

**EFFICACY OF PRE AND POST EMERGENCE  
HERBICIDES AGAINST WEED FLORA IN  
ONION (*Allium cepa* L.)**

**THESIS**

**Submitted to  
Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola  
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**MASTER OF SCIENCE  
IN  
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## DECLARATION OF STUDENT

I hereby declare that the experimental work and its interpretation in the thesis entitled “**EFFICACY OF PRE AND POST EMERGENCE HERBICIDES AGAINST WEED FLORA IN ONION (*Allium cepa* L.)**” or part thereof has neither been submitted for any other degree or diploma of any University, nor the data have been derived from any thesis or publication of any University or scientific organization. The source of material used and all assistance received during the course of investigation have been duly acknowledged.

Place : Akola

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Date : 30/07/ 2020

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## CERTIFICATE

This is to certify that thesis entitled “**EFFICACY OF PRE AND POST EMERGENCE HERBICIDES AGAINST WEED FLORA IN ONION (*Allium cepa* L.)**” submitted in partial fulfillment by **Thakare Akanksha Manoj** for the requirement of the degree of “**Master of Science in Agriculture (Agronomy)**” to the university of Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola is a record of bonafide research work carried out by her during the period of her study in this University, under my guidance and supervision, and the thesis has not previously formed the basis for the award of any degree, diploma, associateship, fellowship or other similar titles.

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**(Thakare Akanksha Manoj)**

**Date :**     /     / 2020 Enrolment No. MM/134

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## **(D) List of Abbreviations**

|                  |   |                          |
|------------------|---|--------------------------|
| %                | - | per cent                 |
| °C-              |   | Degree Celsius           |
| /                | - | Per                      |
| @                | - | At the rate of           |
| a.i.             | - | Active ingredient        |
| BSH              | - | Bright sunshine hours    |
| CD               | - | Critical difference      |
| cm               | - | Centimetre               |
| cm <sup>2</sup>  | - | Square centimetre        |
| cfu-             |   | Colony forming unit      |
| DAT              | - | Days after Transplanting |
| DAT              | - | Days after Treatment     |
| e.g.             | - | For example              |
| et al.           | - | et alia (And associates) |
| etc              | - | Etcetera                 |
| Evap.            | - | Evaporation              |
| Fig.             | - | Figure                   |
| g                | - | Gram                     |
| G.M.             | - | General Mean             |
| GMR              | - | Gross Monetary Returns   |
| H                | - | Hoeing                   |
| ha               | - | Hectare                  |
| ha <sup>-1</sup> | - | Per hectare              |
| HI               | - | Harvest Index            |
| Hrs              | - | Hours                    |
| HW               | - | Hand Weeding             |
| i.e.             | - | id est. (that is)        |
| K                | - | Potash                   |
| kg               | - | Kilogram                 |
| lit              | - | Litre                    |
| m                | - | Meter                    |
| m <sup>2</sup>   | - | Meter square             |

|                 |   |                            |
|-----------------|---|----------------------------|
| m <sup>-2</sup> | - | Per meter square           |
| mm              | - | Millimeter                 |
| MW              | - | Meteorological Week        |
| N               | - | Nitrogen                   |
| NMR             | - | Net Monetary Returns       |
| No.             | - | Number                     |
| NS              | - | Non significant            |
| P               | - | Phosphorus                 |
| pH              | - | Hydrogen ion concentration |
| PoE             | - | Post Emergence             |
| PE              | - | Pre Emergence              |
| Q               | - | Quintal                    |
| RBD             | - | Randomized block design    |
| RF              | - | Rainfall                   |
| RH              | - | Relative humidity          |
| Rs.             | - | Rupees                     |
| SE(m)±          | - | Standard error of mean     |
| Viz.            | - | Videlicet (Namely)         |
| T               | - | Treatment                  |
| T MAX           | - | Temperature maximum        |
| T MIN           | - | Temperature minimum        |
| WCE             | - | Weed Control Efficiency    |
| WI              | - | Weed index                 |
| WS              | - | Wind speed                 |

**(E) THESIS ABSTRACT**

- a) Title of the thesis : "EFFICACY OF PRE AND POST EMERGENCE HERBICIDES AGAINST WEED FLORA IN ONION (*Allium cepa* L.)"
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---

**ABSTRACT**

The field experiment was conducted at AICRP-Weed Management, Agronomy farm, Dr. Panjabrao Deshmukh Krishi Vidyapith, Akola to study the "Efficacy of pre and post emergence herbicides against weed flora in onion (*Allium cepa* L.)" during the year of 2018-19 in *rabi* season.

The experiment was carried out to study the relative efficacy of herbicides and cultural practice on weed control in onion as well as to study its effect on growth and yield of onion. The experiment was laidout in

randomized block design with nine treatment replicated thrice. In the present experimentation, chemical weed management practices i.e. herbicides used under treatment were Pendimethalin 24% + Oxyfluorfen 4% ZE @480+82 g a.i./ha(T<sub>1</sub>), Pendimethalin 24% + Oxyfluorfen 4% ZE @541.80+92.56 g a.i./ha(T<sub>2</sub>), Pendimethalin 24% + Oxyfluorfen 4% ZE @600+102.5 g a.i./ha(T<sub>3</sub>), Pendimethalin 24% + Oxyfluorfen 4% ZE @1083.60+185.12 g a.i./ha(T<sub>4</sub>) are the herbicide with combine (pre-mix) formulation with different concentration of active ingredient and other treatments were Pendimethalin 38.7% CS@ 677.25 g a.i./ha(T<sub>5</sub>), Oxyfluorfen 23.5% EC@ 200 g a.i./ha(T<sub>6</sub>), Quizalofop ethyl 5% EC@ 50 g a.i./ha (T<sub>7</sub>), 2 HW 25 & 45 DAT (T<sub>8</sub>) and weedy check (T<sub>9</sub>). All the recommended agronomic practices were followed for raising the crop.

The soil of experimental field characterized as clayey in texture, having slightly alkaline pH (7.7), moderate organic carbon status (0.41%), low nitrogen content (197.21 kg ha<sup>-1</sup>), medium available phosphorus content (18.76 kg ha<sup>-1</sup>), high potassium status (366.49 kg ha<sup>-1</sup>). Onion (Variety-Akola safed) was transplanted on 14<sup>th</sup> December 2018 at 20 x 10 cm spacing with 100:50:50 kg ha<sup>-1</sup> NPK. The crop was harvested on 9<sup>th</sup> April 2019.

Weed species recorded in experimental field were *Stromatium dhatura*, *Parthenium hysterophorus*, *Euphorbia hirta* L., *Commelinabenghalensis*, *Alternanatheratriandra*., *Digera arvensis* Forst., *Tridax procumbens* L., *Euphorbia geniculata* Orteg., *Argemone mexicana* L., *Xanthium strumarium* L., *Chenopodium album* L., *Phyllanthus niruri* L., *Portulaca oleracea* L., *Lagascamollis*, *Acalypha indica* among the dicot weeds and among monocot the dominant weeds were *Cyprus rotundus*, *Cynodondactylon*, *Eleusinindica* L. and *Dactyloctenium aegyptium* L.

Weedy condition throughout the crop growth period caused 40 to 80 % reduction in bulb yield of onion. Among the herbicidal treatments, Pendimethalin 24% + Oxyfluorfen 4% ZE @600+102.5 g a.i./ha was found to be effective in controlling weeds across the crop growth period. Among the various treatments under study weed free recorded significantly higher values of major parameters whereas, in herbicidal treatments, the maximum growth and yield attributes were recorded with

treatment Pendimethalin 24% + Oxyfluorfen 4% ZE @600+102.5 g a.i./ha which were at par with Pendimethalin 24% + Oxyfluorfen 4% ZE @1083.60+185.12 g a.i./ha. The same treatment recorded better weed control efficiency and lowest weed index. The lowest weed density of both monocot as well as dicot was observed in treatment with spraying of pendimethalin 24% + oxyfluorfen 4% ZE @600+102.5 g a.i./ha as pre emergence which ultimately result in lowest weed dry matter accumulation , higher weed control efficiency and lower weed index. The nutrients uptake by weeds was more in weedy condition. However, total nutrient uptake by crop was observed maximum with application of Quizalofop ethyl 5% EC@ 50 g a.i./ha. Treatment with application of pendimethalin 24% + oxyfluorfen 4% ZE @600+102.5 g a.i./ha PE was recorded with highest onion bulb yield production and hence these treatment was found most economical with maximum value of GMR (188290 Rs ha<sup>-1</sup>) and B: C ratio (3.04).

# CHAPTER I

## INTRODUCTION

### 1.1 Background Information

Onion is the biggest used flavouring vegetable in the world since ancient times and references to their history go back 5000 years or more with Chinese cultivation, 3500 BC for the Egyptians, the sixth century BC in India and the first century AD in Greece.

Onion (*Allium cepa* L.) belongs to the family Amaryllidaceae. The genus 'allium' also contains a number of other species that are cultivated for food, such as the Japanese bunching onion (*Allium fistulosum*), Egyptian onion (*A. proliferum*) and Canadian onion (*A. canadense*). The vast majority of cultivar of *Allium cepa* belong to the "common onion group" (*A. cepa* var. *cepa*) and are usually referred to simply as onions. The aggregatum group of cultivars (*A. cepa* var. *aggregatum*) includes both shallots and bulb onions (Sharma, 2014). It is one of the most important commercial bulbous vegetable crop, grown from ancient times in world as well as in India. The word "onion" is derived from latin word meaning "Large pearl". It is comparable to pearl not only for shape but also for its highly valueable nutritional and medicinal value.

Onion is an important and indispensable item in every kitchen as condiment and vegetable and hence, commands an extensive internal market. The green leaves, immature and mature bulbs are eaten raw as salad and used in preparation of vegetables. Dehydrated bulbs, onion powder and oleoresin are some byproducts of onion which are under a great demand due to low transport costs, longer storage life and less losses. Onion oleoresin can be used for flavouring of many food products, especially those of smooth texture. It can be usable in dairy products such as flavoured cream cheese, sour cream or in meat products as sausage, processed hams, cold meats and meat cans (Simandiet *al.*, 2000). The typical flavour of onion is owing to the presence of a volatile oil known as allyl propyl disulphide which helps to prevent from strong sunstroke during summer as well as important constituent of cookery industry.

Onion can be grown under a wide range of climatic conditions, but mild season with optimum temperature is the best suited for it. Hence, it is considered as a cool season crop. Extreme heat, cold or excessive rainfall adversely affects the onion cultivation. It is cultivated both as a *kharif* and *rabi* crop. It requires a temperature of 12.5<sup>0</sup> to 23.9<sup>0</sup>C before bulbing and for better bulb production it requires 15.6<sup>0</sup> to 21.1<sup>0</sup>C for about 10 hours a day and about 70 per cent relative humidity (Nath *et al.*, 1984). Onion can be grown on clay loam, sandy loam, silt loam and well drained medium heavy clay soils. But, for successful onion production deep friable soils are desirable.

Onion has culinary, dietary and medicinal importance in daily life of Indian people and due to its export trade. It is also a major vegetable crop to fetch handsome foreign currency. It contains carbohydrates (11.0 g), proteins (1.2 g), fiber (0.6 g), moisture (86.8 g) and several vitamins like vitamin A (0.012 mg), vitamin C (11 mg), thiamine (0.08 mg), riboflavin (0.01 mg) and niacin (0.2 mg) and also some minerals like phosphorus (39 mg), calcium (27 mg), sodium (1.0 mg), iron (0.7 mg) and potassium (157 mg) (Rahman *et al.*, 2012).

Onion, an important vegetable crop grown in India and either can be used as raw or dehydrated form to add flavour and taste to Indian cuisine. Onion is popularly known as “Queen of kitchen” because of its characteristics flavour and mostly used flavouring vegetable in the world. It is used for flavouring or seasoning the food both as mature and immature bulb. Besides it is being used as salad and pickle. The agroclimatic conditions enable India to produce onion round the year. For India, onion is a consistent earner of foreign exchange and the exports of onion and onion products reach several estimations. Onion is a rich source of chromium and this trace mineral helps tissue cells respond appropriately to insulin levels in the blood. It thus, facilitates insulin action and control sugar levels in diabetes. It is also a good source of antioxidant flavonoid, quercetin, which is found to have anti-carcinogenic, anti-inflammatory and anti-diabetic functions. It is also good in vitamin-C and mineral manganese. Manganese is required as a

co-factor for anti-oxidant enzyme, superoxide dismutase. In addition, isothiocyanate anti-oxidants in them help in relief from cold and flu by exerting anti-inflammatory actions. Onion is also good in B-complex group of vitamins like pantothenic acid, pyridoxine, foliates and thiamin (Anonymous, 2012). Apart from furnishing nutritions, it provides relishing flavour to our diet. It is also used to cure a wide array of physiological disorder such as cough, obesity, insomnia, hemorrhoid and constipation (Ibrahim *et al.*, 2011). All onions and onion relatives (garlic, leeks, chives and scallions or spring onions) are rich in organosulfur compounds, which have been shown to help prevent cancer in lab animals. Onions have potent antibacterial activity, destroying many disease causing pathogens, including *E. coli* and salmonella.

Onion is one of the most important commercial vegetable crops grown all over the world. India ranks second in area and production of onion in world after china. Major contributing states in onion production are Maharashtra, Karnataka, Madhya Pradesh, Bihar and Gujrat. In India onion occupies about 1.20 million hectare area having 19.40 million metric tonnes of production and average productivity of 16.13 metric tonnesha<sup>-1</sup>. In Maharashtra, it is grown over an area of 0.9 million hectare with total production of 2.06 million metric tonnes with average productivity of 16.51 metric tonnesha<sup>-1</sup> (Anonymous, 2017).

