences among all the treatments regarding the days taken for 50 per cent flowering, which was ranged from 83.00 to 103.00 days.

The data presented in the Table 13 indicated that T₁₂-weed free recorded significantly minimum number of days taken for 50 per cent flowering (83.00), which was on par with T₈-pendimethalin @ 1.0 kg *a.i./* ha (86.00). Whereas, T₁₁-weedy check recorded significantly maximum number of days taken for first floret opening (103.00).

4.5.4 Duration of flowering (days)

Flower duration was significantly influenced by different herbicide concentration (Table 13). The flower duration among the treatments was ranged between 8.72 to 17.37 days. The significantly maximum flower duration was recorded with the treatment T₁₂-weed free (17.37), which was on par with T₈-pendimethalin @ 1.0 kg *a.i./*ha (16.27).Whereas, significantly minimum flower duration was recorded in the T₁₁-weedy check (8.72).

Table 13. Effect of different herbicides on flowering parameters in gladiolus

Treatments	Days taken for initiation of inflorescence	Days taken for first floret opening	Days taken for 50% of flowering	Duration of flowering (days)
T ₁ - Atrazine @ 1.0 kg <i>a.i./ha</i>	81.00	86.00	90.00	11.82
T ₂ - Atrazine @ 1.5 kg <i>a.i./ha</i>	80.00	85.00	89.00	11.56
T ₃ - Metribuzin @ 0.25 kg <i>a.i./ha</i>	85.00	91.00	95.00	15.33
T ₄ - Metribuzin @ 0.5 kg <i>a.i./ha</i>	78.00	84.00	88.00	13.37
T ₅ - Butachlor @ 1.0 kg <i>a.i./ha</i>	86.00	92.00	97.00	12.71
T ₆ - Butachlor @ 1.5 kg <i>a.i./ha</i>	86.00	93.00	96.00	11.87
T ₇ - Pendimethalin @ 0.75 kg <i>a.i./ha</i>	79.00	83.00	87.00	14.98
T ₈ - Pendimethalin @ 1.0 kg <i>a.i./ha</i>	78.00	82.00	86.00	16.27
T ₉ - Oxyfluorfen @ 0.5 kg <i>a.i./ha</i>	82.00	87.00	91.00	13.09
T ₁₀ - Oxyfluorfen @ 1.0 kg <i>a.i./ha</i>	83.00	88.00	92.00	14.27
T ₁₁ -Weedy check	90.00	98.00	103.00	8.72
T ₁₂ -Weed free	74.00	79.00	83.00	17.37
S.Em ±	4.98	4.99	1.92	1.48
CD @ 5%	14.61	14.63	5.65	4.35

4.6 Effect of different herbicides on flower quality parameters in gladiolus

4.6.1 Spike length (cm)

It is evident from the Table 14 that, T₈-pendimethalin @ 1.0 kg *a.i./ ha* recorded significantly maximum length of the spike (65.91 cm), which was on par with T₇-pendimethalin @ 0.75 kg *a.i./ ha* (65.39 cm), T₂-atrazine @ 1.5 kg *a.i./ ha* (63.29 cm), T₁₂-weed free (62.32 cm) and T₁-atrazine @ 1.0 kg *a.i./ ha* (61.23 cm). Whereas, significantly minimum length of the spike was recorded in the T₁₁-weedy check (50.81 cm).

4.6.2 Rachis length (cm)

It is evident from the table 14 that, there was significant differences among different herbicide concentration, concerning to the rachis length, which was ranged from 30.02 cm to 38.94 cm. T₈-pendimethalin @ 1.0 kg *a.i./ ha*, recorded significantly maximum rachis length (38.94 cm), which was on par with T₇-pendimethalin @ 0.75 kg *a.i./ ha* (36.24 cm), T₂-atrazine @ 1.5 kg *a.i./ha* (36.03 cm) and T₁-atrazine @ 1.0 kg *a.i./ ha* (35.76 cm). Whereas, significantly minimum rachis length was recorded in the T₁₁-weedy check (30.02 cm).

4.6.3 Number of florets per spike

The data about the number of florets per spike had shown significant differences among all the treatments in gladiolus (Table 14).

Significant differences were observed with respect to the number of florets per spike, which ranged from 9.54 to 11.50. Treatment T₈-pendimethalin @ 1.0 kg *a.i./ ha* were recorded significantly maximum number of florets per spike (11.50), which was on par with T₇-pendimethalin @ 0.75 kg *a.i./ ha* (11.20), T₁₂-weed free (11.32), T₂-atrazine @ 1.5 kg *a.i./ ha* (11.13), T₁-atrazine @ 1.0 kg *a.i./ ha* (11.02), T₁₀-oxyfluofen @ 1.0 kg *a.i./ ha* (10.87) and T₉-oxyfluofen @ 0.5 kg *a.i./ ha* (10.62). Whereas, significantly minimum number of florets per spike was recorded in the treatment T₁₁-weedy check (9.54).

4.6.4 Length of floret (cm)

All the treatments were differed significantly with respect to floret length and recorded at the time of peak flowering stage (Table 14).

The length of the floret among the treatments was ranged from 8.53 cm to 10.92 cm. T₈-pendimethalin @ 1.0 kg *a.i./ ha* was recorded significantly maximum length of the floret (10.92 cm), which was on par with T₇-pendimethalin @ 0.75 kg *a.i./ ha* (10.31 cm), T₁₂-weed free (10.23), T₂-atrazine @ 1.5 kg *a.i./ ha* (10.03), T₁-atrazine @ 1.0 kg *a.i./ ha* (9.84) and T₄-metribuzin @ 0.5 kg *a.i./ ha* (9.79). Whereas, significantly minimum number of florets per spike was recorded in the treatment T₁₁-weedy check (8.53).

Table 14. Effect of different herbicides on flower quality parameters in gladiolus

Treatment	Spike length (cm)	Rachis length (cm)	Number of florets / spike	Length of florets (cm)	Floret diameter (cm)	Spike girth (mm)	Weight of the spike (g)	Vase life (days)
T ₁ - Atrazine @ 1.0 kg a.i./ha	61.23	35.76	11.02	9.84	7.87	8.24	63.12	9.51
T ₂ - Atrazine @ 1.5 kg a.i./ha	63.29	36.03	11.13	10.03	7.97	8.44	64.31	9.92
T ₃ - Metribuzin @ 0.25 kg a.i./ha	60.08	33.82	10.54	8.92	8.18	7.84	61.62	9.04
T ₄ - Metribuzin @ 0.5 kg a.i./ha	52.33	32.78	10.21	9.79	8.64	6.51	46.91	8.02
T ₅ - Butachlor @ 1.0 kg a.i./ha	53.41	31.16	10.12	9.67	9.63	6.89	58.41	8.89
T ₆ - Butachlor @ 1.5 kg a.i./ha	55.09	33.51	10.31	9.41	9.02	7.12	49.05	8.12
T ₇ -Pendimethalin @ 0.75 kg a.i./ha	65.39	36.24	11.20	10.31	10.13	8.61	66.23	10.11
T ₈ - Pendimethalin @ 1.0 kg a.i./ha	65.91	38.94	11.50	10.92	10.21	8.73	68.87	10.16
T ₉ - Oxyfluorfen @ 0.5 kg a.i./ha	51.89	34.03	10.62	9.29	9.72	6.12	56.18	8.52
T ₁₀ - Oxyfluorfen @ 1.0 kg a.i./ha	52.34	34.18	10.87	9.32	9.81	6.81	52.29	8.24
T ₁₁ -Weedy check	50.81	30.02	9.54	8.53	7.13	5.42	42.12	7.35
T ₁₂ -Weed free	62.32	34.29	11.32	10.23	9.97	8.39	64.03	9.33
S.E.m ±	1.76	1.52	0.50	0.42	0.57	0.57	2.05	0.50
CD @ 5%	5.16	4.46	1.47	1.24	1.67	1.68	6.01	1.48

4.6.5 Diameter of floret (cm)

The data indicate the existence of significant differences with respect to the floret diameter as influenced by differences among all the treatments in gladiolus (Table 14).

The diameter of the floret recorded at the time of peak flowering stage differed significantly among the treatments and it was ranged from 7.13 cm to 10.21 cm. T₈-pendimethalin @ 1.0 kg *a.i./ha* recorded significantly maximum diameter of floret (10.21 cm), which was on par with T₇-pendimethalin @ 0.75 kg *a.i./ha* (10.13 cm), T₁₂-weed free (9.97 cm), T₁₀-oxyfluofen @ 1.0 kg *a.i./ha* (9.81 cm), T₉-oxyfluofen @ 0.5 kg *a.i./ha* (9.72 cm), T₅-butachlor @ 1.0 kg *a.i./ha* (9.63 cm) and T₄-metribuzin @ 0.5 kg *a.i./ha* (8.64 cm) Whereas, significantly minimum diameter of floret was recorded in the treatment T₁₁-weedy check (7.13 cm).

4.6.6 Spike girth (mm)

The data indicate the existence of significant differences concerning the spike girth as influenced by differences among all the treatments in gladiolus (Table 14)

Significant differences were exhibited among the different herbicidal concentration with respect to spike girth, which was ranged from 5.42 mm to 8.73 mm T₈-pendimethalin at 1.0 kg *a.i./ha* recorded significantly maximum spike girth (8.73 mm), which was on par with T₇-pendimethalin @ 0.75 kg *a.i./ha* (8.61 mm) and T₂-atrazine @ 1.5 kg *a.i./ha* (8.44 mm), whereas, significantly minimum spike girth was recorded in the treatment T₁₁-weedy check (5.42 mm).

4.6.7 Spike weight (g)

The data indicate the existence of significant differences with respect to the spike weight as influenced by differences among all the treatments in gladiolus (Table 14).

Significant differences with respect to spike weight. Spike weight ranged from 42.12 g to 68.87 g. T₈-pendimethalin @ 1.0 kg *a.i./ha* recorded significantly maximum spike weight (68.87 g), which was on par with T₇-pendimethalin @ 0.75 kg *a.i./ha* (66.23 g), T₂-atrazine @ 1.5 kg *a.i./ha* (64.31 g), T₁₂-weed free (64.03 g) and T₁- atrazine @ 1.0 kg *a.i./ha* (63.12 g). Whereas, significantly minimum spike weight was recorded in treatment T₁₁-weedy check (42.12 g).

4.6.8 Vase life (days)

The data with regard to vase life of cut spikes are presented in the Table 14. The vase life varied significantly as influenced by differences among all the treatments in gladiolus and it ranged from 7.35 days to 10.16 days. Significantly maximum vase life was recorded in the treatment T₈-pendimethalin @ 1.0 kg *a.i./ha*

(10.16 days), which was on par with the treatment T₇-pendimethalin @ 0.75 kg *a.i.*/ha (10.11 days). Whereas, significantly minimum vase life was recorded in the treatment T₁₁-weedy check (7.35 days).

4.7 Effect of different herbicides on flower yield parameters in gladiolus

4.7.1 Number of spikes per plant

The data about the influence differences among all the treatments on spike yield per plant is presented in the Table 15. There was a significant differences with respect to the number of spikes per plant which ranged from 1.16 to 1.40. Significantly maximum number of spikes per plant was recorded in the treatment T₁₂- weed free (1.40), which was on par with T₇-pendimethalin @ 0.75 kg *a.i.*/ ha (1.34), T₈-pendimethalin @ 1.0 kg *a.i.*/ha (1.33), T₁-atrazine @ 1.0 kg *a.i.*/ ha (1.28), T₅-butachlor 1.0 kg *a.i.*/ ha (1.27). Whereas, significantly minimum number of spikes per plant was recorded in the T₁₁-weedy check (1.01).

4.7.2 Number of spikes per plot (2 m × 1 m)

The results showed that spikes yield per plot were significantly influenced by differences among all the treatments (Table 15). It was revealed that there was a significant differences with respect to the number of spikes per plot. The range of spike yield per plot was recorded between 26.19 to 42.12. Significantly maximum number of spikes per plant was recorded in the treatment T₁₂-weed free (42.12), which was on par with T₇-pendimethalin @ 0.75 kg *a.i.*/ha (40.21) and T₈-pendimethalin @ 1.0 kg *a.i.*/ ha (39.98) . Whereas, significantly minimum number of spikes yield per plot was recorded in the T₁₁-weedy check (26.19).

4.7.3 Number of spikes per hectare

Significant differences among themselves with respect to spike yield per hectare (Table 15). Significantly maximum number of spikes per hectare was recorded in the treatment T₁₂-weed free (2,10,600.00), which was on par with T₇-pendimethalin @ 0.75 kg *a.i.*/ha (2,01,050.00) and T₈-pendimethalin @ 1.0 kg *a.i.*/ ha (1,99,900.00). Whereas, significantly minimum number of spikes yield per hectare was recorded in the T₁₁-weedy check (1,30,950.00).

4.8 Effect of different herbicides on corm and cormels characteristics in gladiolus

4.8.1 Weight of corms per plant (g)

Effect of different concentrations of herbicide application influenced significantly on the weight of corms per plant (Table 16).

Table 15. Effect of different herbicides on flower yield parameters in gladiolus

Treatment	Spike yield / plant (No's)	Spike yield / plot (No's)	Spike yield / hectare (No's)
T ₁ - Atrazine @ 1.0 kg <i>a.i./ha</i>	1.28	38.52	1,92,600.00
T ₂ - Atrazine @ 1.5 kg <i>a.i./ha</i>	1.13	34.14	1,70,700.00
T ₃ - Metribuzin @ 0.25 kg <i>a.i./ha</i>	1.07	32.18	1,60,900.00
T ₄ - Metribuzin @ 0.5 kg <i>a.i./ha</i>	1.19	29.23	1,46,150.00
T ₅ - Butachlor @ 1.0 kg <i>a.i./ha</i>	1.27	38.21	1,91,050.00
T ₆ - Butachlor @ 1.5 kg <i>a.i./ha</i>	1.21	36.59	1,82,950.00
T ₇ - Pendimethalin @ 0.75 kg <i>a.i./ha</i>	1.34	40.21	2,01,050.00
T ₈ - Pendimethalin @ 1.0 kg <i>a.i./ha</i>	1.33	39.98	1,99,900.00
T ₉ - Oxyfluorfen @ 0.5 kg <i>a.i./ha</i>	1.03	30.91	1,54,550.00
T ₁₀ - Oxyfluorfen @ 1.0 kg <i>a.i./ha</i>	1.16	30.45	15,2250.00
T ₁₁ -Weedy check	1.01	26.19	1,30,950.00
T ₁₂ -Weed free	1.40	42.12	2,10,600.00
S.Em ±	0.05	0.94	6548.20
CD @ 5%	0.14	2.75	19205.23

Among the treatments, T₈-pendimethalin at 1.0 kg *a.i./ha* recorded significantly maximum weight of corms per plant (96.66 g), which was on par with T₇-pendimethalin @ 0.75 kg *a.i./ha* (94.21 g), T₁₂-weed free (93.69 g) and T₂-atrazine @ 1.5 kg *a.i./ha* (91.64 g). Whereas, significantly minimum weight of corms per plant was observed in T₁₁-weedy check (78.11 g).

4.8.2 Weight of corms per plot (kg)

There was a significant difference with respect to the weight of corms per plot which ranged from 2.34 kg to 2.89 kg. Among the treatments, T₈-pendimethalin @ 1.0 kg *a.i./ha* recorded significantly maximum weight of corms per plot (2.89 kg), which was on par with T₇-pendimethalin @ 0.75 kg *a.i./ha* (2.82 kg), T₁₂-weed free (2.81 kg) and T₂-atrazine @ 1.5 kg *a.i./ha* (2.75 kg). Whereas, significantly minimum weight of corms per plot was observed in T₁₁-weedy check (2.34 kg) (Table 16).

4.8.3 Weight of cormels per plant (g)

Results showed that cormels weight per plant was ranged from 14.82 g to 28.19 g. Among the treatments, T₈-pendimethalin @ 1.0 kg *a.i./ha* recorded significantly maximum weight of cormels per plant (28.19 g), which was on par with T₇-pendimethalin @ 0.75 kg *a.i./ha* (27.41 g), T₁₂-weed free (27.29 g) and T₂-atrazine @ 1.5 kg *a.i./ha* (26.33 g). Whereas, significantly minimum weight of cormels per plant was recorded in the T₁₁-weedy check (14.82 g). (Table 16).

4.8.4 Weight of cormels per plot (g)

Gladiolus influenced by different concentrations of herbicide application exhibited significant differences with respect to weight of cormels per plot and it was ranged from 119.13 to 182.44 g. Among the treatments, T₈-pendimethalin at 1.0 kg *a.i./ha* was recorded significantly maximum weight of cormels per plot (182.44 g), which was on par with T₇-pendimethalin @ 0.75 kg *a.i./ha* (179.49 g) and T₁₂-weed free (174.43 g). Whereas, significantly minimum weight of cormels per plot was observed in the treatment T₁₁-weedy check (119.13 g). (Table 16).

4.8.5 Diameter of corms (cm)

Significant differences with respect to the diameter of corms. It was ranged from 3.62 cm to 5.10 cm. Among the treatments, T₈-pendimethalin at 1.0 kg *a.i./ha* was recorded significantly maximum diameter of corm (5.10 cm), which was on par with T₇-pendimethalin @ 0.75 kg *a.i./ha* (5.02), T₁₂-weed free (4.98 cm), T₂-atrazine @ 1.5 kg *a.i./ha* (4.91 cm), T₁-atrazine @ 1.0 kg *a.i./ha* (4.72 cm), T₆-butachlor @ 1.5 kg *a.i./ha* (4.51 cm) and T₉-oxyfluofen @ 0.5 kg *a.i./ha* (4.34 cm). Whereas, significantly minimum diameter of corms was observed in the T₁₁-weedy check (3.62 cm) (Table 16).