## **1.2 Importance of study**

The growth and yield of cultivated crop plants are mainly influenced by two principal factors viz., genetic and cultural or management factors. The first factor, deals with various plant breeding techniques for the improvement in crop varieties. The second factor, deals with supply of adequate nutrition, irrigation and plant protection including control of weeds etc.

Now a day, many problems faced by onion growers, the most troublesome one is the control of weed, particularly during the early stage of crop growth. Being a slow growing crop and having erect tubular leaves, it suffers heavily from weed competition during establishment of seedlings and weeds over top the crop. Due to growing habit of onion such as short

stature, non-branching habit, sparse foliage and extremely slow growth which cause rapid growth of weed. In addition to this, frequent irrigation water and fertilizer application allows for successive flushes of weeds in onion.

The weeds compete for the nutrients, moisture, space and light which affect growth and development of the crop during early stages of growth, thus adversely affecting bulb initiation and development. Critical period for crop-weed competition effectively begins from 15-16 days till initial bulb development period after transplanting. Therefore, it is essential to keep field weed free for about 15 to 60 days after transplanting. Yield loss due to weed infestation in onion is to the tune of 40 to 80% (Channapagoudar and Biradar, 2007).

As onion is commercial crop, farmers invest more money through costly inputs like seed, fertilizers, plant protection and irrigation etc. for achieving higher yield. Inadequate and delayed weed control results in decreased benefit to the farmers from these inputs. So, it is utmost important to control weeds during the critical period of crop-weed competition.

Onion is closely planted and shallow rooted crop. Manual weeding during the establishment stage of the crop causes physical damage to the crop resulting in sub-optimal plant population. Hand weeding is effective, but it is time consuming, cumbersome, laborious besides too expensive. It is, therefore, imperative to control the weeds before their emergence in the field with the use of herbicides. Pre and post emergence weed control method is becoming popular and regarded potentially as one of the most labour saving innovation in modern agriculture. Spraying of pre-emergence herbicides helps to minimize the crop weed competition during such critical growth stages resulting in higher crop yields.

Application of pre-emergence herbicides keep crop in weed free condition during early stage. Then, at later stage, hand weeding helps to reducing weed infestation and to keep the weed population below economic threshold level throughout the crop growth period. The traditional method of weed control i.e. hand weeding via *khurpi* is widely practiced in

onion field in India but with the rapid industrialization, increased literacy and mass migration of rural population to urban areas, labour availability is becoming increasingly scarce and costlier. The mechanical cultivation in onion is difficult due to high plant density. Hence, these factors have induced interest in herbicidal weed control. Keeping these facts in view, an experiment was undertaken to determine effective weed control for longer duration, by using different herbicide like pendimethalin, oxyfluorfen, quizalofop ethyl and newly formulated premixed herbicide combination like pendimethalin + oxyfluorfen.

### **1.3 Hypothesis**

Improved weed control practices that include chemical weed control with newer formulations, herbicide mixture and integrated cultivation need to be developed and refined. The hypothesis is that weeds can be controlled efficiently having no adverse effect on soil microflora and yield can maintained at a lower rate of input practice by the better used management strategy.

Also use of newly released herbicide having new mode of action, which can control narrow as well as broad spectrum weeds in onion. Similarly, combination i.e. pre-mix herbicide may result in effective weed control.

### **1.4 Scope and limitations**

Critical period for crop-weed competition effectively begins from 15-16 days till initial bulb development period after transplanting. Therefore, it is essential to manage weeds during this period (15 to 60 days after transplanting) is most critical for higher yields. Thus, attention must be focused on weed control measures so as to maintain the competitive ability of the crop by minimizing weed interference during the growth phases of crop. Accordingly, the nature of weed interference influences strongly the choice of weed control measures. The methods of weed control include cultural, biological, chemical means among others. The use of herbicides has assumed a great significance particularly in intensive agriculture due to

their ability of providing quick, effective, selective and economic weed management in term of time, money and labour.

Onion crop is grown by raising nursery in an irrigated transplant ecosystem. Onion has poor competitive ability with its slow initial growth and lack of adequate foliage makes onion weak against weeds. In addition, their cylindrical upright leaves do not shade the soil to smother weed growth. Yield loss due to weed infestation in onion has been recorded to the tune of 40-80 % (Vishnu *et al.*, 2014).

Success of crop depends largely on effective weed control under weed management strategy, cultivation is effective but cost and labour intensive. Chemical weed control is an alternative method that may be less expensive but more risky because of weed becoming herbicide resistant and because of concerns about unwanted side effective of herbicides. In situations where timely weeding is not feasible due to paucity and high cost of labour or unfavorable soil conditions, chemical weed control through pre or post emergence herbicides may be preferred along with cultural practices for better weed management across the crop growth period. The advantage of post emergence herbicide application is that the treatment can be ascertained after assessing degree of weed infestation and type of weed flora. The present study with weed control practices comprising newer premixed combine formulations with integrated cultivation is a further step in the weed management strategy of onion crop. It also involves evaluation of weed control practices in terms of energetic. As such there is limited documented work on weed management in onion.

### **1.5 Objectives of Study**

With changing scenario of weed management, farmers need pre and post emergences herbicides and there is an urgent need to evaluate the performances of new herbicides combined formulation for grassy weeds, sedges and broad leaf weeds control in onion. By using different herbicide like pendimethalin, oxyfluorfen, quizalofop ethyl and pendimethalin + oxyfluorfen premixed combination in comparison with weedy check in onion and effect of herbicide by analysing farmer feedback associated with onion crop. Hence present investigation was conducted to

study the “Efficacy of pre and post emergence herbicides against weed flora in onion (*Allium cepa*. L.)” was conducted with the following objectives

1. To evaluate the bio-efficacy of different pre and post emergence herbicides against weed flora, growth and yield of onion.
2. To evaluate the phytotoxicity of different pre and post emergence herbicides in onion.
3. To study the economics of different method of weed control.

## **CHAPTER II**

### **REVIEW OF LITERATURE**

Weed menace is one of the major constraint responsible for low productivity of onion as weed compete with the crop for moisture, nutrients, space and light. Weed management in onion involves integrated efforts to manage weeds in onion crop to selectively minimize the weed competition so as to enable onion crop to optimally use resources such as soil fertility, water and sunlight, for attaining the optimal harvestable bulb yield. In order to overcome risk, use of herbicides momentum for weed management and popularizing among farmers.

An attempt has been made to review and present a brief summary of work carried out by various research workers in India as well as abroad relating to the problem under study which has been highlighted and reviewed under the following subheads.

The review has been highlighted in the following major heads:

1. Losses caused by weeds
2. Weed flora of onion
3. Crop weed competition in onion
4. Cultural method of weed control
5. Effect of herbicide on weeds and crop
6. Effect of herbicides on soil micro flora
7. Integrated method of weed control
8. Economics of weed control

#### **2.1 Losses caused by weeds:**

Losses caused by weeds have been estimated to be much higher than those caused by insect, pest and diseases. Generally, the bulb yield of onion reduced by 25% by pest and diseases, 35-45% by insects but due to weed infestation losses occurred 30-60% bulb reduction. The extent

of losses caused by weeds observed in onion is very wide and it differs with environment, season and management factors where the crop is cultivated.

Ved Prakash *et al.* (2000) conducted a field experiment in Almora, Uttar Pradesh, India during the winter season of 1996-97 and 1997-98 to study the effect of herbicides and reported that, the season long crop weed competition reduced the bulb yield by 81.2% as compared to weed free check.

Kolhe (2001) conducted an experiment and reported that, the weeds reduced the yields of onion bulbs to the extent of 40 to 80%.

Tewari *et al.* (2003) studied that the onion, weed competition throughout crop period, caused 82.2% reduction in bulb yield.

Singh *et al.* (2006) observed that, weeds compete with onions for nutrients, soil moisture, space and light.

Channapagoudar and Biradar (2007) conducted field experiment during *kharif* 2003, in Dharwad (Karnataka) India, to evaluate the effects of different weed management practices in direct sown onion. They reported that yield loss due to weed infestation in onion is to the tune 40 to 80%.

Lawande *et al.* (2009) conducted research on biotechnology for crop improvement in onion and garlic in India is in a nascent stage. They reported that weed infestation in garlic is one of the major factors for loss in yield and bulb loss to the tune of 30-60%.

Sharma *et al.* (2009) conducted a field experiment during rainy (*kharif*) seasons of 2003-04 and 2004-05 to evaluate the impact of different weed control measures on growth and yield of onion (*Allium cepa*). They revealed that depending upon the nature of intensity and duration of weed competition, weed infestation can reduce bulb yield to the tune of 40-80%.

Vishnu *et al.* (2014) carried out field experiment during *rabi* season of 2012-13 at Junagadh to find out practically convenient and economically feasible weed management practice in onion. It was reported that yield loss due to weed infestation in onion to the tune of 40-80%.

Sankar and Lawande (2015) conducted an experiment at Directorate of Onion and Garlic Research, Rajgurunagar, Pune in clay loam soil using *rabi* onion cultivar N 2-4-1 with different herbicides like oxyflurofen, quizalofop ethyl and pendimethalin in comparison with weedy check. They reported that weed competition reduced the bulb yield of onion to the extent of 2.35 – 61.8 per cent depending upon the duration of crop weed competition and intensity.

Singh *et al.* (2018) conducted experiment of intercropping at the Bhadiarkhar farm of the CSK HPKV during year 2016-17. While conducting investigation he found that 43.8% losses due to weed in the total production in onion-okra-radish intercropping.

Ughade *et al.* (2019) conducted field experiment near Devgad, Block Newasa, District Ahmednagar, Maharashtra, India and they observed that weedy mimic in onion was morphologically similar to cultivated onion. Therefore it causes major loss from economic threshold level to economic injury level in onion production.

## **2.2 Weed flora in onion:**

Weed flora is an integral part of each and every crop as well as cropping system. Their interference with crop plant is natural. Because of high competitive ability of weed and allelopathic influence, weed causes maximum damage to the crops. Knowledge on the composition of weed flora in a particular crop and their correct identity is necessary to formulate effective measures for their control. The range of weed flora noticed in onion is very wide and it varies with ecosystem and other edaphic factors where the crop is grown.

Rameshwar *et al.* (2001) reported that, the weed flora comprised of weed like *Malva parviflora*, *Chenopodium album*, *Amaranthus spp.*, *Anagallis arvensis*, *Melilot indica*, *Poa annua* and *Digitariasanguinalis* were affecting the onion crop under Lari (H.P.) conditions.

Mondal *et al.* (2005) conducted an experiment during *rabi* seasons of 2002 and 2003 at farmers field, Shriniketan (West Bengal).

They observed that *Digitaria sanguinalis* (40.5%), *Echinochloa colonum* (4.0 %), *Cynodon dactylon* (2.1 %), *Alternanthera sessilis* (1.4 %), *Eclipta prostrata* (19.6 %), *Croton bonplandianum* (18.8 %), *Chenopodium album* (2.2 %) and *Polygonum plebeium* (11.2 %) were the major weeds in the field.

Bhutia *et al.* (2005) noticed that, the most dominant weeds in onion weeds in field under Nadia (W.B) conditions were *Argentum conyzoides* L., *Amaranthus viridis* L., *Argemone Mexicana* L., *Portulaca oleracea* L., *Euphorbia hirta* L., and *Physalis minima* L. (among broad- leaved weeds) and *Cyperus rotundus* L., *Digitaria sanguinalis* (L.) Scop., *Echinochloa crusgali* (L.) Beauv., *E. colonum* L., and *Eleusine indica* (L.) Gaertn (among narrow- leaved weeds).

In an experiment conducted by Warade *et al.* (2006) during rabi seasons of 2003 and 2004 at Akola (Maharashtra) reported that *Cyperus rotundus*, *Cynodon dactylon*, *Physalis minima*, *Chenopodium album*, *Portulaca oleracea*, *Euphorbia hirta*, *Amaranthus viridis*, *Tribulus terrestris* and *Parthenium hysterophorus* were major weeds in onion.

Chopra and Chopra (2007) carried out experimental field at Karnal, Haryana condition observed that, weeds which infesting onion field were *Cyperus rotundus* (28%), *Coronopus didymus* (48%) *Angallis arvensis* (6%) *Spergula arvensis* (6%) and other weeds (20%) which include *Convolvus arvensis*, *Chenopodium album*, *Melilotus spp.* *Poa annua*. *Coronopus didymus* was the dominant broad- leaf weeds, and *Cyperus rotundus* was the dominant among sedges and grasses.

Sharma *et al.* (2009) noticed that, weeds flora of onion crop at Bathinda, (Punjab) conditions were *Cyperus rotundus* (0.35%), *Rumex dentatus* (2.4%), *Melilotus alba* (0.35), *Chenopodium album* (0.35%), *Fumaria parviflora* (1.0%), *Anagallis arvensis* (1.25%), *Veronica agrestis* (0.35%), *Spergula arvensis* (20.3%), *Trigonella polycerata* (1.4%), *Medicago denticulate* (1.05%), *Lepidium sativa* (41.7%) and *Aerva sp.* (29.5%).

Chandrika *et al.* (2009) conducted research at Tirupati (Andhra Pradesh) and they observed that *Cynodondactylon*, *Dactyloctenium aegypticum*, *Digitaria sanguinalis*, *Cyperus rotundus*, *Cyperus iria*, *Amaranthus viridis*, *Borreria hispidia*, *Cleome viscosa*, *Commelinabenghalensis*, *Euphorbia hirta* and *Euphorbia thymifolia* were infested in onion field.