Table 16. Effect of different herbicides on corm and cormels characteristics in gladiolus

Treatment	Corm weight		Cormels weight		Diameter of the corms (cm)	Diameter of the cormels (mm)
	Per plant (g)	Per plot (kg)	Per plant (g)	Per plot (g)		
	T ₁ - Atrazine @ 1.0 kg a.i./ha	85.43	2.56	20.11	135.11	4.72
T ₂ - Atrazine @ 1.5 kg a.i./ha	91.64	2.75	26.33	162.33	4.91	4.92
T ₃ - Metribuzin @ 0.25 kg a.i./ha	79.64	2.40	15.49	123.21	3.89	3.51
T ₄ - Metribuzin @ 0.5 kg a.i./ha	81.62	2.44	16.18	125.74	4.08	3.69
T ₅ - Butachlor @ 1.0 kg a.i./ha	88.33	2.64	22.98	150.39	4.63	3.98
T ₆ - Butachlor @ 1.5 kg a.i./ha	86.84	2.60	21.42	139.45	4.51	4.53
T ₇ - Pendimethalin @ 0.75 kg a.i./ha	94.21	2.82	27.41	179.49	5.02	5.12
T ₈ - Pendimethalin @ 1.0 kg a.i./ha	96.66	2.89	28.19	182.44	5.10	5.18
T ₉ - Oxyfluorfen @ 0.5 kg a.i./ha	84.07	2.52	20.02	143.71	4.34	3.73
T ₁₀ - Oxyfluorfen @ 1.0 kg a.i./ha	83.29	2.48	18.91	129.23	4.10	3.92
T ₁₁ -Weedy check	78.11	2.34	14.82	119.13	3.62	2.21
T ₁₂ -Weed free	93.69	2.81	27.29	174.43	4.98	5.06
S.E.m ±	3.15	0.11	1.03	5.26	0.33	0.14
CD @ 5%	9.23	0.32	3.02	15.42	0.97	0.41

4.8.6 Diameter of cormels (mm)

Significant differences with respect to diameter of cormels and it was ranged from 2.21 mm to 5.18 mm. Among the treatments, T₈-pendimethalin @ 1.0 kg *a.i./ha* was recorded significantly maximum diameter of cormels (5.18 mm), which was on par with T₇- pendimethalin @ 0.75 kg *a.i./ha* (5.12 mm) ,T₁-atrazine @ 1.0 kg *a.i./ha* (5.08 mm), T₁₂-weed free (5.06 mm) and T₂-atrazine @ 1.5 kg *a.i./ha* (4.92 mm). Whereas, significantly minimum diameter of cormels was observed in the treatment T₁₁-weedy check (2.21 mm) (Table 16).

4.9 Effect of different herbicides on corm and cormels yield in gladiolus

4.9.1 Number of corms per plant

The data on the effect of differences among all the treatments on the number of corms per plant was depicted in the Table 17. Among the treatments, T₈-pendimethalin @ 1.0 kg *a.i./ha* was recorded significantly maximum number of corms per plant (1.73), which was on par with T₇-pendimethalin @ 0.75 kg *a.i./ha* (1.69), T₂-atrazine @ 1.5 kg *a.i./ha* (1.62) and T₁-atrazine @ 1.0 kg *a.i./ha* (1.59). Whereas, significantly minimum number of corms per plant was recorded in the T₁₁-weedy check (1.12).

4.9.2 Number of corms per plot

The number of corms per plot differed significantly among the different concentrations of herbicides in gladiolus (Table 17) and it was ranged from 33.60 to 51.90. Among the treatments, T₈-pendimethalin @ 1.0 kg *a.i./ha* was recorded significantly maximum number of corms per plot (51.90), which was on par with T₇- pendimethalin @ 0.75 kg *a.i./ha* (50.70), T₂-atrazine @ 1.5 kg *a.i./ha* (48.60) and T₁- atrazine @ 1.0 kg *a.i./ha* (47.70). Whereas, significantly minimum number of corms per plot was recorded in the T₁₁-weedy check (33.60).

4.9.3 Corms yield per hectare (kg / ha)

Significant differences with respect to corm yield per hectare and it was ranged from 11,700 to 14,450 kg per hectare. Among the treatments, T₈-pendimethalin at 1.0 kg *a.i./ha* was recorded significantly maximum yield of corms (14,450 kg/ha), which was on par with T₇-pendimethalin @ 0.75 kg *a.i./ha* (14,100 kg/ha), T₂-atrazine @ 1.5 kg *a.i./ha* (14,050 kg/ha) and T₁₂-weed free (13750 kg/ha). Whereas, significantly minimum corm yield per hectare was recorded in the T₁₁-weedy check (11,700 kg/ha).(Table 17).

4.9.4 Number of cormels per plant

The data about the number of cormels per plant showed the significant differences as influenced by different concentrations of herbicides in gladiolus (Table 17).

Table 17. Effect of different herbicides on corm and cormels yield in gladiolus

Treatment	Corm yield			Cormels yield		
	Per plant (No's)	Per plot (No's)	kg / hectare	Per plant (No's)	Per plot (No's)	kg / hectare
T ₁ - Atrazine @ 1.0 kg a.i./ha	1.59	47.70	12,800	19.92	597.60	675.55
T ₂ - Atrazine @ 1.5 kg a.i./ha	1.62	48.60	14,050	22.91	687.30	872.15
T ₃ - Metribuzin @ 0.25 kg a.i./ha	1.15	34.50	12,000	24.16	724.80	616.05
T ₄ - Metribuzin @ 0.5 kg a.i./ha	1.14	34.20	12,200	26.33	789.84	628.70
T ₅ - Butachlor @ 1.0 kg a.i./ha	1.25	37.52	13,200	25.21	756.30	751.95
T ₆ - Butachlor @ 1.5 kg a.i./ha	1.32	39.60	13,000	24.78	743.40	697.25
T ₇ - Pendimethalin @ 0.75 kg a.i./ha	1.69	50.70	14,100	30.18	1377.00	897.45
T ₈ - Pendimethalin @ 1.0 kg a.i./ha	1.73	51.90	14,450	33.21	1557.00	912.20
T ₉ - Oxyfluorfen @ 0.5 kg a.i./ha	1.48	44.40	12,600	28.81	905.40	872.15
T ₁₀ - Oxyfluorfen @ 1.0 kg a.i./ha	1.53	45.90	12,400	27.19	1332.00	811.65
T ₁₁ -Weedy check	1.12	33.60	11,700	17.28	518.90	595.65
T ₁₂ -Weed free	1.41	42.30	13,750	29.23	1396.90	872.15
S.Em ±	0.05	2.01	258.91	1.18	37.84	14.58
CD @ 5%	0.16	5.91	759.36	3.45	110.99	42.76

Number of cormels per plant was ranged from 17.28 to 33.21. Among the treatments, T₈-pendimethalin @ 1.0 kg *a.i./ha* was recorded significantly maximum number of cormels per plant (33.21), which was on par with T₇-pendimethalin @ 0.75 kg *a.i./ha* (30.18). Whereas, significantly minimum number of cormels per plant was observed in the treatment T₁₁-weedy check (17.28).

4.9.5 Number of cormels per plot

Treatments differed significantly with respect to number of cormels per plot. It was ranged from 518.90 to 1557.00. Among the treatments, T₈-pendimethalin @ 1.0 kg *a.i./ha* was recorded significantly maximum number of cormels per plot (1557.00). Whereas, significantly minimum number of cormels per plot was recorded in the treatment T₁₁-weedy check (518.90) (Table 17).

4.9.6 Cormels yield per hectare (kg/ha)

Significant differences with respect to cormels yield per hectare and it was ranged from 595.65 to 912.20 kg per hectare. Among the treatments, T₈-pendimethalin @ 1.0 kg *a.i./ha* was recorded significantly maximum yield of cormels (912.20 kg / ha), which was on par with T₇-pendimethalin @ 0.75 kg *a.i./ha* (897.41) and T₉-oxyfluofen @ 0.5 kg *a.i./ha* (872.15 kg / ha). Whereas, significantly minimum cormels yield per hectare was recorded in the T₁₁-weedy check (595.65 kg / ha) (Table 17).

4.10 Effect of different herbicides on economics of gladiolus production

The data on the cost of cultivation, gross returns, net returns and benefit-cost ratio (B:C) in relation to gladiolus with different treatments of herbicides are presented in the Table 18.

Among the treatments, T₈-pendimethalin @ 1.0 kg *a.i./ha* was recorded significantly maximum gross return (23,42,610.00), net return (14,59,605.00) and B: C ratio (1.65) per hectare, which was on par with T₇-pendimethalin @ 0.75 kg *a.i./ha* (23,13,333.00, 14,30,826.00 and 1.62 respectively). Whereas, significantly minimum net return was observed in T₁₁-weedy check (6,66,025.50) with a benefit cost ratio and gross income of 0.76 and 15,47,033.00, respectively.

Table 18. Effect of different herbicides on economics of gladiolus production

Treatment	Cost of cultivation (₹ / ha)	Returns from spike yield (₹ / ha)	Returns from corm yield (₹ / ha)	Returns from cormels yield (₹ / ha)	Gross income (₹/ha)	Net income (/ha)	B:C ratio
T ₁ - Atrazine @ 1.0 kg a.i./ha	8,82,083	9,63,000	11,92,500	33,777.5	21,89,278	13,07,195	1.48
T ₂ - Atrazine @ 1.5 kg a.i./ha	8,82,621	8,53,500	12,15,000	43,607.5	21,12,108	12,29,487	1.39
T ₃ - Metribuzin @ 0.25 kg a.i./ha	8,82,092	8,04,500	8,40,000	30,802.5	16,75,303	7,93,210.5	1.21
T ₄ - Metribuzin @ 0.5 kg a.i./ha	8,83,208	7,30,750	8,55,000	31,435	16,17,185	7,33,977	1.29
T ₅ - Butachlor @ 1.0 kg a.i./ha	8,82,207	9,55,250	9,37,500	37,597.5	19,30,348	10,48,141	1.19
T ₆ - Butachlor @ 1.5 kg a.i./ha	8,82,807	9,14,795	9,90,000	34,862.5	19,39,658	10,56,851	1.20
T ₇ -Pendimethalin @ 0.75 kg a.i./ha	8,82,507	10,05,250	12,67,500	40,582.5	23,13,333	14,30,826	1.62
T ₈ - Pendimethalin @ 1.0 kg a.i./ha	8,83,005	9,99,500	12,97,500	45,610	23,42,610	14,59,605	1.65
T ₉ - Oxyfluorfen @ 0.5 kg a.i./ha	8,82,027	7,72,750	11,10,000	35,927.5	19,18,678	10,36,651	1.18
T ₁₀ - Oxyfluorfen @ 1.0 kg a.i./ha	8,83,047	7,61,250	11,47,500	32,307.5	19,41,058	10,58,011	1.20
T ₁₁ -Weedy check	8,81,007	6,54,750	8,62,500	29,782.5	15,47,033	6,66,025.5	0.76
T ₁₂ -Weed free	8,81,007	10,53,000	10,57,500	44,872.5	21,55,373	12,74,366	1.45

*Spike rate: ₹ 5/ Spike *corm rate: ₹ 5/Corm *cormels rate: ₹ 50/kg

DISCUSSION

V DISCUSSION

Gladiolus is grown commercially in India for its spike which is sold in the market as a cut flower. Weed infestation in gladiolus crop needs to be controlled to produce quality spikes. Three to four hand weeding are required to raise the crop successfully. Weeding through manual labour is extremely cost-expensive operation. Therefore, an experiment was conducted at College of Horticulture, Mudigere during 2019-20 to work out alternative method of weed control through herbicides in gladiolus cv. Summer Sunshine.

5.1 Effect of different herbicides on growth parameters in gladiolus

5.1.1 Days taken for sprouting, sprouting per cent and number of shoots per corm

The maximum days taken for sprouting was noticed in the treatment weedy check followed by butachlor at lower and higher concentration. This may be due to unchecked weed growth causes suppression of early sprouts. Whereas minimum days taken for sprouting was noticed in the treatment weed free followed by atrazine. This may be due to herbicides are sprayed on the soil surface and there is no weed growth at early stages of crop growth results in reduction in competition for nutrients, moisture and sunlight which improved early germination in gladiolus (Fig. 2).

The maximum sprouting per cent and number of shoots per corm was noticed in the treatment weed free followed by pendimethalin (1.0 kg *a.i./ha*). This may be due to weed free treatment reduced the weed flora there by improved nutrient availability and uptake which led to increased sprouting per cent in gladiolus. Bhat *et al.* (2013) reported that among the treatments, weed free and pendimethalin 1.5 kg ha⁻¹ showed better results with sprouting per cent and number of shoots per corm in gladiolus. Swaroop *et al.* (2014) found the similar results in gladiolus.

5.2 Effect of different herbicides on vegetative growth parameters

The plant growth is a dynamic process and is affected by the complex interaction between environmental factors and physiological processes. Besides these factors, weeds play a very important role. Effective weed control treatments have significantly increased the plant growth. Influence of different herbicides can be expressed in different growth attributes such as plant height, number of leaves per plant, leaf area and leaf area index at 30, 45 and 60 days after planting. Plants grown in weedy check plot showed marked suppression of plant growth.

5.2.1 Plant height (cm)

It was evident from the data (Table 2) that the treatment with different herbicides showed various responses on growth of the crop. Plant height at various

stages of crop growth revealed that all the weed control treatments significantly influenced the plant height.

Among weed control treatments, weed free (T₁₂) recorded maximum plant height and was followed by pendimethalin at (1.0 kg *a.i.* /ha) and (0.75 kg *a.i.*/ ha) concentrations recorded maximum plant height during various stages of crop growth. This may be due to less weed competition during the critical growth period and better availability of nutrients, moisture, sunlight and space for crop growth. Increase in plant height was associated with rapid meristematic activity, probably due to rapid cell division and elongation during the tender growth period (Sharova *et al.*, 1977). Removal of weeds during early stages of crop growth resulted in reduced weed competition and enabled the crop to grow taller. At all stages of crop growth, Weedy check resulted in the plants of short stature, which might be due to competition extended by the weeds. This is in conformity with the findings of Koutepas (1982), Pal and Das (1990) and Basavaraju *et al.* (1992).

5.2.2 Number of leaves

It was evident from the (Table 3) that, all the weed control treatments significantly influenced on the total number of leaves per plant than weedy check.

Among the weed control treatments, over pendimethalin (1.0 kg *a.i.*/ ha) recorded significantly maximum number of leaves than other treatments at 30, 45 and 60 days after planting. This might be due to better control of weeds at early stages of crop growth which coincided with critical crop growth period and weed competition followed by reduction in competition for nutrients, moisture and sunlight which improved the crop growth in terms of number of leaves per plant. These results are in conformity with the Shalini and Patil in gerbera (2004). It was concluded that weeds should be controlled before three leaf stage of gladiolus crop to enable the production of good quality of cut flower Cheong and Park (2000).

5.2.3 Leaf area (cm²)

The data on leaf area as influenced by different weed control treatments at different growth stages in gladiolus indicated significant differences at all the stages of crop (Table 4).

During all the stages of crop growth, the maximum leaf area was recorded with pendimethalin (1.0 kg *a.i.*/ ha) at 30, 45 and 60 days after planting. Pendimethalin is an effective herbicide for gladiolus crop (Mishra, 1997). This may be due to production of more number of long and wider leaves and accelerated relative growth which was controlled by cell division and cell elongation, which ultimately led to higher leaf area. This may be due to availability of nutrients and soil moisture. Minimum leaf area was recorded in weedy check treatment at all stages of

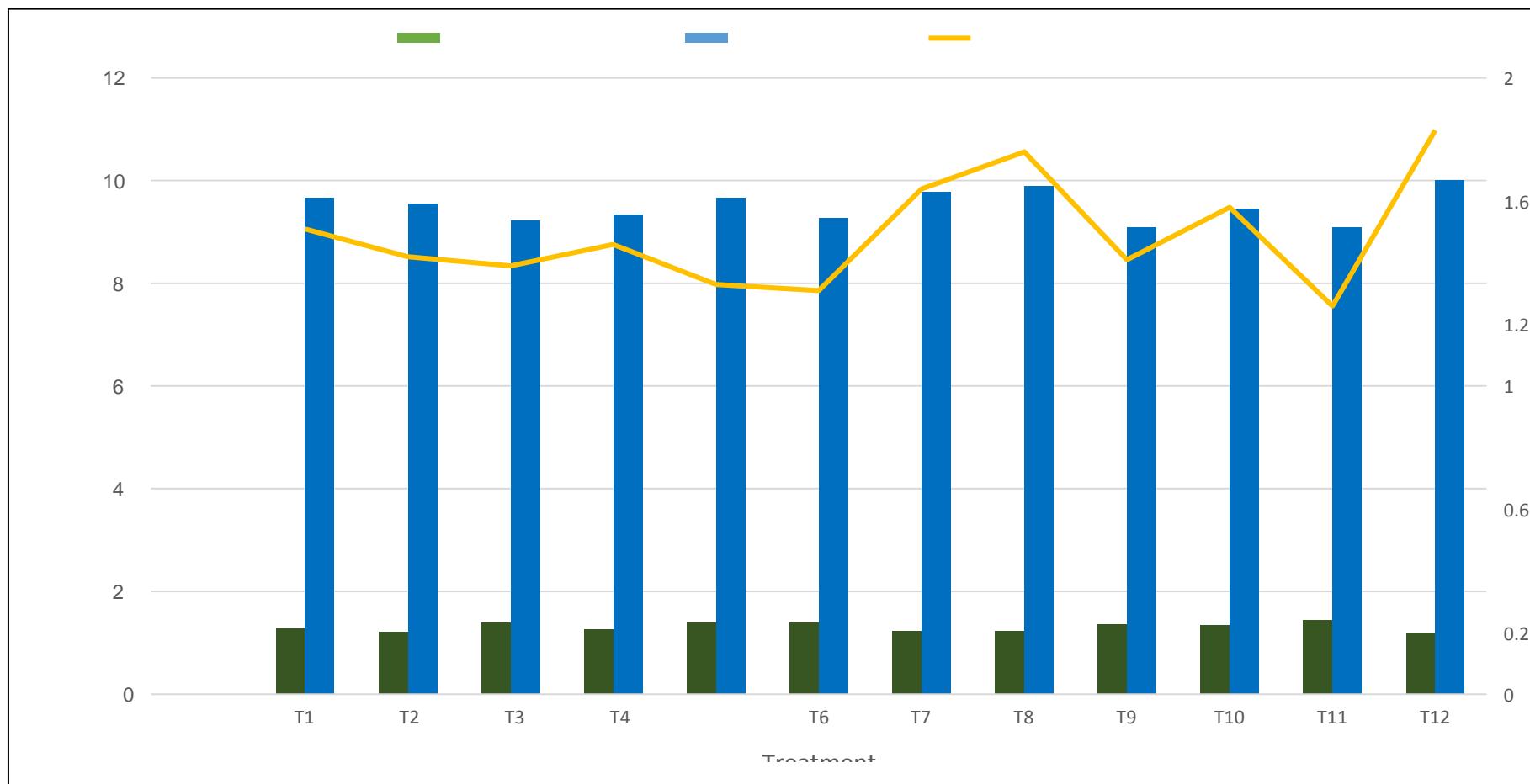


Fig. 2: Effect of different herbicides on growth parameters in gladiolus

crop growth due to severe weed competition for growth factors of the crop. These results are in conformity with the findings of Pitt *et al.* (1981), Anandamurthy and Narayanagowda (1993) and Shalini and Patil in gerbera (2004).

5.2.4 Leaf area index (LAI)

The data on leaf area index as influenced by different weed control treatments at different growth stages in gladiolus indicated significant differences at all the stages of crop (Table 5).