Ibrahim *et al.* (2011) conducted research at Nigeria and they revealed that grasses such as *Cynodondactylon* (L) *pers*, *Digitaria ciliaris* Willd, *Eleusine indica* Gaertn and *Dactyloctenium* (L) Beauv and broad leaves weeds such as *Solanum nigrum* L., *Ageratum conyzoides* L., *Amaranthus spinosus* L. and *Acanthospermum hispidum* DC found dominant in onion field.

Research was conducted at Mahatma Phule Krishi Vidyapeeth, Rahuri (Maharashtra) by Khathepur *et al.* (2011<sup>a</sup>) who observed major weed flora of monocotyledon like *Panicum isachimi*, *Cynodondactylon*, *Cyperus rotundus* and dicotyledonous weeds, while *Amaranthus polygamus* L., *Parthenium hysterophorus*, *Euphorbia hirta* and *Acalypha indica* as dicot weeds during *rabi* season in onion crop.

Bharathi *et al.* (2011) under Hyderabad condition recorded that, the weed flora of the onion experimental site consisted *Cynodon* sp., *Cyperus* sp., *Trianthema portulacastrum* (33%), *Digera arvensis* (21%), *Celosia argentea* (9%) *Cleome viscosa* (7%), *Cynodondactylon* (15%) *Cyperus rotundus* (10%) and other weed species.

A field experiment was conducted during *rabi* season of the year 2008-09 and 2009-10 at Instructional Farm, Navsari Agricultural University, Navsari (Gujarat) by Patel *et al.* (2011). They noticed that major weed flora of onion were *Echinochloa* spp., *Trianthema portulacastrum*, *Digera arvensis*, *Physalis minima* L. and *Cynodondactylon*.

An experiment carried out by Pramod *et al.* (2012) during *kharif* seasons of 2010 at DWSR, University of Agriculture Sciences, Hebbal, Bengaluru (Karnataka). They reported that *Echinochloa colona*, *Digitaria marginata*, *Eleusine indica*, *Dactyloctenium aegyptium* and *Cynodondactylon* as major grassy weeds in onion.

Saini and Walia (2012) carried out a field experiment during 2006-07 to 2007-08 on loamy sand soil of Research Farm, Punjab Agricultural University, Ludhiana (Punjab). They noticed that *Chenopodium album*, *Malva neglecta*, *Medicago denticulate*, *Solanum nigrum*, *Lepidium sativum*, *Trigonella polycerata*, *Melilotus spp.* and *Oenothera drumendii* were major weeds in onion.

Sharma and Tiwari (2012) conducted a field experiment at Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur (Madhya Pradesh), India to study the efficacy of different herbicides against weeds in onion. From the results, they reported that the experimental field was mainly infested with *Chenopodium album*, *Melilotus albus*, *Eragrostis cillans*, *Parthenium hysterophorus*, *Anagallis arvensis*, *Cyperus rotundus* and *Sperogulla arvensis* in onion crop.

Yadav *et al.* (2012) reported that *Cyperus rotundus*, *Chenopodium album*, *Medicago hispida*, *Phalaris minor*, *Fumaria parviflora*, *Parthenium hysterophorus*, *Convolvulus arvensis*, *Cynodon dactylon* and *Sperogulla arvensis* were dominant weeds in onion at Gwalior (Madhya Pradesh).

Patel *et al.* (2012) reported that, the dominant weeds identified in the onion experiment at Navsari, Gujarat condition were *Echinochloa colonum*, *Eleusine indica*, *Eragrostis major* among monocots, while *Trianthema spp.*, *Amaranthus spp.*, *Eliptica alba*, among dicot weeds. *Cyperus rotundus* was the only sedge found throughout the growing season.

Kalhpure and Shete (2013) observed that, the prominent weed species in the onion experimental plot were *Chenopodium album*, *Portulaca oleracea*, *Euphorbia spp.*, *Cynodon dactylon*, *Parthenium hysterophorus*, *Cyperus rotundus*, *Amaranthus viridis*, etc under Rahuri Maharashtra condition

A field experiment was conducted during *rabi* season of the year 2011 and 2012 at Mahatma Phule Krishi Vidyapeeth, Rahuri by Kalhpure *et al.* (2014). They noticed that the major weed flora of onion were *Cynodon dactylon*, *Dinebra retroflexa*, *Setaria italica*,

*Digitaria sanguinalis*, *Echinochloa crusgali*, *Cyperus rotundus*, *Acrachnera racemosa* and *Dactyloctenium aegyptium*. Whereas, the broad leaved weeds were *Boerhavia diffusa*, *Parthenium hysterophorus*, *Digera arvensis*, *Alternanthera echinata*, *Amaranthus viridis*, *Legascea mollis*, *Phyllanthus maderaspatensis*, *Euphorbia* spp. and *Portulaca oleracea* in onion experiment.

Rathod *et al.* (2014) conducted field trial at Junagadh Agricultural University, Junagadh (Gujarat) during 2007-08 and 2008-09 to study efficacy of pre and post-emergence herbicides in onion and they reported that, the predominant weeds in the onion experimental field were *Chenopodium album*, *Digera arvensis*, *Cyperus rotundus*, *Echinochloa colonum*, and *Dactyloctenium aegyptium* under Junagadh (Gujrat) condition.

As reported by Jangre *et al.* (2014), *Parthenium hysterophorus*, *Physalis minima*, *Chenopodium album*, *Cyperus rotundus*, *Cynodon dactylon*, *Melilotus indica* and *Alternanthera triandra* were prominent weeds flora in onion at Kawardha (Chhattisgarh).

Shete *et al.* (2014) carried out a field experiment during 1998 to 2000 on onion and they discerned that dominant grassy weeds species were *Cynodon dactylon*, *Dinebra retroflexa*, *Setaria italica*, *Digitaria marginata*, *Echinochloa crusgali*, *Cyperus rotundus*, *Acrachnera racemosa* and *Dactyloctenium aegyptium* while broad leaved weeds viz., *Boerhavia diffusa*, *Parthenium hysterophorus*, *Digera arvensis*, *Alternanthera echinanta*, *Amaranthus viridis*, *Legascea mollis*, *Phyllanthus maderaspatensis*, *Euphorbia* spp. and *Portulaca oleracea* were notable weeds in onion.

Sinaree *et al.* (2014) conducted an experiment during *kharif* seasons of 2012 at Rahuri (Maharashtra). They observed that sedges viz., *Cyperus rotundus*, monocot weeds viz., *Cynodon dactylon*, *Echinochloa crusgali* and broad leaved weeds viz., *Parthenium hysterophorus*, *Amaranthus spinosus*, *Convolvulus arvensis*, *Digera arvensis* and *Euphorbia* spp. were dominant in the field of onion.

A field experiment was conducted by Panaraet *al.* (2015) in *rabi* season of the year 2011-12 and 2013-14 on calcareous clayey soil at College of Agriculture, Junagadh Agricultural University, Junagadh (Gujarat). The experimental field was mainly infested with monocot weeds, viz. *Brachiaria spp.*, *Indigoferaglandulosa L.*, *Asphodelus tenuifoliuc L. Cav.*, *Echinocholacolona L.*, and dicot weeds viz., *Amaranthus viridis L.*, *Physalis minima L.*, *Portulaca oleracea L.*, *Euphorbia hirta L.* and *Leucas aspera* (Willd.) Spreng and sedge weed *Cyperusrotundus L.* in garlic.

Shingrupet *al.* (2015) conducted research in summer season at Dr. Panjabrao Deshmukh Krishi Vidyapith, Akola (Maharashtra). They found major weed flora viz., *Commelinabenghalensis*, *Dinebra arabica*, *Poaannua*, *Echinocholacrusgalli*, *Eragrostis major*, *Cynodondactylon*, *Cyperusrotundus*, *Lagascamollis*, *Euphorbia hirta*, *Digera arvensis*, *Tridexprocumbense*, *Parthenium hystrophorus*, *Celosia argenteae*, *Euphorbia geniculata*, *Alysicarpugosus*, *Alternanatheratriandra*, *Xanthium strumarium*, *Portulacaoleraceae* and *Amaranthus viridis* were infested in onion.

Sinareet *al.* (2015) noted that weed flora of onion in *kharif* season at Rahuri (Maharashtra) consisting *Echinochloacrusgalli*, *Parthenium hystrophorus*, *Cyperusrotundus*, *Cynodondactylon*, *Amaranthus spinosus*, *Convolvulus arvensis*, *Digera arvensis* and *Euphorbia spp.*

Kadu *et al.* (2017) conducted a field experiment during *rabi* seasons of year 2014-15 and 2015-16 at the farm of AICRP weed management, B. A. College of Agriculture, Anand Agricultural University, Anand (Gujarat) to study the integrated efficacy of various herbicides applied as pre- and post-emergence in onion (*Allium cepa L.*) The predominant weed flora of the experimental field was consisted of *Chenopodium album*, *Melilotusindica L.*, *Digera arvensis* Forst., *Trianthemamonogyana L.*, *Boerhaviadiffusan L.*, *Dactylocteniumaegyptium L.*, *Eleusinindica L. Gaertn.*, *Chloris barbata L.*, *Asphodelus tenuifolius L.* and *Cyprus rotundus*.

Kumari *et al.* (2019) conducted the experiment at Agricultural Research Institute, Patna under Bihar Agricultural University, Sabour, Bhagalpur. The weed community in the experiment site comprised of *Physalis micrantha*, *Cyperus rotundus* L, *Vicia sativa* L, *Chenopodium album*, *Blumeawightiana*, *Crotalaria retusa* L, *Trianthemaportutalastrum*, *Nicotiana plumbaginifolia*, *Cynodondactylon*, *Melilotus* spp.

### **2.3 Crop- weeds competition in onion**

A weed management is essential for onion production because unique challenge posed by their higher planting density and susceptibility to weed competition due to narrow, upright leaves and long growing season allow successive flushes of weed. Weeds compete with crop so as to unable crops to optimally utilize resources such as soil fertility, water and sunlight.

VedPrakash *et al.* (2000) found that season-long crop-weed competition reduced bulb yield by 81.2% compared with the weed-free condition.

Kizilkaya *et al.* (2001) concluded that weeds cause serious losses to onion bulb yield and quality and therefore must be controlled at 4-5 weeks after emergence.

Rameshwar *et al.* (2001) reported that the highest onion bulb and onion yield contributing characters were obtained in plots remained weed-free for the first 60 days after transplanting.

Kalyanmurthy (2002) under red soils of Bangalore, observed 15-60 days after sowing was very critical for drill sown onion. However, for transplanted onion the duration was less by 15 days i.e., 15 DAT to 45 DAT.

Jamal Qasem (2005) reported that weed-free periods for 42 to 49 days after onion transplanting reduced growth and competition effect of the subsequently emerged weeds and significantly increased onion growth and yield compared with other weed-free periods.

Dhananivetha *et al.* (2017) concluded that onion exhibits greater susceptibility to weed competition due to inherent characteristics such as slow growth, small stature, shallow root and lack of dense foliage.

From the above review, it seems that, the critical period of crop-weed competition in onion was from 15 to 60 days after transplanting of the seedlings.

## **2.4 Cultural method of weed control**

Ushakumari *et al.* (2001) found that, the hand weeding at 20, 40 and 60 DAT significantly reduced the weed population in the experimental plots of onion.

Naresh Kumar *et al.* (2002) observed that, the minimum number of weeds at 40 and 60 DAP, minimum weed biomass at 120 DAP and the highest weed control efficiency were recorded in treatment where 3 hoeing and weeding were done in onion experimental plot.

Muhammad Saleem Jilani *et al.* (2007) reported that, among the weed management strategies, three hand hoeing practice showed the best results followed by pendimethalin in bulb diameter, bulb weight, and bulb yield  $\text{ha}^{-1}$ .

Zahid Hussain *et al.* (2008) observed that, the maximum size of onion bulbs (79 g), onion count (50 / $\text{m}^2$ ) and yield (28730 kg  $\text{ha}^{-1}$ ) were recorded in the hand weeded plot.

Yumnam *et al.* (2009) found that, hand weeding at 20 DAP and 40 DAP had significantly lower weed density (38.0) and dry weight (73.84 g).

Ei-Metwally *et al.* (2010) recorded that, hand hoeing twice gave the highest efficiency in decreasing total number of weeds at 75 and 110 days from transplanting.

Habib ur Rahman *et al.* (2011) found that, highest yield (9.33 and 12.25 tons  $\text{ha}^{-1}$ ) was recorded in plots, where weeds were controlled manually throughout the crop season.

Ibrahim *et al.* (2011) conducted an experiment on evaluation of herbicide on weed control, performance and profitability of onion in forest zone of Nigeria during 2009 and 2010 at Akufo farm, Ibadan. They reported that, three times hoe weeding reduced weeds competition which resulted in greater number of bulbs plot, highest survival percentage and highest bulb diameter.

Kalhpure *et al.* (2013) reported that, highest growth attributes in onion (viz. plants height, neck thickness, bulb weight and bulb diameter) were observed with three hand weeding at 20, 40 and 60 DAT.

Dhananivetha *et al.* (2017) conducted field experiment and reported that hand weeding helps to keep the weed population below economic threshold level throughout the crop growth period.

Jangreet *et al.* (2018) conducted field trial at Sant Kabir College of Agriculture and Research Station, Kawardha (Chhattisgarh) during *rabi* season of 2008-09. They reported that two HW and other practices such as crop rotation, inter cropping reduces weed upto 60 % due to competition with weed.

Minzet *et al.* (2018) conducted field experiment at Birsa Agricultural University, Kanke, Ranchi, during the year 2016-17 to study the effect of herbicides on growth, yield and quality of onion. They revealed that maximum bulb production was under hand weeding treatment.