During early stages of crop growth, the maximum leaf area index was recorded with pendimethalin (0.75 kg *a.i./* ha), while during later stages of crop growth, the maximum leaf area index was recorded with pendimethalin (1.0 kg *a.i./* ha). This might be due to production of more number of long and wider leaves and accelerated relative growth which was controlled by cell division and cell elongation, which ultimately led to maximum leaf area index. These results are in conformity with the findings of Pitt *et al.* (1981), Anandamurthy and Narayanagowda (1993) and Shalini and Patil (2004).

5.3 Effect of different herbicides on chlorophyll content (mg/g of fresh weight)

Significant differences were observed among the plants, different concentrations of herbicide application with respect to the leaf chlorophyll content (Table 6).

Chlorophyll 'a', Chlorophyll 'b' and Total chlorophyll content in leaves

Significantly maximum chlorophyll 'a', chlorophyll 'b' and total chlorophyll content in leaves was recorded in the treatment pendimethalin (1.0 kg *a.i./* ha). This increase in chlorophyll content in leaves may be due to increase in availability and uptake of more water and essential nutrients during critical growth stages of crop which led to more accumulation of photo assimilates in leaves and also might be due to pendimethalin reduced the competition for space and light by increasing weed control efficiency.

5.4 Effect of herbicides on weed flora at different stages of growth in gladiolus

The number of grasses, sedge, broad leaved weeds, total weed population and dry weight of weed at all the crop growth stages (30, 45 and 60 DAP) differed significantly among the treatments (Table 7-11).

Weed free treatment recorded minimum weed density and dry weight of weed throughout the cropping season, since weeds were removed at regular intervals. At 30, 45 and 60 DAP, all the weed control treatments recorded minimum weed density proving their effectiveness in combating weed menace from initial stages of crop growth (Plate. 8). Except Weedy check, all herbicidal treatments recorded

significantly minimum grasses at different stages of crop growth. Among different herbicides treatment pendimethalin at 1.0 kg *a.i./* ha recorded significantly minimum number of grasses. The treatment weed free was effective at critical crop growth period, since the hand weeding disturbed during critical stages of crop growth period which did not allow the weeds to establish. Maximum grasses weed density and their dry weights in some of the chemical treatments at later stages of crop growth justified their degradation and ineffectiveness due to minimum herbicidal activity of these chemicals thereby could not be able to control newly emerged weeds up to longer periods (Rao *et al.*, 2014).

The variability in weed densities in different treatments can be attributed to the fact that some herbicides are more effective for weed control than other (Nasir *et al.*, 2012) but the pendimethalin at 1.0 kg *a.i./*ha effectively controlled weeds at early as well as late flushes of weeds and did not allow weeds to regenerate. This may be due to the fact that application of pendimethalin might have caused the death of relative weeds from starvation and oxidative damage caused by breakdown in electron transport process because the herbicide functions by binding to the plasto-quinone binding protein in photosynthesis (Appleby *et al.*, 2002) as a result of minimum weed population, weed dry weight also got reduced considerably. The minimum dry weight accumulation in pendimethalin treated plots may be attributed to better control of weeds and suppression of weed growth (Meena, 2004). These results are in line with findings of Leela (1976), Gomez and Gomez 1984), Jana and Bose (1981), Murthy and Gowda (1994) and Shalini and Patil (2006).

5.5 Effect of herbicides on weed control efficiency at different stages of growth in gladiolus

Weed control efficiency is a measure of expressing the efficiency of a weed control method. The data at various crop growth stages revealed that all the weed control treatments significantly increased the weed control efficiency as compared weedy check (Table 12) and (Fig. 3).

The maximum weed control efficiency was obtained with weed free treatment followed by pendimethalin (1.0 kg *a.i./* ha). The effective control of weeds under these treatments may be due to minimum weed dry matter that ultimately resulted in highest weed control efficiency at 30, 45 and 60 DAP. Similar results were noticed by Mishra *et al.* (1986), Anandamurthy and Narayanagowda in tuberose (1992), Porwal in garlic (1995), Saimbhi *et al.* (2000), Tewari *et al.* (2001) and Kolhe in onion (2001), Sudakara *et al.* (2002) in rose and Nagar *et al.* in coriander (2009).

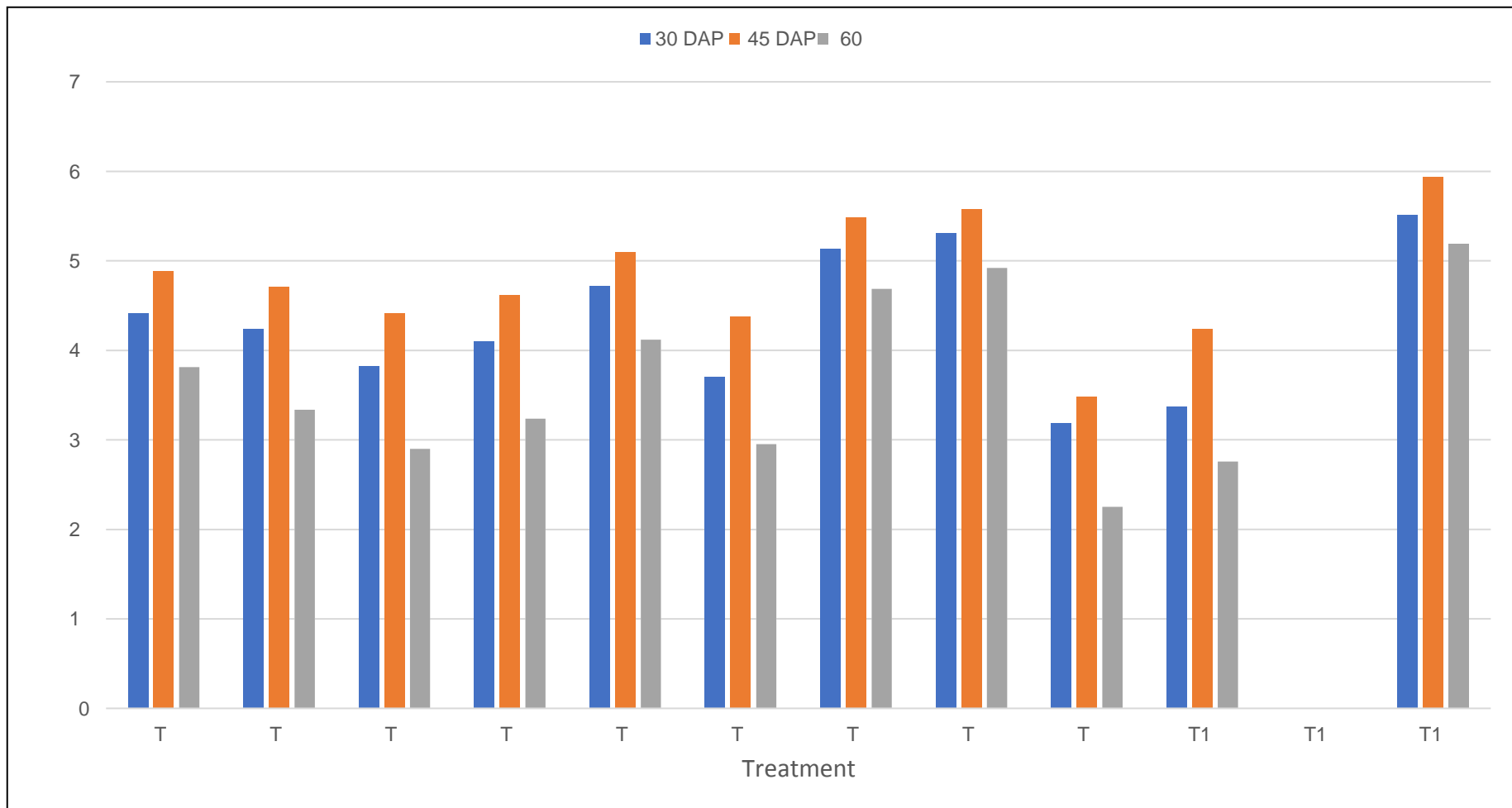


Fig. 3: Effect of different herbicides on weed control efficiency



Plate. 8. Weedy check plot and weed free plot

5.6 Effect of different herbicides on weed index in gladiolus

The effectiveness of herbicides can be best judged based on weed index values. All the weed control treatments recorded significantly lower weed index than weedy check (Table 12).

Among the chemical herbicidal treatments, pre-emergence application of pendimethalin at (0.75 kg *a.i./ha*) recorded minimum weed index and found superior over other treatments. This might be due to better control of weeds at initial and later stages of crop growth. This enable the crop to utilize available nutrients, moisture and space more effectively which resulted in better growth and development and ultimately increased flower yield. These results are conformed with the findings of Nagar *et al.* (2009) and Sethivel (2001) in coriander. Maximum weed index indicating yield reduction due to weed competition in weedy check treatment. This may be due to presence of maximum number of weeds, which compete with crop. This is in conformity with findings of Hanumanthanaik (1998) in gerbera.

5.7 Effect of different herbicides on flowering parameters

5.7.1 Days taken for initiation of inflorescence, days taken for first floret opening, days taken for 50 per cent flowering

There was marked difference in days taken for initiation of inflorescence, days taken for first floret opening and days taken for 50 per cent flowering among the different weed control treatments (Table 13) and (Fig. 4).

The minimum number of days taken for inflorescence initiation, first floret opening and 50 per cent flowering was observed in Weed free treatment followed by plots received pre-emergent spray of pendimethalin (1.0 kg *a.i./ha*). This may be due to reduction in weed population and right from the initial stages of plant growth. In Weedy check opening of flowering was late. This may be because of severe infestation of weeds that resulted in competition (Singh and Karki, 2005) in rose. There was marked difference in days taken for first flower's opening among the different weed control treatments. Similar results were reported by Koutepas (1982), Hanamant in golden rod (1999), Vijaykumar in gladiolus (2001), Vinaykumar and Gowada, (2011) and Nagapushpa *et al.* (2018) in china aster.