Sahoo and Tripathi (2019) conducted field experiment to compare different weed control methods in onion during *rabi* 2010-11 to 2011-12 and revealed significantly highest vegetative growth and bulb production with the application of oxyflurofen 23.5 % EC @ 2ml/l before planting along with one hand weeding at 40-60 DAT.

## **2.5 Effect of herbicides on weeds and crop**

### **2.5.1 Pendimethalin**

Pendimethalin is also a pre-emergence or an early post-emergence selective herbicide having residual toxicity. It penetrates germinating seedlings of weed through hypocotyl and root and kills them.

Saimbhiet *et al.* (2000) reported that, minimum weed density and reduced dry matter of weed were seen under the treatment receiving pendimethalin @ 0.56 kg ha<sup>-1</sup> at seven days after planting supplemented with one hand weeding at 105 days after sowing in the seed crop of onion under Ludhiana conditions.

Ushakumari *et al.* (2001) revealed that, the pre-emergence application of pendimethalin @ 1.0 kg ha<sup>-1</sup> with one hand weeding at 40 DAT reduced the number and dry weight of weed in onion under Hyderabad (A.P.) conditions.

Rameshwar *et al.* (2002) noticed that, significantly lowest population and dry matter accumulation of weed with the pre-emergence application of pendimethalin @ 1.5 kg ha<sup>-1</sup> followed by one hand weeding at 60 DAT in onion under Lari (H.P.) conditions.

Sukhadia *et al.* (2002) conducted an experiment at Junagadh to study the response of onion to method of sowing and weed management practices. They reported that pre-emergence application pendimethalin @ 0.90 kg ha<sup>-1</sup> along with one HW at 20 DAS significantly reduced the weed population, weed dry weight and recorded significantly the highest bulb girth (13.80 cm) and bulb yield (27.2 t ha<sup>-1</sup>) of onion.

Priyadharshini and Anburani (2004) conducted an experiment at Annamalai nagar (Tamil Nadu) and reported that pendimethalin applied @ 1 kg ha<sup>-1</sup> caused significant reduction in weed population, weed dry weight and recorded significantly the highest bulb yield of onion (25.51 t ha<sup>-1</sup>).

Nargis *et al.* (2006) suggested that pendimethalin proved to be the best herbicide in controlling weeds in onion field, by producing maximum sized bulbs and highest yield.

Muhammad Saleem Jilani *et al.* (2007) reported that, the application of pendimethalin @ 3.125 L ha<sup>-1</sup> significantly controlled weeds as it contained the lowest (0.4) number of weed m<sup>-2</sup>, minimum fresh weed biomass yield (0.3 g/m<sup>2</sup>) and the minimum dried weed biomass 0.04 and 0.26 g were recorded.

Habib ur Rahman *et al.* (2011) reported that, pendimethalin 30% was found to be the best for controlling weeds.

Vashi *et al.* (2011) noted that, the lowest dry weight of weeds was observed with pendimethalin @ 1.00 kg ha<sup>-1</sup> pre-emergence which remained at par with two hand weeding at 20 and 40 days after transplanting + soil stirring.

Shinde *et al.* (2013) observed that, the maximum weed control efficiency in grasses (89.01%) was noticed by Pendimethalin 38.7% CS @ 1.75 l ha<sup>-1</sup>

Mohite *et al.* (2015) carried out field investigation at main garden, University Department of Horticulture, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola during the *rabi* season of 2011-2012 and revealed that, the treatment pendimethalin @ 1.0 kg a.i./ha before planting and quizalofop ethyl 0.050 kg a.i./ha at 30 DAP was obtained superior in respect of growth characters like maximum height of plant, leaves per plant, plant population and yield character also.

Choudhary *et al.* (2016) reported that being a broad spectrum herbicide, pendimethalin is very popular amongst farmers for weed management in several crops.

Mallik *et al.* (2017) reported that application of pendimethalin 30 EC + one hand weeding at 45 DAT controlled most of weeds along with maximum weed control efficiency in garlic crop.

Minz *et al.* (2018) conducted research at Birsa Agriculture University, Ranchi, during the year 2016-17 to study the effect of herbicides on growth, yield and quality of onion. They reported that application of pendimethalin immediately after transplanting of onion may be recommended for achieving the highest productivity and profitability in onion.

### **2.5.2 Oxyfluorfen**

Oxyfluorfen belongs to a diphenyl ether group of herbicide. It is used for both pre-emergence as well as early post-emergence

application. It requires light for its activity. Mode of action of this herbicide is cell membrane disruption through lipid peroxidation.

Nandal and Singh (2002) conducted an experiment at Regional Research Station, Dhaulakuan, Sirmour (Himachal Pradesh) during *rabi* 1999 and 2000. The minimum weed dry weight was recorded with pre-emergence application of oxyfluorfen @ 0.37 kg ha<sup>-1</sup> followed by application of oxyfluorfen @ 0.25 kg ha<sup>-1</sup> along with hand weeding at 40 DATP.

Mondal *et al.* (2005) conducted a field experiment at All India Coordinated Research Programme on Weed Control, Visva-Bharti, Shantineketan, West Bengal to study the chemical weed control in onion. The minimum weed density and dry weight of weed was obtained at 60 days after transplanting under application of oxyfluorfen @ 200 g ha<sup>-1</sup>. The bulb yield and net return was recorded higher in oxyfluorfen @ 100 g ha<sup>-1</sup> fb hand weeding at 25 DATP.

Chopra and Chopra (2007) noted that, the mother bulb yield was significantly higher (121.9 qha<sup>-1</sup>) with the application of oxyfluorfen @ 0.15 kg a.i.ha<sup>-1</sup> a day after transplanting was found to be efficient with higher bulb diameter (4.0 cm). Higher dose of oxyfluorfen (0.30 kg a.i.ha<sup>-1</sup>) was not efficient in achieving higher yields.

Saraf (2007) found that, the maximum height was recorded under oxyfluorfen (69.97 cm) in onion experimental field.

Hussain *et al.* (2008) conducted field experiment at NWFP Agricultural University, Peshawar, Pakistan to evaluate of different herbicides for weed control in onion during *rabi* season of 2004-05. The highest bulb yield (28100 kg ha<sup>-1</sup>) was recorded under pre-emergence application of pendimethalin @ 1.32 kg ha<sup>-1</sup>.

Kolseet *al.* (2010) noted that, among the herbicide treatments oxyfluorfen @ 0.25 kg ha<sup>-1</sup> recorded higher seed weight per umbel, test weight and seed yield in onion experimental field.

Ibrahim *et al.* (2011) found that, the use of oxyflorfen gave the highest numbers of bulb, bulbdiameter and onion yield and was significantly better thanhoe weeding.

Saini and Walia (2012) reported that,application of oxyflourfen gave the highest bulb yield, which was at par with pendimethalin and two hand weedings in onion experimental field.

Shinde *et al.* (2012) found that, the maximum yield (29.62 t ha<sup>-1</sup>) was recorded in the treatment oxyflourfen 23.5% EC (625 ml ha<sup>-1</sup>) at 15 days after transplantingin onion experimental field.

Tripathy *et al.* (2013) observed that, heaviest bulb, highest marketable and total bulb yield was recorded in treatment oxyfluorfen 23.5EC @ 2ml L<sup>-1</sup> before planting and one hand weeding at 40-60 DAT in onion experimental field.

Vishnu *et al.* (2014) conducted experiment in Junagadh and they found that combined application of oxyfluorfen @ 0.24 kg/ha as PE recorded lowest weed index and high bulb.

Borseet *al.* (2015) conducted field trial over three consecutive year of *rabi* season of the Khar Land Research Station, Raigad (Maharashtra). Lower dry weight of weeds during initial growth period recorded under oxyflurofen applied @ 0.176 kg ha<sup>-1</sup>. While higher weed control efficacy (88.49) and bulb yield of onion was found under oxyfluorfen applied @ 0.176 kg ha<sup>-1</sup> along with one hand weeding at 50 DATP followed by oxyflurofen applied @ 0.176 kg ha<sup>-1</sup> as alone.

Shingrupet *al.* (2015) conducted field investigation at Dr. PanjabraoDeshmukh Krishi Viddhyapeeth, Akola (Maharashtra) during *rabi* season of 2014 to study the efficacy of different herbicides against weed flora in onion. Among the different chemical treatments, post-emergence application of oxyfluorfen @ 0.200 kg ha<sup>-1</sup> recorded the lowest total weed population, weed dry weight and highest weed control efficacy and bulb yield of onion.

At Junagadh Agricultural University (Junagadh), conducted an experiment over three consecutive year of *rabi* season 2011-12, 2012-

13 and 2013-14 by Panara *et al.* (2015). They reported that lower dry weight of weed, weed index and higher weed control efficacy, plant height, bulb diameter, 100 cloves weight and bulb yield of garlic were achieved with application of oxyfluorfen applied @ 240 g ha<sup>-1</sup> fb one HW at 90 DATP

Sankar *et al.* (2015) conducted a field experiment at Directorate of Onion and Garlic Research, Rajgurunagar, Pune (Maharashtra during). They revealed that the application of oxyfluorfen 23.5% EC @ 1.5ml/L before planting shows effective treatment in weed control.

Sahoo *et al.* (2017) recorded that significantly higher number of leaves/plant was noted in Weed free (10.00), followed by Oxyfluorfen @ 1kg/ha (pre-emergence) + Quizalofop-ethyl @ 1 kg/ha (post-emergence) throughout the growing period.

Thakare *et al.* (2018) conducted research at Dr. Panjabrao Thakare Krishi Vidyapeeth, Akola during *rabi* 2015. They recorded that application of oxyfluorfen @ 0.200 kg/ha proved to be most effective weed control treatment over other chemical weed control method.

Siddhu *et al.*, (2018) conducted field research on weed management in garlic (*Allium sativum* L.) at All India Coordinated Research Project on Vegetable Crops, Department of Horticulture, Mahatma Phule Krishi Vidyapeeth, Rahuri. They reported that oxyfluorfen 0.150 kg/ha + quizalofop ethyl 0.05 kg/ha found effective in controlling weed and enhancing garlic production.

### **2.5.3 Quizalofop ethyl**

Quizalofop ethyl is systemic herbicide absorbed through leaves and translocated all over the plant through conducting tissue xylem, phloem and accumulating in meristematic tissue and act as an acetyl CoA carboxylase inhibitor (ACCase)

Yumnam *et al.* (2009) conducted research and concluded that application of quizalofop-ethyl 5% EC @ 2.5 ml per liter of water at 20 DAP along with one hand weeding at 40 days after transplanting was the best treatment in controlling weeds in the experimental plots of onion.

Tripathy *et al.* (2013) conducted field experiment at Sabalpur, Odisha and found that, maximum WCE was recorded in combined spray of pendimethalin 30EC @ 2.5ml per liter water and quizalofop ethyl 5EC @ 1.75 ml per liter water at the time of planting and at 30 DAT (75.41) in onion field.

Kalhapure *et al.* (2014) found that, combination of pre-planting application of pendimethalin 0.750 kg/ha with mixed use of oxyfluorfen 0.250 kg ha<sup>-1</sup> and quizalofop ethyl 0.050 kg ha<sup>-1</sup> as post-emergence recorded lower density of grassy and broad-leaved weeds, weed biomass and weed index and higher weed control efficiency.

Udit Kumar *et al.* (2014) noted that, minimum weed population and maximum WCE was recorded in the treatment with the application of oxyfluorfen 23.5EC @ 2 ml L<sup>-1</sup> before planting and quizalofop ethyl 5EC @ 3.5 ml L<sup>-1</sup> at 30 DAT (46.01) in the experimental plots of onion.

Rathod *et al.* (2014) during experimentation found that, among the different weed management treatments, significantly the lowest weed index (0.85%) and highest weed control efficiency (91.93%) were recorded when weeds control through pre emergence application of pendimethalin @ 0.9 kg ha<sup>-1</sup> + post emergence application of oxadiargyl @ 90 g ha<sup>-1</sup> at 60 DAT followed by pre emergence application of pendimethalin @ 0.9 kg ha<sup>-1</sup> + post emergence application of quizalofop-p-ethyl @ 40 g ha<sup>-1</sup> 60 DAT.

Sinaree *et al.* (2014) conducted field experiment at Ahmednagar, Maharashtra and found that, among the herbicidal treatments, application of quizalofop-ethyl 0.037 kg ha<sup>-1</sup> + oxyfluorfen 0.18 kg ha<sup>-1</sup> at 21 DAT (POE) followed by 1 HW at 45 DAT recorded significantly higher weed control efficiency (88.49%) and lower weed index (4.42%).

Dhananivetha *et al.* (2015) recorded that higher bulb yield was recorded under early post emergence application of quizalofop-ethyl under grass dominated field.

Sahoo *et al.* (2017) observed that treatment plot with application of quizalofop-ethyl @ 1kg/ha has better plant height and more no of leaves.

Reddy *et al.* (2018) conducted an experiment at Horticultural college and Research Institute, Dr. Y.S.R Horticultural University, Venkataramannagudem, Tadepalligudem, West Godavari District, A.P during *Rabi* season of 2011-12 and 2012-13. They reported that Application of pendimethalin and oxyflourfen supplemented with Quizalofop ethyl @ 75 g a.i / ha as post emergence found to be effective in managing weed and incresing production of bulb.

Dechen Angmoet *al.*(2018) carried out field experiment during *rabi* season of 2015-16 at Chatha, Jammu andreported thatpre emergence application of oxyfluorfen 0.15 kg /ha followed by post emergence quizalofop ethyl 0.05 kg/ha can be effectively used for weed control in onion under sub-tropical condition of Jammu.