5.7.2 Duration of flowering

There was marked difference was observed in duration of flowering among the different weed control treatments (Table 13).

The maximum flowering duration was observed in weed free treatment followed by plots received pre-emergent spray of pendimethalin (1.0 kg *a.i./ha*) at higher concentration. This might be due to reduction in weed population, increased

availability and uptake of water and nutrients. Similar results were obtained by Koutepas (1982), Hanamant in golden rod (1999) and Vijaykumar in china aster (2001).

5.8 Effect of different herbicides on flower quality parameters

5.8.1 Spike length and rachis length

Flower quality of gladiolus was measured in terms of spike length and rachis length. Significant differences in length of spike and rachis were observed due to different herbicidal treatments (Table 14) and (Fig. 5).

The maximum length of spike and rachis was observed in the treatment pendimethalin (1.0 kg *a.i./ha*). This may be due to better control of weeds during crop growth period in these treatments and also no phytotoxicity effects were observed on the crop which resulted in better growth and quality flowers. It might be due to pre-emergence application of herbicides which stimulated the elongation of the rachis and spike length Pal and Das, (1990) in tuberose.

5.8.2 Number of florets per spike, length of florets and floret diameter

Significant differences in number of florets per spike, length of florets and floret diameter were observed due to different chemical weed control treatments (Table 15).

The maximum number of florets per spike, length of florets and floret diameter was observed in the treatment pendimethalin (1.0 kg *a.i./ha*). Flower quality measured in terms of number of florets per spike, length of florets and floret diameter of the flowers which may be due to better utilization of photosynthates which were accumulated due to more number of leaves and leaf area because of better control of the weeds. These results are in line with the findings of Shalini and Patil (2004) in gerbera .

5.8.3 Spike girth (mm) and Spike weight

Significant differences in spike girth and spike weight were observed due to different chemical weed control treatments (Table 14) and (Fig. 5).

The maximum number of florets per spike, length of florets and floret diameter was observed in the treatment pendimethalin (1.0 kg *a.i./ha*). This may be due to better control of weeds during crop growth period in these treatments and also no phytotoxicity effects were observed on the crop which resulted in better growth of plants which intern increased uptake and assimilation of nutrients and photosynthates there by increased girth and weight of spike. These results are in line with the findings of Shalini and Patil (2004) in gerbera.

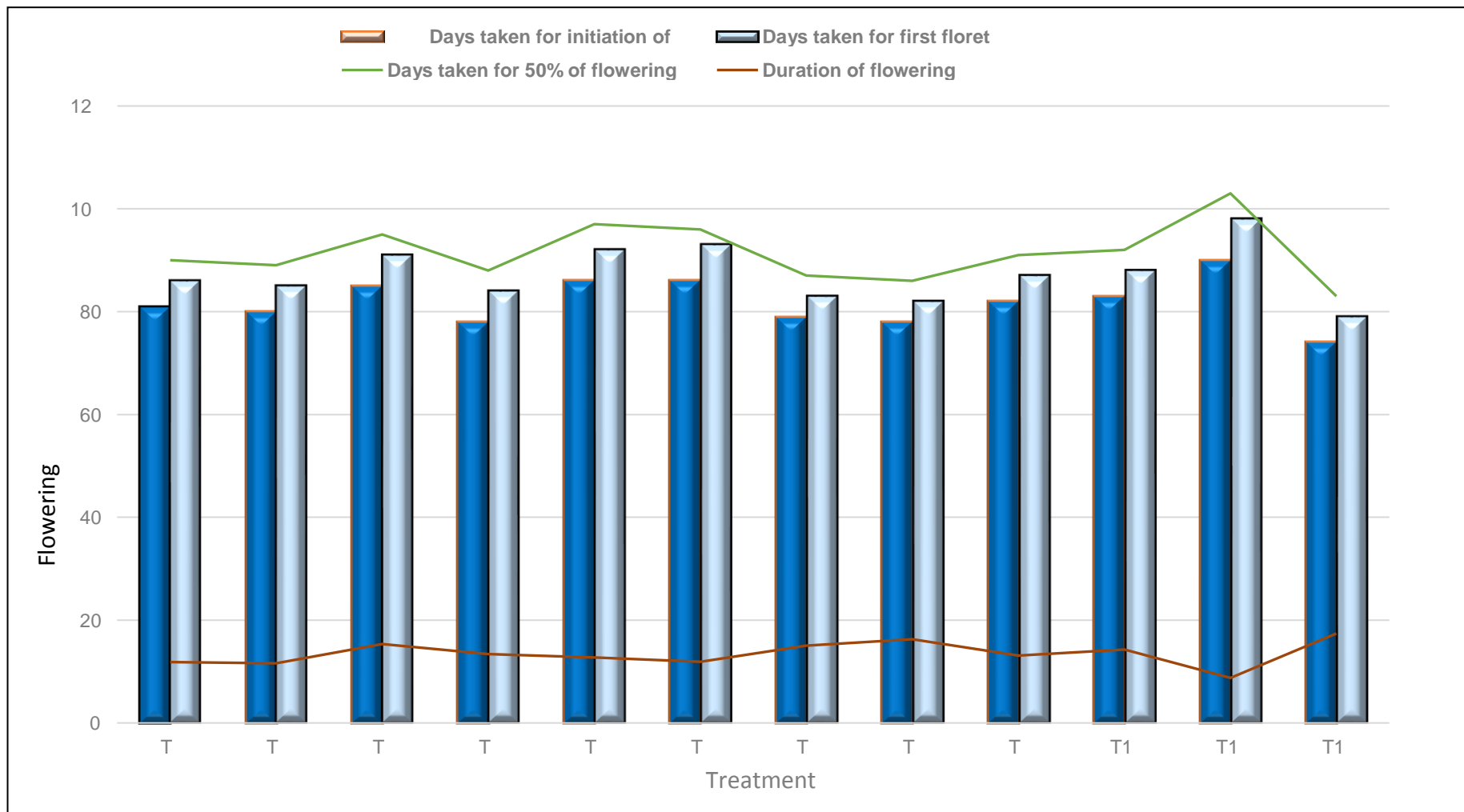


Fig. 4: Effect of different herbicides on flowering parameters in gladiolus

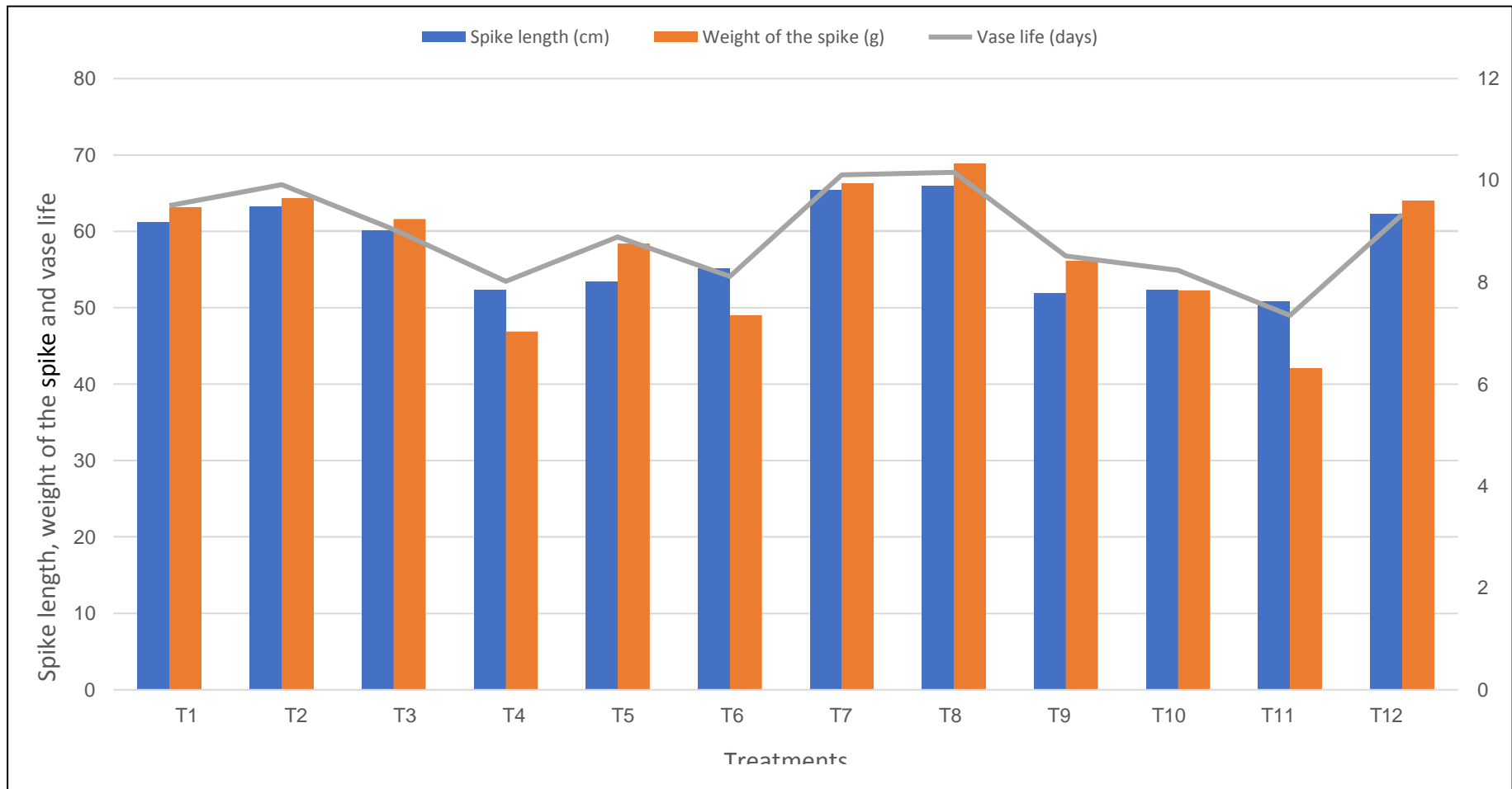


Fig. 5: Effect of different herbicides on flower quality parameters in gladiolus

5.8.4 Vase life (days)

A significant difference in vase life of flowers was observed due to different chemical weed control treatments (Table 14) and (Fig. 5).

The maximum vase life of flowers was observed in the treatment pendimethalin (1.0 kg *a.i./ha*) at higher concentration. This may be due better control of weeds and no phytotoxic effects on reproductive parts of the plants (Plate. 7).

5.9 Effect of different herbicides on flower yield parameters

5.9.1 Number of spikes per plant, number of spikes per plot and number of spikes per hectare

A significant difference was noticed for number of spikes per plant, number of spikes per plot and number of spikes per hectare due to different chemical weed control treatments (Table 15).

The maximum number of spikes per plant, number of spikes per plot and number of spikes per hectare was observed in the weed free treatment. Followed by pendimethalin (1.0 kg *a.i./ha*). This may be due to effective control of weeds causing high nutrient availability which in turn significantly increased the growth and produced more number of spikes. Sandhu *et al.* (1993) proved the superiority of pendimethalin (1.0 kg *a.i./ha*) in combination with one manual hand weeding in onion crop. The minimum flower spikes were recorded with Weedy check due to severe competition of weeds and suppression of growth due to non-availability of nutrients, moisture stress resulted in minimum number of flower spikes. Similar results reported in gladiolus by Wilfreet and Burgis (1977), Yadav and Bose (1987), Murthy and Gowda (1994) in tuberose and gladiolus.

5.10 Effect of different herbicides on corm and cormels parameters

5.10.1 Number of corms per plant, number of corms per plot and corms yield per hectare (kg/ha)

The number of corms per plant, number of corms per plot and corms yield per hectare was significantly maximum in all treatments as compared to Weedy check (Table 17) and (Fig. 6). Maximum number of corms per plant, number of corms per plot and corms yield per hectare was obtained in the treatment pendimethalin (1.0 kg *a.i./ha*). This may be due to less crop weed competition for growth and availability of resources between crop and weeds. These results are in line with the findings of Patel *et al.*, 1983 in onion.

5.10.2 Number of cormels per plant, number of cormels per plot and cormels yield per hectare (kg/ha)

The number of cormels per plant, number of cormels per plot and cormels yield per hectare was significantly maximum in all treatments as compared to Weedy check (Table 17) and (Fig. 6). Maximum number of cormels per plant, number of cormels per plot and cormels yield per hectare was obtained in the treatment pendimethalin (1.0 kg *a.i./ha*). This may be due to less crop weed competition for growth and availability of resources between crop and weeds. These results are in line with the findings of Patel *et al.*, 1983 in onion.

5.10.3 Weight of corms per plant and weight of corms per plot (kg)

The weight of corms per plant and weight of corms per plot was significantly maximum in all treatments as compared to weedy check (Table 16). Maximum weight of corms per plant and weight of corms per plot was obtained in the treatment pendimethalin (1.0 kg *a.i./ha*). This may be due to reduced weed competition and it effective in promoting crop growth which provided a favourable environment for the growth and there by resulted in more number of corms per plant and highest average corm weight. These results are in line with the results of (Manuja *et al.*, 2005).

Minimum weight of corms per plant and weight of corms per plot was obtained in the treatment weedy check. This may be due to more competition between weeds and crop for light and nutrients during grand growth stage.

5.10.4 Weight of cormels per plant and weight of cormels per plot (g)

The weight of cormels per plant and weight of cormels per plot was significantly maximum in all treatments as compared to weedy check (Table 16). Maximum weight of corms per plant and weight of cormels per plot was obtained in the treatment pendimethalin (1.0 kg *a.i./ha*). This may be due to reduced weed competition and it effective in promoting crop growth which provided a favourable environment for the growth and there by resulted in more weight of cormels per plant and weight of cormels per plot. These results are in line with the results of (Manuja *et al.*, 2005).

Minimum weight of cormels per plant and weight of cormels per plot was obtained in the treatment weedy check. This may be due to more competition between weeds and crop for light and nutrients during grand growth stage.

5.10.5 Diameter of corms (cm) and diameter of cormels (mm)

The diameter of corms and diameter of cormels was significantly maximum in all treatments as compared to weedy check (Table 16). Maximum diameter of corms

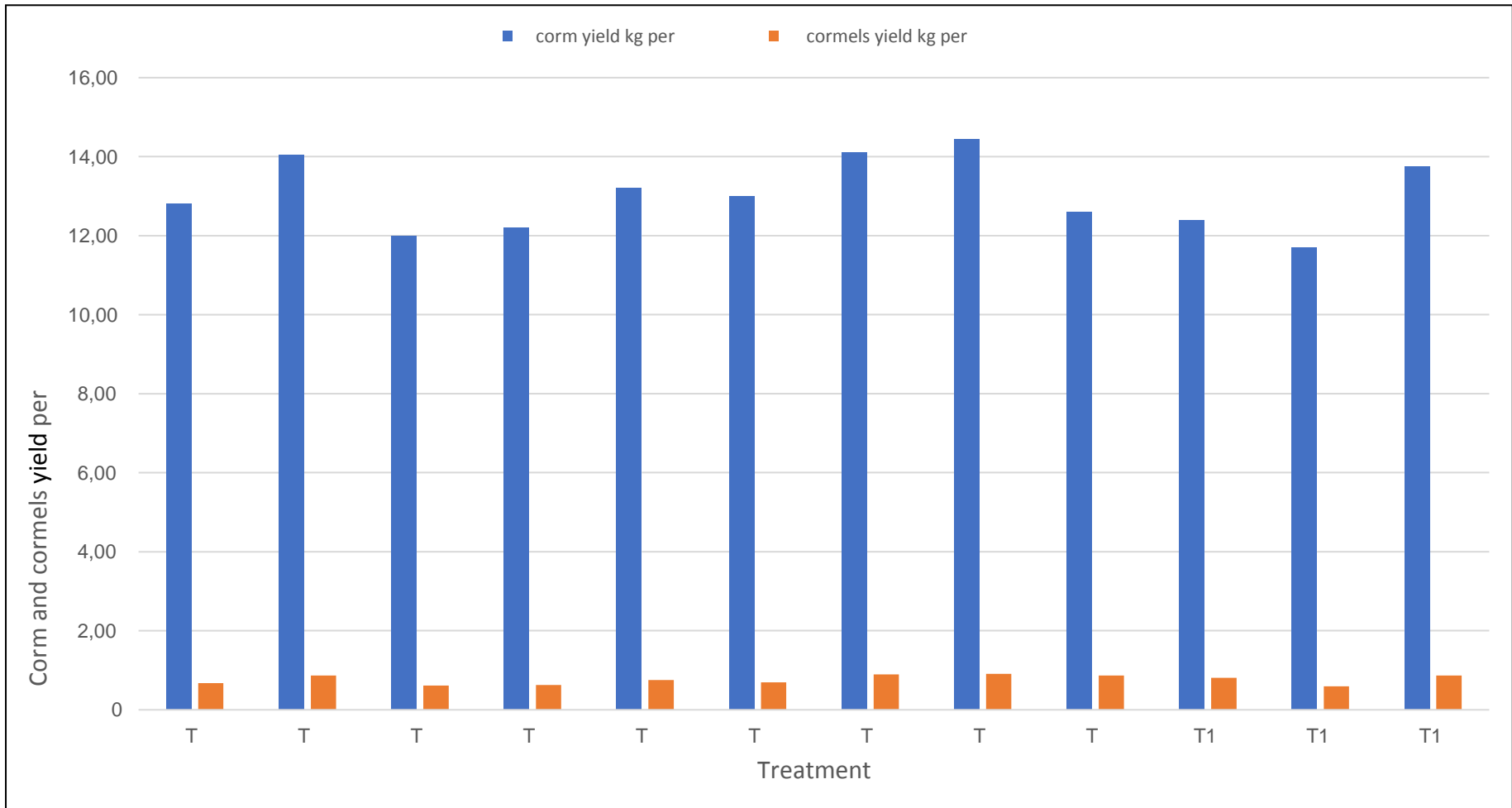


Fig. 6: Effect of different herbicides on corm and cormels yield of gladiolus



Plate. 7. Vase life studies in gladiolus



Plate. 9. Best treatment (Pendimethalin @ 1.0 kg *a.i.*/ ha)

and diameter of cormels was obtained in the treatment pendimethalin at higher concentration (1.0 kg *a.i./ha*). This may be due to better control of weeds at early stages of crop growth which coincided with critical crop growth period and weed competition followed by reduction in competition for nutrients, moisture and sunlight which improved the diameter of corms and cormels. These results are in conformity with the findings of Desai *et al.*, (2011).