Sahooand Tripathi (2019) conducted field experiment to compare different weed control methods in onion during *rabi* 2010-11 to 2011-12 and revealed that combined spray of pendimethalin 30% EC@2.5 ml l<sup>-1</sup> and quizalofop ethyl 5% EC1.75 ml l<sup>-1</sup> at the time of planting and at 30 DAT reduces the weed infestations with higher bulb production in onion.

#### **2.5.4 Pendimethalin + Oxyfluorfen**

Sheteet *al.*(2014) conducted a research at Rahuri and found that the pre-plant application of pendimethalin 0.750 kg/ha followed by post-emergence application of oxyfluorfen 0.250 kg/ha mixed with quizalofop-ethyl 0.050 kg/ha resulted in effective control of various broad-leaf and grassy-weeds and recorded lower weed density, weed biomass, weed index and higher weed control efficiency.

Sahoo *et al.* (2017) reported that application of oxyfluorfen 23.5% EC @2ml l<sup>-1</sup> before planting and one hand weeding at 40-60 DAT or combined spray ofpendimethalin 30% EC@2.5 ml l<sup>-1</sup> and quizalofop ethyl 5% EC1.75 ml l<sup>-1</sup> at the time of planting and at 30 DAT reduces the weed infestations with higher bulb yield in onion.

Gupta *et al.*(2019) carried out field experiment at the Krishi Vigyan Kendra, Dewas during *kharif* 2015-16, 2016-17 and 2017-18 and reported that application of pendimethalin @ 1.0 Kg/ha (PPI) + oxyfluorfen @ 0.250

Kg/ha (PoE) + one hand weeding at 40 DAT making it practically more convenient and economically viable weed management practice.

Kumari *et al.* (2019) conducted research at Agricultural Research Institute, Patna under Bihar Agricultural University, Sabour, Bhagalpur during two consecutive *rabi* Season 2016-17 and 2017-2018 and concluded that combined application of glyphosate, pendimethalin and oxyflurfen proves superior over other treatment.

Barla and Upasani (2019) conducted a research at Birsa Agriculture University, Zarkhand and reported that higher onion yield obtained by application oxyfluorfen 0.25 kg/ha PE, pendimethalin 1 kg/ha PE and hand weeding during 2016-17 gives higher net monetary return.

## **2.6 Effect of herbicide on soil micro flora**

Higher concentration of herbicide treatment resulted in much lower microbial counts compared to soils treated with recommended herbicide dose. Herbicide treatments also resulted in the elimination of some microbial species.

Araujo *et al.* (2003) revealed that herbicide showed no toxic effect on total bacterial population in the soil.

Barman (2008) found that micro-organisms are able to degrade some herbicide and utilize them as a source of biogenic element.

Pal *et al.* (2009) noted that all herbicides tested had no detrimental effect after 30 days of application though population in initial stage showed slightly decrease in fungi, actinomycetes and total bacteria.

Sebiomo *et al.* (2011) reported that, some microorganisms were able to degrade the herbicide, while some others were adversely affected depending on the application rates and the type of herbicide used.

Ghosh *et al.* (2012) noticed that, for all the cases of herbicidal treatments, total bacteria recovered from initial loss and exceeded the initial counts.

Bera and Ghosh (2013) reported that microorganisms are able to degrade herbicides and utilize them as a source of biogenic elements for their own physiological processes.

Nalini *et al.* (2013) observed that the counts of bacteria, fungus and actinomycetes recorded at 3 DAHS revealed that soil microbes were more sensitive to pendimethalin (38.7%) 1.5, 2.0, 2.5 and 4.0 kg ha<sup>-1</sup> and pendimethalin (30%) 1.0 kg ha<sup>-1</sup> as evident from significant reduction in their population on 15 and 30 DAHS, eventually microbial density started to recover slowly.

Adhikary *et al.* (2014) noticed that, the herbicide treatments significantly inhibited the development of microbial populations in the soil, and the degree of inhibition varied with the types of herbicide.

Trimurtulu *et al.* (2015) showed that increase in microbial populations by herbicides may be due to the direct action of herbicide molecule as the substrate for microbial growth or due to indirect effect of enhanced release of root exudates in the rhizosphere soil.

## **2.7 Integrated method of weed control**

Conventional method of weed control (hoeing and hand weeding) is laborious, expensive and some time causes damages to crop. On the other hand, use of herbicides alone does not prove effective for broad spectrum weed control because of their selectivity and environmental hazards with its continuous use. Hence, an attempt has been made to find out the appropriate combination of cultural and chemical weed management practices for weed control in onion which is practically effective and economically feasible for farmers. Weeds can also harbour destructive insects and diseases that can severely damage the crop.

Bhutia *et al.* (2005) reported that, integrated method was proved to be superior to other herbicidal treatments to increase bulb length, diameter, weight and yield in onion field.

Warade *et al.* (2006) conducted experiment at Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola (Maharashtra) studied the integrated weed management in onion and found that pendimethalin @ 0.5 kg ha<sup>-1</sup> fb

2 HW at 30 and 60 DAT and fluchloralin applied @ 1.0 kg ha<sup>-1</sup>fb 2 HW at 30 and 60 DAT recorded significantly lower weed density and dry matter of weeds at 80 DAT and at harvest and recorded significantly the highest bulb yield of onion during both the year of 2003 and 2004.

A field experiment was carried out at N. G. Ranga Agricultural University, Tirupati (Andhra Pradesh) during *rabi* season of year 2005-06 and 2006-07 to study the influence of graded levels of nutrients, time of N application and weed management practices on weed dynamics, yield attributes and bulb yield of onion. Chandrika *et al.* (2009) reported twice two hand weeding (20 and 40 DAT), pre-emergence application of oxyflurofen @ 0.24 kg ha<sup>-1</sup> with one HW at 40 DAT and pre-emergence pendimethalin @ 0.75 kg ha<sup>-1</sup> and one HW at 40 DAT were found at par for reducing the weed dry weight of monocot, dicot and total weeds. Further, maximum weed control efficiency, bulb diameter, bulb length and bulb yield of onion were observed under oxyflurofen @ 0.24 kg ha<sup>-1</sup> with one HW at 40 DAT.

Rajkumara and Palled (2009) conducted a field experiment during 2005 and 2006 at Water Management Research Centre, Belvatagi (Karnataka). The lower dry weight of weeds was recorded in twice hand weeding (20 and 30 DAS) followed by pre-emergence application of pendimethalin fb hand weeding at 30 DAS. The highest net return was observed under twice hand weedings (20 and 30 DAS) followed by preemergence application of pendimethalin fb hand weeding at 30 DAS.

Kathepuriet *al.* (2011a) conducted an experiment to study the effect of integrated weed management on economics of *rabi* onion (*Allium cepa* L.) during *rabi* 2002 at Mahatma Phule Krishi Vidhyapeeth, Rahuri (Maharashtra)observed that two HW at 20 and 40 DAT significantly superior for weed control followed by spraying of pendimethalin 30 EC @ 1kg a.i./ha.

A field experiment was conducted during *kharif* 2010-12 at Bidhan Chandra Krishi Viswavidyalaya, Mohanpur (West Bengal) by Bera and Ghosh (2013) to study the effect of integrated weed and nutrient management in green gram-rice-onion cropping sequence on yield and

nitrogen balance sheet. The maximum positive N balance reported in treatment combination of Quazalopop-ethyl @ 50 g ha<sup>-1</sup> at 30 DAS in green gram, petilachlor @ 500 g ha<sup>-1</sup> at 3 DATP in rice and oxyflurofen @ 100 g ha<sup>-1</sup> at 4 DAT in onion.

Sable *et al.*(2015) observed that effective weed control was attained under oxyfluorfen 0.26 kg a.i./ha with one HW (30 DAT) shows better control on weeds.

Sankar *et al.* (2015) conducted experiment at Directorate of Onion and Garlic Research, Rajgurunagar, Pune in clay loam soil using *rabi* onion cultivar N 2-4-1 was observed that among the various herbicides evaluated, application of Oxyflurofen 23.5 % EC @ 1.5ml/L before planting and one hand weeding at 40-60 days after onion seedlings transplanting recorded the higher marketable bulb yield with maximum weed control efficiency and highest B:C ratio.

Dhananivetha *et al.* (2017) concluded that onion has very poor weed competing ability due to its natural inherent character. So weed control with cultural, mechanical, chemical practices i.e. IWM found more profitable.

Gaharwaret *al.* (2017)carried out field experiment on integrated weed management during the *Rabi* season of 2015-16 at the farm of KVK, Yavatmal and reported that application of herbicide oxyflurfen 23.5% EC 0.1-0.15 Kg a.i./ha 15-20 DAT + 1HW @ 45 DAT is more practically convenient and economically feasible.

Reddy *et al.* (2018) conducted an experiment at Horticultural college and Research Institute, Dr. Y.S.R Horticultural University, Venkataramannagudem, Tadepalligudem, West Godavari District, A.P during *Rabi* season of 2011-12 and 2012-13. They reported that Application of pendimethalin and oxyflourfen supplemented with Quizalofopethyl @ 75 g a.i / ha as post emergence found to be effective in managing weed and incresing production of bulb.

## **2.8Economics of weed control:**

Mondal *et al.* (2005) reported that, the maximum net return was obtained when lower dose of oxyfluorfen ( $100 \text{ g ha}^{-1}$ ) was supplemented with one hand weeding at 25 DAT (Rs. 33650  $\text{ha}^{-1}$ ) in onion field.

Channappagoudar and Biradar (2007) reported that, the economic analysis of weed management practices indicated that pre emergent application of pendimethalin @  $1.0 \text{ kg a.i.ha}^{-1}$  supplemented with one hand weeding gave highest net return of Rs. 51, 296 with maximum B:C ratio of 8.77 in onion field.

Chopra and Chopra (2007) reported that, Maximum additional monetary returns (Rs 42,990 and 36,850  $\text{ha}^{-1}$ ) and net monetary returns (Rs 37,350 and 31,750  $\text{ha}^{-1}$ ) were recorded by oxyflurofen  $0.15 \text{ kg ha}^{-1}$  integrated with one hand-weeding at 35 DAT and oxyfluorfen  $0.30 \text{ kg ha}^{-1}$ , respectively in onion experimental field.

Field experiment conducted by Patel *et al.* (2011) at Navsari (Gujarat) during 2008-09 and 2009-10 and reported that maximum net profit of 2,69,422  $\text{ha}^{-1}$  was obtained with pendimethalin @  $1 \text{ kg ha}^{-1}$  along with one HW (40 DAT) with benefit :cost 7.85 followed by oxyflurofen  $0.24 \text{ kg ha}^{-1}$  pre-emergence along with one HW at 40 DAT (2,63,410  $\text{ha}^{-1}$ ) and weed free control (HW at 20, 40 and 60 DAT) 2,51,910.

Kathepuriet *al.* (2011<sup>b</sup>) conducted an experiment to study the effect of integrated weed management on economics of *rabi* onion (*Allium cepa* L.) during *rabi* 2002 at Mahatma Phule Krishi Vidhyapeeth, Rahuri (Maharashtra) and found that pre-plant application of pendimethalin @  $1 \text{ kg ha}^{-1}$  and one HW (40 DAT) recorded higher net profit (61,000  $\text{ha}^{-1}$ ), additional income over control (48,882  $\text{ha}^{-1}$ ) and cost benefit ratio 1:3.49 followed by oxyflurofen (PPI) along with one HW (40 DAT) in case of chemical and integrated methods of weed control.

A field experiment was conducted at Tamil Nadu Agricultural University, Coimbatore (Tamil Nadu) by Govindarajan *et al.* (2012) and reported that net return of 1,93,715 Rs/ha and 1,28,598 Rs/ha were registered under herbicidal treatment and manual weeded farm,

respectively. The cost of production 7.70 kg<sup>-1</sup> of manually weeded and 5.98 kg<sup>-1</sup> of onion in herbicide applied farms. They concluded that the average price gross return as well as net return was remunerative and higher to farms with herbicidal weed management than the manually weeded farms.

A field experiment conducted at Punjab Agricultural University, Ludhiana, (Punjab) during *rabi* 2006-07 and 2007-08 by Saini and Walia (2012) and reported that among the different weed control treatments, maximum net returns of 1,85,600 ha<sup>-1</sup> with BCR 7.63 was registered under oxyflurofen @ 0.225 kg ha<sup>-1</sup>. Unweeded control treatment recorded the lowest net return of 94,000 ha<sup>-1</sup>.

Kalhapure and Shete (2013) conducted a field trial at Rahuri during 2010 and 2011. They reported maximum benefit: cost ratio (2.76) was recorded under pendimethalin 1.0 kg ha<sup>-1</sup> (PP) along with oxyflurofen 0.250 kg ha<sup>-1</sup> (POE) and one HW at 40 DAS and this treatment economically feasible for control of weeds in onion.

Rathod *et al.* (2014) reported that, maximum net return of Rs. 50538 ha<sup>-1</sup> was occurred under pre emergence application of pendimethalin @ 0.90 kg ha<sup>-1</sup> + post emergence application of oxadiargyl @ 90 g ha<sup>-1</sup> at 60 DAT which was closely followed by pre-emergence application of pendimethalin @ 0.90 kg ha<sup>-1</sup> + post emergence application of quizalofop-p-ethyl @ 40 g ha<sup>-1</sup> at 60 DAT in onion.

Jangreet *et al.* (2014) Conducted field trial at Sant Kabir College of Agriculture and Research Station, Kawardha (Chhattisgarh) during *rabi* season of 2008-09. They revealed that pre-transplant application of oxyflurofen @ 0.20 kg ha<sup>-1</sup> along with one HW at 20 DAT recorded maximum net return and benefit: cost ratio followed by pendimethalin @ 1.25 kg ha<sup>-1</sup> pre-transplant + one HW at 20 DAT.

Sankar *et al.* (2015) conducted field trial at Directorate of Onion and Garlic Research, Pune (Maharashtra) and reported that maximum B:C ratio (3.06) was obtained under application of oxyflurofen before planting and HW at 40-60 DATP.

Minzet *et al.* (2018) conducted field experiment at Birsa Agricultural University, Kanke, Ranchi, during the year 2016-17 to study the effect of herbicides on growth, yield and quality of onion. They recorded that application of pendimethalin immediately after transplanting of onion recorded higher net returns (70.88%) and B: C ratio (68.94%).

Jangreet *et al.* (2019) conducted in order to identify the weed species in onion fields in Chhattisgarh plain. An experiment was conducted during *rabi* season (October-March) of 2008-2009 to find out the effect of weed management practices on growth and yield of onion, weed dynamics and economics. The findings revealed that hand weeding (H.W) twice at 20 and 40 DAT recorded the highest bulb yield, whereas, net return and cost: benefit ratio were highest under oxyfluorfen @ 0.20 kg ha<sup>-1</sup> pre transplanting + HW at 20 DAT followed by pendimethalin @ 1.25 kg ha<sup>-1</sup> Pre-transplanting + HW at 20 DAT.

## CHAPTER III

### MATERIAL AND METHODS

The present investigation was carried out at All India Cordinated Research Project Weed Management, Department of Agronomy, Dr.PDKV, Akola during *rabi* 2018-2019 forevaluating efficacy of pre and post emergence herbicide against weed flora in onion. The details of the materials used and methods adopted during the course of investigation are summarized in this chapter under appropriate headings.

#### 3.1 Details of the experimental material

##### 3.1.1 Experimental site

The field experiment was carried out in Field No.88/89 at the All India Cordinated Research Project Weed Management, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola during the *rabi* season of 2018-2019. It was one year study being conducted at the site. The topography of the field was fairly uniform and level. The soil was medium black cotton and clayey in texture with slightly alkaline in nature.

##### 3.1.2 Soil of the experimental field

In order to know the physico-chemical properties of the experimental soil, the composite soil samples to the depth of 0-30 cm were randomly collected from the experimental field before transplanting with the help of screw auger and composite sample was analyzed for physico-chemical properties. The results and methods adopted for analysis are presented in Table 1.

Perusal of data from Table 1 indicates that the soil of experimental plot was clayey in texture, low in organic carbon, slightly alkaline in reaction, low in available nitrogen and phosphorus and fairly high in available potassium.

**Table 1: Physico-chemical properties of experimental site**

| S. N. | Particulars                                                    | Composition | Analytical methods adopted                            |
|-------|----------------------------------------------------------------|-------------|-------------------------------------------------------|
| A)    | Mechanical composition                                         |             |                                                       |
| 1.    | Sand (%)                                                       | 28.61%      | Bouyoucoshydrometer method (Piper, 1966)              |
| 2.    | Silt (%)                                                       | 23.71 %     |                                                       |
| 3.    | Clay (%)                                                       | 47.68 %     |                                                       |
| 4.    | Texture                                                        | Clayey      |                                                       |
| B)    | Chemical composition                                           |             |                                                       |
| 1.    | Organic carbon (%)                                             | 0.41        | Walkley and Black’s rapid titration method (1934)     |
| 2.    | Soil pH                                                        | 7.7         | Glass electrode pH meter (Jackson, 1967)              |
| 3.    | Electrical conductivity (dSm <sup>-1</sup> )                   | 0.32        | Conductivity meter (Jackson, 1967)                    |
| 4.    | Available Nitrogen (kg ha <sup>-1</sup> )                      | 197.21      | Alkalinepermanganate method (Subbiah and Asija, 1956) |
| 5.    | Available P <sub>2</sub> O <sub>5</sub> (kg ha <sup>-1</sup> ) | 18.76       | Olsen’s method (Olsen and Sommers, 1982)              |
| 6.    | Available K <sub>2</sub> O (kg ha <sup>-1</sup> )              | 366.49      | Flamephotometer (Jackson, 1967)                       |

### 3.1.3 Cropping history of experimental plot

The cropping history of the experimental plot for last four years is presented in Table 2. It revealed that the experimental plot was fairly leveled and residual effect of previous crop was practically uniform.

**Table2. Cropping history of experimental plot for last four years**

| Year      | Season        |                       |        |
|-----------|---------------|-----------------------|--------|
|           | <i>Kharif</i> | <i>Rabi</i>           | Summer |
| 2015-2016 | Greengram     | Chickpea              | --     |
| 2016-2017 | Maize         | Wheat                 | --     |
| 2017-2018 | Soyabean      | Onion                 | --     |
| 2018-2019 | Maize         | Present investigation | --     |

**3.1.4Climate and weather condition:**

Akola is situated at 307.41 meters above the mean sea level at 22° 42' North latitude and 77° 02' East longitude and lies in subtropical continental climate. The climate of Akola is characterized by a hot summer and general dryness throughout the year except during South-West monsoon (1<sup>st</sup> June to 15<sup>th</sup> Sept.). Maximum rainfall (80 per cent) is received during June to September i.e. in monsoon season; however 20 per cent rainfall received during post monsoon season. Akola receives an annual mean precipitation of 802 mm in about 46 rainy days and grouped under assured rainfall zone. During monsoon season, July is the wet month with 253.1 mm average monthly rainfall. The mean maximum temperature varies from 29.0 °C to about 44.3°C in May, whereas, the mean minimum temperature varies from 9.40°C during winter to 27.6 °C in summer. The relative humidity ranges from 30.75% and 61.62% in summer and rainy season respectively. The data collected on rainfall, number of rainy days, temperature, relative humidity, sunshine hours and evaporation at Meteorological Observatory, Dr.Panjabrao Deshmukh Krishi Vidyapeeth, Akola during the period of experimentation (2018-2019) along with the last 30 years normal's of weather parameter are presented in Table 3 and depicted in Fig. 1.

**Table 3: Weekly Weather data for the year 2018 recorded at Meteorological  
Observatory Department of Agronomy Dr. PDKV., Akola**

| Weeks | Dates     | Actual     |      |            |      | 2018      |     |            |     |          |    |           |    | Normal    |      |         |      | 1971-2000 |            |     |
|-------|-----------|------------|------|------------|------|-----------|-----|------------|-----|----------|----|-----------|----|-----------|------|---------|------|-----------|------------|-----|
|       |           | T MAX (oC) |      | T MIN (oC) |      | BSH (hrs) |     | WS (km/hr) |     | RH I (%) |    | RH II (%) |    | Evap (mm) |      | RF (mm) |      | CRF (mm)  | Rainy Days |     |
|       |           | N          | A    | N          | A    | N         | A   | N          | A   | N        | A  | N         | A  | N         | A    | N       | A    |           | N          | A   |
| 47    | 19-25 Nov | 31.0       | 32.8 | 13.1       | 17.2 | 8.6       | 7.8 | 4.4        | 0.6 | 71       | 78 | 30        | 34 | 4.6       | 4.8  | 10.1    | 4.5  | 839.5     | 0.3        | 1.0 |
| 48    | 26-2 Dec  | 30.3       | 31.0 | 12.4       | 12.3 | 8.8       | 8.0 | 4.6        | 0.5 | 71       | 74 | 31        | 27 | 4.3       | 4.4  | 6.8     | 0.0  | 839.5     | 0.3        | 0.0 |
| 49    | 3-9       | 29.8       | 29.8 | 11.2       | 15.9 | 8.7       | 5.2 | 4.7        | 1.0 | 70       | 76 | 29        | 41 | 4.3       | 4.0  | 1.3     | 0.0  | 839.5     | 0.2        | 0.0 |
| 50    | 10-16     | 29.4       | 29.0 | 10.3       | 12.3 | 8.8       | 6.6 | 4.5        | 1.1 | 70       | 83 | 27        | 31 | 4.2       | 4.1  | 1.3     | 0.0  | 839.5     | 0.2        | 0.0 |
| 51    | 17-23     | 29.5       | 26.5 | 10.6       | 10.2 | 8.7       | 7.5 | 4.7        | 1.1 | 69       | 74 | 29        | 34 | 4.3       | 4.2  | 0.9     | 0.0  | 839.5     | 0.1        | 0.0 |
| 52    | 24-31     | 29.2       | 27.5 | 10.7       | 9.6  | 8.6       | 8.4 | 4.8        | 1.5 | 70       | 59 | 31        | 23 | 4.3       | 5.0  | 2.6     | 0.0  | 839.5     | 0.2        | 0.0 |
| 1     | 1-7 Jan   | 29.0       | 29.8 | 10.3       | 9.4  | 8.7       | 8.4 | 4.9        | 0.7 | 78       | 68 | 30        | 22 | 4.2       | 4.0  | 1.7     | 0.0  | 0.0       | 0.2        | 0.0 |
| 2     | 8-14      | 29.2       | 28.1 | 11.3       | 10.0 | 8.6       | 7.8 | 6.3        | 1.2 | 71       | 72 | 30        | 30 | 4.5       | 5.4  | 3.4     | 0.0  | 0.0       | 0.2        | 0.0 |
| 3     | 15-21     | 29.9       | 29.4 | 11.6       | 10.4 | 8.9       | 7.6 | 5.4        | 1.2 | 69       | 66 | 28        | 24 | 4.8       | 5.2  | 0.9     | 0.0  | 0.0       | 0.1        | 0.0 |
| 4     | 22-28     | 30.8       | 28.1 | 11.8       | 14.0 | 9.1       | 6.1 | 5.5        | 1.7 | 67       | 75 | 27        | 36 | 5.2       | 5.0  | 1.1     | 0.0  | 0.0       | 0.2        | 0.0 |
| 5     | 29-4 Feb  | 31.1       | 28.1 | 12.1       | 10.7 | 9.3       | 7.9 | 5.8        | 1.5 | 61       | 61 | 25        | 22 | 5.6       | 5.3  | 2.8     | 0.0  | 0.0       | 0.2        | 0.0 |
| 6     | 5-11      | 31.3       | 29.6 | 11.9       | 13.3 | 9.1       | 8.2 | 5.6        | 3.6 | 59       | 49 | 23        | 20 | 5.9       | 6.3  | 4.9     | 0.0  | 0.0       | 0.4        | 0.0 |
| 7     | 12-18     | 32.5       | 32.2 | 13.4       | 15.9 | 9.4       | 7.9 | 6.1        | 2.3 | 56       | 54 | 22        | 24 | 6.6       | 5.9  | 0.1     | 0.0  | 0.0       | 0.0        | 0.0 |
| 8     | 19-25     | 33.0       | 35.5 | 13.8       | 18.6 | 9.5       | 8.6 | 6.5        | 2.4 | 57       | 55 | 22        | 21 | 7.3       | 6.1  | 3.3     | 1.9  | 1.9       | 0.5        | 0.0 |
| 9     | 26-4 Mar  | 34.7       | 33.2 | 14.8       | 17.7 | 9.6       | 8.9 | 7.0        | 4.0 | 50       | 47 | 17        | 23 | 8.1       | 7.8  | 3.4     | 0.0  | 1.9       | 0.3        | 0.0 |
| 10    | 5-11      | 36.1       | 33.7 | 16.7       | 16.2 | 9.6       | 9.1 | 6.8        | 3.2 | 44       | 48 | 18        | 21 | 9.0       | 7.5  | 2.1     | 0.0  | 1.9       | 0.3        | 0.0 |
| 11    | 12-18     | 37.3       | 36.8 | 17.5       | 16.9 | 9.6       | 8.5 | 6.9        | 3.1 | 42       | 43 | 17        | 21 | 9.5       | 8.1  | 2.5     | 0.0  | 1.9       | 0.3        | 0.0 |
| 12    | 19-25     | 38.5       | 37.9 | 18.3       | 15.9 | 9.6       | 8.9 | 6.9        | 2.2 | 37       | 47 | 13        | 18 | 10.5      | 8.4  | 0.3     | 0.0  | 1.9       | 0.1        | 0.0 |
| 13    | 26-1 Apr  | 39.0       | 41.2 | 19.7       | 18.9 | 9.6       | 9.1 | 7.6        | 3.1 | 36       | 34 | 15        | 15 | 11.3      | 9.6  | 2.9     | 0.0  | 1.9       | 0.3        | 0.0 |
| 14    | 2-8 Apr   | 40.1       | 42.1 | 21.1       | 21.3 | 9.8       | 8.9 | 7.9        | 4.4 | 36       | 39 | 15        | 20 | 11.7      | 10.0 | 0.6     | 0.0  | 1.9       | 0.1        | 0.0 |
| 15    | 9-15      | 40.8       | 43.1 | 22.5       | 23.3 | 9.9       | 9.4 | 9.3        | 4.6 | 34       | 43 | 12        | 24 | 13.4      | 10.8 | 0.3     | 0.0  | 1.9       | 0.1        | 0.0 |
| 16    | 16-22     | 41.7       | 38.4 | 23.5       | 19.7 | 10.2      | 7.3 | 9.1        | 2.5 | 34       | 53 | 14        | 31 | 13.7      | 8.6  | 0.3     | 13.5 | 15.4      | 0.0        | 1.0 |
| 17    | 23-29     | 42.1       | 44.3 | 24.8       | 24.0 | 10.1      | 9.6 | 10.2       | 3.3 | 37       | 32 | 14        | 15 | 14.4      | 11.4 | 0.0     | 0.0  | 15.4      | 0.1        | 0.0 |
| 18    | 30- 6 May | 42.7       | 42.7 | 26.0       | 25.5 | 9.9       | 8.8 | 11.4       | 9.9 | 38       | 42 | 14        | 23 | 15.4      | 13.9 | 0.3     | 0.0  | 15.4      | 0.2        | 0.0 |
| 19    | 7-13      | 42.6       | 42.0 | 26.5       | 25.6 | 10.1      | 9.5 | 12.7       | 7.9 | 43       | 43 | 17        | 22 | 16.4      | 15.4 | 0.3     | 0.0  | 15.4      | 0.1        | 0.0 |

### 3.5Experimental details

#### 3.5.1Experimental design and treatments details

The present experiment comprised of nine treatments having three and one combined formulation of different herbicide in different concentration which were tested in randomized block design in three replications. The treatment details along with the symbols used are presented in Table 4 and plan of layout is shown in Fig. 2.