5.11 Effect of different herbicides on economics of gladiolus cultivation

Economics of production play a vital role in making recommendations for adoption of any technology by the farmers. Three important variables namely gross return, net return and benefit cost ratio. All the weed management practices fetched significantly higher net returns and B:C ratio over weedy check (Table 18).

The maximum gross return, net return and benefit to cost ratio was achieved in the treatment pendimethalin (1.0 kg *a.i./ha*). Whereas, minimum in the treatment weedy check (Plate. 9). This may be due to the fact that weed count was more in control which might have resulted in severe competition by weeds with the crop for resources which made the crop to suffer and ultimately reduced the yield. These results are in line with the results of De Frank *et al.* (1989) in anthurium and Anandamurthy and Narayanagowda (1993) in china aster.

Conclusion

From the study, it can be concluded that, the applications of herbicides used in this investigations proved effective in controlling both growth and density of grasses, sedges and broad leaved weeds and leading to better growth of gladiolus crop. In case of weedy check, on the other hand, plant growth was severely suppressed due to the presence of larger number of weeds which utilized the nutrients and moisture from the soil. Similarly, the flower production was increased in the herbicide treated plants and it was mainly due to the improvement in the growth of the plants ultimately resulting in the production of greater number of spikes. Among the herbicides, pendimethalin and atrazine were found superior from the point of lower cost of weed management compared to hand weeding. It is concluded that pendimethalin at 1.0 kg *a.i./ha* and atrazine 1.0 kg *a.i./ha* can be recommended as pre-emergence herbicides for good weed control, production of better quality flowers and economics in hill zone conditions under sandy loam soils.

Future line of work

The aspects of which future investigation in weed management in gladiolus suggested are as under,

1. The effect of different herbicides along with cultural practices on type of weed flora control is needed to be studied.
2. Need for Integrated weed management practices for gladiolus based cropping system.
3. Residual effect of herbicides on succeeding crop needs to be studied.
4. Study on effect of these herbicides on soil microflora and fauna is needed.

SUMMARY

VI SUMMARY

The present investigation entitled “Efficacy of herbicides on growth, flowering, quality and yield of gladiolus (*Gladiolus grandiflora* L.) under the hill zone of Karnataka” was conducted during the year 2019-20 at the College of Horticulture, Mudigere. The results of the study are summarized here under.

The minimum number of days taken for sprouting (12.00), maximum sprouting percentage (100.00 %) and maximum shoots per corm (1.83) were observed in weed free at 30 days after planting.

The maximum plant height (68.30 cm), number of leaves per plant (10.20), leaf area per plant (1023.93 cm²) and leaf area index per plant (1.72) were recorded in the treatment pendimethalin @ 1.0 kg *a.i.* / ha at 60 DAP as compared to other treatments.

The maximum chlorophyll ‘a’ content (1.57 mg / g), chlorophyll ‘b’ (0.79 mg / g) and total chlorophyll content (2.36 mg / g) were noticed in the treatment pendimethalin at 1.0 kg *a.i.* / ha at 60 DAP as compared to all other treatments.

The minimum number of grassy weed population (3.92), number of sedge weed population (2.79), number of broad leaved weed population (2.57), total number of weed population (9.28) and dry weight of weed population (3.92) were observed in treatment with pendimethalin at 1.0 kg *a.i.* / ha at 60 DAP as compared to all other treatments.

The maximum weed control efficiency (49.22 %) was observed in the treatment pendimethalin at 1.0 kg *a.i.* / ha at 60 DAP as compared to all other treatments.

The minimum number of days taken for initiation of inflorescence (74.00), number of days taken for first floret opening (79.00), number of days taken for 50 per cent flowering (83.00) and maximum flower duration (17.37) were recorded with the treatment weed free.

The maximum length of the spike (65.91 cm), rachis length (38.94 cm), number of florets per spike (11.32), length of the floret (10.92 cm), diameter of floret (10.21 cm) and spike girth (8.73 mm) were recorded in the treatment pendimethalin at 1.0 kg *a.i.* / ha.

The maximum spike weight (68.87 g) and vase life (10.16 days) was recorded with treatment pendimethalin at 0.75 kg *a.i.* / ha.

The maximum number of spikes per plant (1.40), number of spikes per plot (42.12) and number of spikes per hectare (2,10,600.00) were registered with weed free.

The maximum weight of corms per plant (96.66 g), weight of corms per plot (2.89 kg), weight of cormels per plant (28.19 g) and weight of cormels per plot (182.44 g) were observed with treatment pendimethalin at 1.0 kg *a.i.* / ha.

The maximum diameter of corm (5.10 cm) was recorded in weed free plot.

The maximum diameter of cormels (5.18 mm), number of corms per plant (1.73), number of corms per plot (51.90), yield of corms (14,450 kg / ha), number of cormels per plant (33.21), number of cormels per plot (1557.00) and yield of cormels (912.20 kg / ha) were recorded in the treatment pendimethalin at 1.0 kg *a.i.* / ha.

The maximum gross return (Rs.23,42,610.00), net return (Rs.14,59,605.00) and B: C ratio (1.65) per hectare were recorded in the treatment pendimethalin at 1.0 kg *a.i.* / ha.

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APPENDICES

VIII APPENDICES

Appendix I: Meteorological Data maintained at ZAHRS, Mudigere

Month and Year	Rain fall (mm)	Temperature (° C)		Relative Humidity (%)	
		Minimum	Maximum	Minimum	Maximum
June-2019	273.7	18.26	27.03	61.13	80.53
July-2019	740.2	19.70	25.16	63.67	75.38
August-2019	1402.7	19.74	24.62	63.70	73.61
September-2019	525.3	19.83	25.26	60.53	79.83
October-2019	329.3	19.58	26.25	60.96	80.19
November-2019	26.3	18.93	29	60.133	80.26
December-2019	1.4	19	28.64	60.25	80.12
January-2020	0	18.06	29	60.12	80
February-2020	0	17.34	30.27	60.82	80.41
March-2020	2.3	18.61	32.70	60.64	80.25
April-2020	60.6	18.77	30.87	60.45	80.53
May-2020	113.7	20.61	28.61	58.32	76.16
June-2020	257.2	20.3	25.36	56.78	71.6
Total	3732.70	248.73	362.77	787.50	1018.87
Mean	287.13	19.13	27.90	60.57	78.37

Appendix II: Physico-chemical properties of the soil

Particulars	Characterization	Method employed
Physical properties		
Coarse sand (%)	44.3	Hydrometer method (Piper,1966)
Fine sand (%)	23.4	
Silt (%)	18.6	
Clay (%)	20.1	
Chemical properties		
Available Nitrogen (kg/ha)	472.06	Subbaiiah and Asija (1956)
Available Phosphorous P ₂ O ₅ (kg/ha)	29.2	Brays-I method Brays and Kurtz (1945)
Available Potassium K ₂ O (kg/ha)	211.1	Nuetral normal Ammonium Acetate method. Jackson (1967)
Soil pH	6.51	Potentiometry Jackson (1967)
Electrical Conductivity (dSm ⁻¹) at 25°C	0.16	Conductivity bridge Jackson (1967)

Appendix III: Cost of cultivation of gladiolus per hectare

Particulars	Quantity (ha)	Rate unit (₹)	Total cost (₹ /ha)
I Inputs			
1.Corms (30 cm x 20 cm)	1,66,666	@ 5/ each	8,33,330.00
2.Fertilizers			
a.Urea (N)	217 kg	@ 6/ kg	1302.00
b. Single super phosphate (P)	375 kg	@ 9/ kg	3375.00
c. Muriate of potash (K)	100 kg	@ 20/ kg	2000.00
d.FYM	25 tons	@ 800/ t	20000.00
3. Plant protection chemicals	2.5 kg	@ 3g/ l	1000.00
II Labour charges			
1. a. Ploughing	1	2400	2400.00
b. Land preparation	6	600	3600.00
c. planting	10	360	3600.00
d. Spraying cost	2	300	600.00
Mean			10,000.00
2. Earthing up and weeding	12	250	3000.00
3. Irrigation	4	500	2000.00
4. Harvesting and miscellaneous charges	10	500	5000.00
Total			8,81,007.00

Appendix IV: Price list of herbicides used in the experiment

Herbicides	Trade name	Quantity kg <i>a.i</i> /ha	Cost (₹ /ha)
Atrazine	Atratop	1.0	1076.00
Atrazine	Atratop	1.5	1614.00
Metribuzin	Lexone	0.25	1085.00
Metribuzin	Lexone	0.5	2201.00
Butachlor	Weedar	1.0	1200.00
Butachlor	Weedar	1.5	1800.00
Pendimethalin	Stomp	0.75	1500.00
Pendimethalin	Stomp	1.0	1998.00
Oxyfluorfen	Goal	0.5	1020.00
Oxyfluorfen	Goal	1.0	2040.00

Appendix V: List of symbols and abbreviations

List of symbols	Abbreviations
B:C	Benefit :Cost ratio
Cv.	Cultivar
DAP	Days after planting
@	At the rate of
FYM	Farm yard manure
CD	Critical difference
cm	Centimeter
cm ²	Centimeter square
a.i.	Active ingredient
DMSO	Dimethyl sulfoxide
<i>et al.</i>	and other
g	Gram
ha	Hectare
No.	Numbers
<i>i.e.</i>	That is
kg	Kilogram
m ²	Meter square
mg	Milligram
mm	Millimeter
ppm	Parts Per Million
RDF	Recommended Dose of Fertilizer
S. Em.	Standard Error of mean
T	Tonne
wt	Weight
<i>Viz.,</i>	As follows