The details of different treatments with their symbol used are given in Table 4.

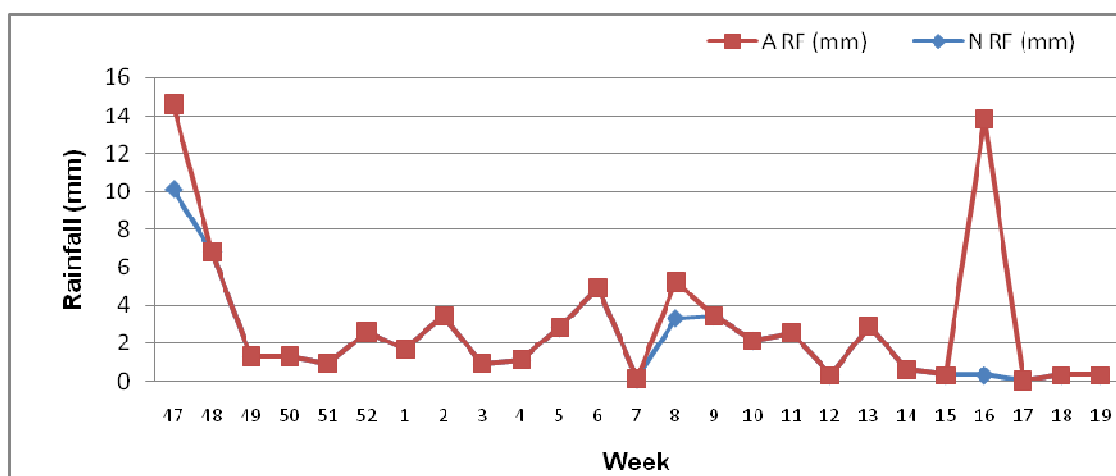
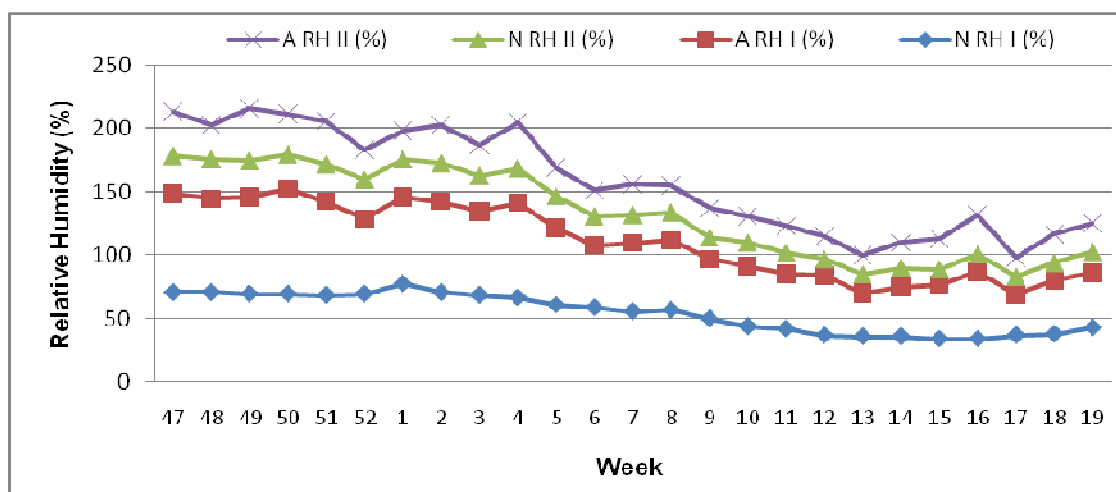
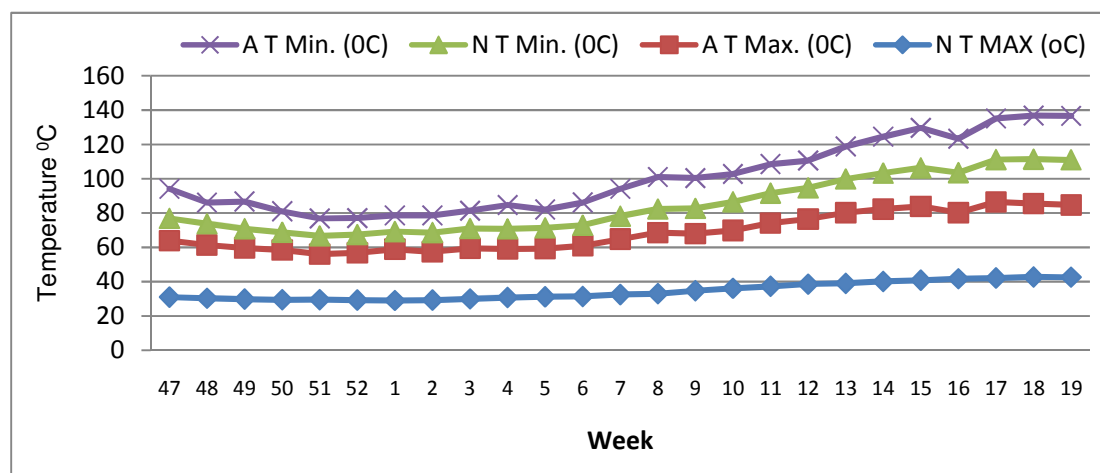


**Fig. 1** Weekly weather data for the year 2018 recorded at Meteorological Observatory, Department of Agronomy, Dr.PDKV, Akola

**Table 4: The details of different treatments**

| Abbreviation   | Treatment                                                       | Time of Application |
|----------------|-----------------------------------------------------------------|---------------------|
| T <sub>1</sub> | Pendimethalin 24% + Oxyfluorfen 4% ZE @480+82 g a.i./ha         | PE                  |
| T <sub>2</sub> | Pendimethalin 24% + Oxyfluorfen 4% ZE @541.80+92.56 g a.i./ha   | PE                  |
| T <sub>3</sub> | Pendimethalin 24% + Oxyfluorfen 4% ZE @600+102.5 g a.i./ha      | PE                  |
| T <sub>4</sub> | Pendimethalin 24% + Oxyfluorfen 4% ZE @1083.60+185.12 g a.i./ha | PE                  |
| T <sub>5</sub> | Pendimethalin 38.7% CS@ 677.25 g a.i./ha                        | PE                  |
| T <sub>6</sub> | Oxyfluorfen 23.5% EC@ 200 g a.i./ha                             | PE                  |
| T <sub>7</sub> | Quizalofop ethyl 5% EC@ 50 g a.i./ha                            | PoE                 |
| T <sub>8</sub> | Two HW (25 & 45 DAT)                                            | -                   |
| T <sub>9</sub> | WeedyCheck                                                      | -                   |

PE : Pre- emergence,                      PoE : Post emergence,  
 DAT : Days after transplanting,      HW : Hand weeding.

### 3.5.2 Experimental details

The details of the experimental layout are as follows.

1. Design : Randomized Block Design
2. Treatments : 9
3. Replication : 3
4. Total plots : 27
5. Plot size : a) Gross plot: 6.5 m x 5.0 m  
b) Net plot : 6.1 m x 4.6 m
6. Area of the net plot : 28.06 m<sup>2</sup>
7. Distance between two replications : 1.5 m
8. Distance between two plots : 0.5 m

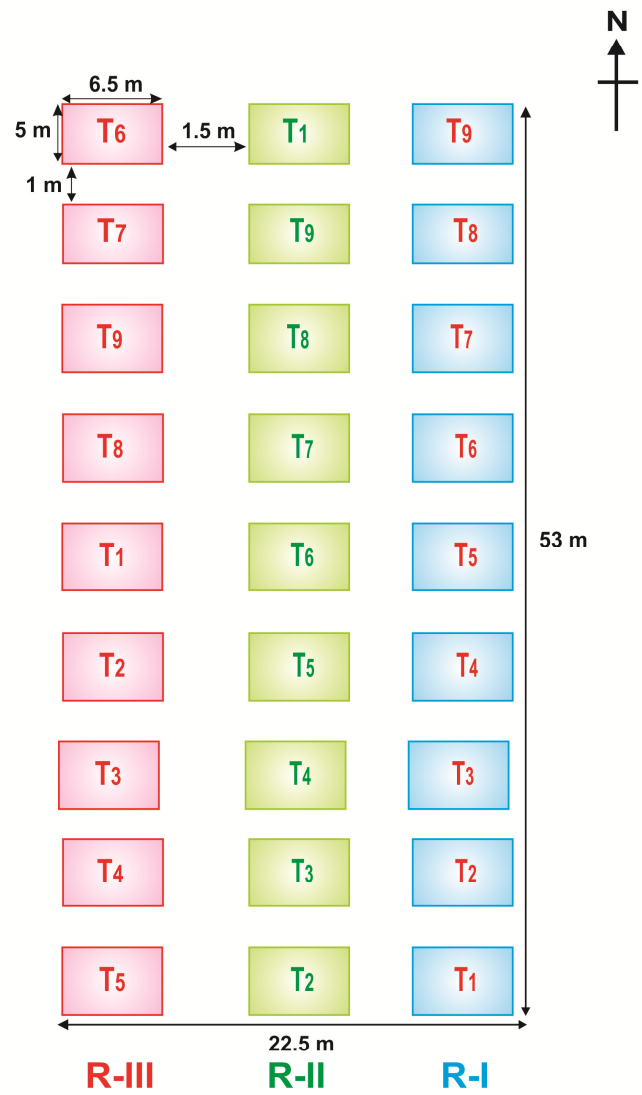


Fig. 2. Plan of layout



Plate 1 Aerial view experimental field



**Plate 2a Spraying of herbicide in the experimental field plot**



**Plate 2b General view of experimental field plot**

## Crop details

### Onion (*Allium cepa*)

- |                                     |   |                                       |
|-------------------------------------|---|---------------------------------------|
| a. Variety                          | : | Akola Safed                           |
| b. No. of plants plot <sup>-1</sup> | : | 1403 (net plot)                       |
| c. Spacing                          | : | 20 x 10 cm                            |
| d. Seed Rate                        | : | 8-10 kg ha <sup>-1</sup>              |
| e. Date of transplanting            | : | Rabi 2018 - 14 <sup>th</sup> December |
| f. Recommended Dose                 | : | 100:50:50 NPK kg ha <sup>-1</sup>     |
| g. Date of harvesting               | : | 9 <sup>th</sup> April 2019            |

### 3.5.3 Seed material

The onion seed of variety Akola Safed developed by Dr. Panjabrao Deshmukh Krishi Vidyapith, Akola was used which was obtained from MSSC Ltd. Akola. The seeds were sown in lines at 10 cm apart on well prepared raised beds in the nursery. Recommended plant protection measures were followed while raising the nursery for the control of common insect pests and diseases.

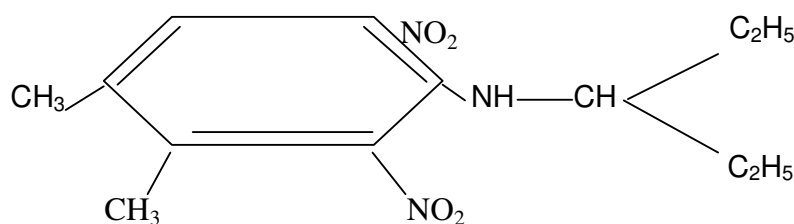
## 3.6 Application of herbicide

Chemical formulations of herbicides used in experiment are given below.

### 3.6.1 Pendimethalin

- |               |   |                                                           |
|---------------|---|-----------------------------------------------------------|
| Common name   | : | Pendimethalin                                             |
| Trade name    | : | Stomp / Prowl / Pendalin / Tata panida                    |
| Origin        | : | American Cyanamid Co. U.S.A.                              |
| Chemical name | : | N- (1-ethylpropyl)-3, 4-dimethyl-2, 6-dinitrobenzenamine. |

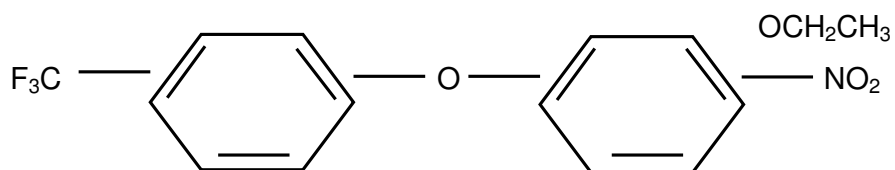
### Structural formula



|                           |                                                                                                                                 |
|---------------------------|---------------------------------------------------------------------------------------------------------------------------------|
| Herbicide group           | : Dinitro anilines                                                                                                              |
| Type of herbicide         | : Selective                                                                                                                     |
| General dosage            | : 0.50-2.0 kg ha <sup>-1</sup> depending on soil texture, organic matter, light sandy soil requires lower rates than heavy soil |
| Application               | : Per-plant incorporation, pre-emergence, early- post emergence                                                                 |
| Uptake and mode of action | : As the pre-emergence weed control by inhibiting seed germination and seedling development Properties                          |
| Solubility                | : Solubility 3 ppm in water at 20 °C                                                                                            |
| Molecular wt.             | : 268                                                                                                                           |
| Melting point             | : 56-57°C                                                                                                                       |
| Corrosiveness             | : Non-corrosive                                                                                                                 |
| Stability                 | : Stable to alkaline and acidic condition                                                                                       |
| LD <sub>50</sub>          | : Acute oral; rat 2930 Dermal; rabbit 6870                                                                                      |

### 3.6.2 Oxyfluorfen

|                    |                                                                    |
|--------------------|--------------------------------------------------------------------|
| Common Name        | : Oxyfluorfen                                                      |
| Trade Name         | : Goal                                                             |
| Origin             | : Rohm and Haas                                                    |
| Chemical Name      | : 2-Chloro-1-(3-ethoxy-4-(4-(trifluoromethyl) benzene              |
| Group of herbicide | : Diphenyl ether                                                   |
| Type of herbicide  | : Selective contact                                                |
| General dose       | : 0.1 – 0.5 kg ha <sup>-1</sup>                                    |
| Application        | : Pre-and post emergence                                           |
| Molecular formula  | : C <sub>15</sub> H <sub>11</sub> ClF <sub>3</sub> NO <sub>4</sub> |
| Molecular weight   | : 361.7                                                            |
| Structural formula | :                                                                  |



Mode of action : Selective contact herbicide absorbed more readily by the foliage than by the roots with very little translocation. Light is required for herbicidal activity.

### Properties

Colour : Orange

Vapour pressure : 0.026 m Pa at 25°C

Solubility : In water and readily soluble in most organic solvents

Melting point : 85 – 90°C

### Important weed's controlled

*Ageratum conyzoides*, *Amaranthus spinosus*, *Chloris barbata* and *Croton hirtus* (Tomik, 1994).

### 3.6.3 Quizalofop-ethyl (Rao 2000)

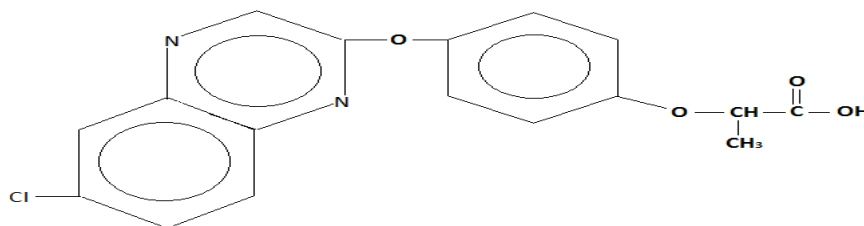
Common name : Quizalofop-ethyl

Trade name : Targa super

Origin : Dhanuka Pesticides Ltd. In technical collaboration with M/ S Nissan Chemical Industries Ltd. Tokyo, Japan

Chemical name : (R)-2{4-(6-chloro-2-quinoxalinyloxy)phenoxy} Propanoic acid

### Structural formula :



|                        |                                                                                                                                                                                                                        |
|------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Herbicide group        | : Aryloxyphenoxypropionates                                                                                                                                                                                            |
| Type of herbicide      | : Selective                                                                                                                                                                                                            |
| General dosage         | : Annual grass weeds: 75-100 g ha <sup>-1</sup>                                                                                                                                                                        |
| Application            | : Perennial grassy weeds: 35-80g ha <sup>-1</sup> , recommended @ 50g ha <sup>-1</sup> Post emergence at 3-6 leaf stage of annual grassy and at 10-15 cm height of perennial weeds                                     |
| Mode of action         | : It is quickly absorbed by foliage after spraying translocate through xylem and phloem in the plant. It is accumulated in nodes and underground rhizomes and top killing activity                                     |
| Solubility             | : 0.4 mg/l of water at 20 <sup>0</sup> C, 650 g/l in acetone, 22 g/l in ethanol, 5 g/l hexane. 360 g/l in Xylene at 20 <sup>0</sup> C                                                                                  |
| Melting point          | : 76-77 <sup>0</sup> C                                                                                                                                                                                                 |
| LD 50                  | : Acute oral, rat 2551(male) 2778 (female) mg kg <sup>-1</sup> body weight. Acute dermal, rat > 2000 mg kg <sup>-1</sup> body weight.                                                                                  |
| Residue Information    | : The compound is rapidly broken down in the soil and half of initial amount of compound does not leach from the soil.                                                                                                 |
| Important weed control | : Annual and perennial grassy weeds Found in a major broad leaf crops. Various weed controlled effectively by Targa super 5% EC are Barnyard grass, large crab grass, Johnson grass oat, Bermuda grass, and wild grass |
| Ecofriendliness        | : It is less toxic and safe to mammals, bird etc. at recommended doses. It is compatible with many herbicide and fungicides.                                                                                           |
| Formulation            | : 5 % EC                                                                                                                                                                                                               |

### **3.7 Raising of seedlings**

The soil of the nursery beds was brought to the fine tilth. While preparing the land, well rotten and dried FYM @ 20 t ha<sup>-1</sup> was mixed thoroughly and raised beds of 2 m x 1 m size with 15 cm height were prepared. The seeds were sown on raised beds in the rows spaced at 10 cm apart on 25<sup>th</sup> October, 2018. The seed was covered with thin layer of fine soil and FYM. The seed beds were irrigated by water can till the good germination took place. On every seed bed, 60 g nitrogen in the form of Urea was applied at 30 days after sowing. Irrigations were given at an interval of 3 – 4 days in first fortnight and thereafter at one week interval. The nursery beds were hand weeded once.

### **3.8 Herbicide application**

The herbicide pendimethalin, oxyfluorfen, premixed formulated combination of pendimethalin and oxyfluorfen are pre-emergence and hence applied one day after transplanting of seedlings in the moist soil. Quizalofop ethyl is post emergence herbicide and applied at 2-4 leaf stage.

The quantity of herbicide per plot area (6.5 m x 5m) was calculated and dissolved in 500 ml of water and spread over an area of 32.5 m<sup>2</sup> according to different treatments by using Knapsack sprayer with flat fan nozzle.

### **3.9 Transplanting of onion**

Seven to eight weeks old seedlings with uniform growth were transplanted in the main field on raised bed by adopting the row spacing of 20 x 10 cm on 14<sup>th</sup> December. The uprooted seedlings were cut 1/3 from top portion and were dipped in the solution of Bavistin before transplanting. The transplanted seedlings were pressed firmly and then plots were irrigated immediately.

### **3.10 Fertilizer application**

The recommended dose of fertilizer (100:50:50) was applied in the experimental field plot. Half of the nitrogen and full dose of phosphorus and potash were applied as basal application at the time of

transplanting. Remaining half dose of nitrogen was top-dressed at 30 days after transplanting as per the treatments. The sources of nutrients were urea (46% N), single super phosphate (16% P<sub>2</sub>O<sub>5</sub>) and murate of potash (60% K<sub>2</sub>O) for nitrogen, phosphorus and potash, respectively.

### 3.11 Irrigation

First irrigation was given one day prior of transplanting seedlings. After transplanting of seedlings, immediately irrigation was given to the crop. The details regarding irrigations given to the crop are furnished in Table 5.

### 3.12 Field operation

The details of field operations carried out during the crop growth period are presented in Table 5.

**Table 5: Details of field operations**

| Sr. No.    | Particulars                       | Date of operation |
|------------|-----------------------------------|-------------------|
| <b>I]</b>  | <b>Nursery management</b>         |                   |
| 1          | Ploughing                         | 10/10/2018        |
| 2          | Harrowing                         | 15/10/2018        |
| 3          | Seed bed preparation              | 22/10/2018        |
| 4          | Sowing of seeds                   | 25/10/2018        |
| 5          | Irrigation                        | 29/10/2018        |
|            |                                   | 2/11/2018         |
|            |                                   | 10/11/2018        |
|            |                                   | 25/11/2018        |
|            |                                   | 10/12/2018        |
| 6          | Weeding                           | 18/11/2018        |
| <b>II]</b> | <b>Crop management</b>            |                   |
| <b>A</b>   | <b>Preparatory tillage</b>        |                   |
| 1          | Ploughing (by tractor)            | 20/11/2018        |
| 2          | Harrow (blade harrow)             | 29/11/2018        |
| 3          | Stubble picking                   | 30/11/2018        |
| 4          | Leveling                          | 07/12/2018        |
| 5          | Layout of experimental plot       | 10/12/2018        |
| <b>B</b>   | <b>Transplanting of seedlings</b> | 14/12/2018        |
| <b>C</b>   | <b>Fertilizer application</b>     |                   |
| 1          | Basal application                 | 15/12/2018        |
| 2          | Top dressing                      | 14/01/2019        |

|          |                                                                |                                                                                                                                          |
|----------|----------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------|
| <b>D</b> | <b>Weed control</b>                                            |                                                                                                                                          |
| 1        | PE Pendimethalin, Pendimethalin + Oxyfluorfen, Oxyfluorfen     | 15/12/2018                                                                                                                               |
| 2        | Post-emergence application of herbicide viz., Quizalofop ethyl | 4/1/2019                                                                                                                                 |
| <b>E</b> | Irrigations                                                    | 14/12/2018<br>18/12/2018<br>24/12/2018<br>07/01/2019<br>19/01/2019<br>31/01/2019<br>12/02/2019<br>26/02/2019<br>07/03/2019<br>16/03/2019 |
| <b>F</b> | Harvesting                                                     | 9/04/2019                                                                                                                                |

### 3.13 Harvesting and curing

The crop of onion was harvested after maturity in all the treatments plots. The maturity of the crop was judged by the 50 per cent of the leaf showing yellowing and senescence of leaves and neck fall. The five observation plants were uprooted and net plot was harvested and weighed separately for each treatment. The weight of onion bulbs from the net plot was taken treatment wise as the final yield. The curing of onion was done for the removal of outer skin and neck of onion which helps in reducing the infestation of diseases.

### 3.14 Biometric observations

Various biometric observations were recorded on five randomly selected plants of onion from each net plot. *Bamboo* pegs were fixed near the observational plants for easy location and for identification label was attached to each plant. All the growth observations were recorded at an interval of 20 days commencing from the date of transplanting till 80 days and at the harvesting stage of the crop.

**Table 6: Details of biometric observations**

| Sr.No.                      | Particulars                                        | Frequency | Days after transplanting                         |
|-----------------------------|----------------------------------------------------|-----------|--------------------------------------------------|
| <b>A) Weed studies</b>      |                                                    |           |                                                  |
| 1.                          | Weed count ( $\text{m}^{-2}$ ) (monocot and dicot) | 5         | 20,40,60,80 and at harvest                       |
| 2.                          | Weed dry matter ( $\text{g m}^{-2}$ )              | 5         | 20,40,60,80 and at harvest                       |
| 3.                          | Phytotoxicity rating on crop                       | 1         | 10 days after herbicide spray.                   |
| <b>B) Crop studies</b>      |                                                    |           |                                                  |
| <b>i. Plant studies</b>     |                                                    |           |                                                  |
| 1.                          | Initial plant stand                                | 1         | 20 DAT                                           |
| 2.                          | Final plant stand                                  | 1         | At harvest                                       |
| <b>ii. Growth studies</b>   |                                                    |           |                                                  |
| 1.                          | Plant height (cm)                                  | 5         | 20,40,60,80 and at harvest                       |
| 2.                          | No of leaves plant <sup>-1</sup>                   | 5         | 20,40,60,80 and at harvest                       |
| 3.                          | Fresh bulb wt.(g)                                  | 5         | 20,40 60, 80 and at harvest                      |
| 4.                          | Fresh leaves wt.(g)                                | 5         | 20,40 60, 80 and at harvest                      |
| 5.                          | Dry matter of plant (g)                            | 5         | 20,40,60,80 and at harvest                       |
| <b>C) Yield studies</b>     |                                                    |           |                                                  |
| 1.                          | Polar diameter of bulb (mm)                        | 1         | At harvest                                       |
| 2.                          | Equatorial diameter of bulb (mm)                   | 1         | At harvest                                       |
| 3.                          | Yield of onion/plot (kg)                           | 1         | After harvest                                    |
| 4.                          | Yield of onion/ha.(q ha <sup>-1</sup> )            | 1         | After harvest                                    |
| 5.                          | Dry wt. of bulb (g)                                | 1         | After harvest                                    |
| <b>D) Microbial studies</b> |                                                    | 3         | Before transplanting, after spray, after harvest |
| <b>E) Chemical studies</b>  |                                                    |           |                                                  |
| 1.                          | Soil analysis (NPK)                                | 1         | Before transplanting                             |
| 2.                          | NPK uptake by crop ( $\text{kg ha}^{-1}$ )         | 1         | At harvest                                       |
| 3.                          | NPK uptake by weed ( $\text{kg ha}^{-1}$ )         | 1         | At harvest                                       |
| <b>F) Economic studies</b>  |                                                    |           |                                                  |
| 1                           | Gross monetary returns (Rs. ha <sup>-1</sup> )     | 1         | After harvest                                    |
| 2                           | Net monetary returns(Rs.ha <sup>-1</sup> )         | 1         | After harvest                                    |
| 3                           | Benefit : cost ratio                               | 1         | After harvest                                    |

### **3.14.1 Weed study**

#### **3.14.1.1 Identification of weed flora**

In treatment plots of each replication at every 20 days interval, with visual observations, the growing weed species were observed, identified and noted accordingly.

#### **3.14.1.2 Weed count**

In each experimental plot, an area of 0.5 m<sup>2</sup> was selected in the middle of the plot and a quadrat was fixed. The specieswise weeds from each quadrat were counted at an interval of 20 days till 80 days and at the harvesting stage from transplanting and were also classified as monocot and dicot weeds. The weed population was recorded accordingly under monocot and dicot groups. The weed count per square metre was worked out and recorded accordingly.

#### **3.14.1.3 Dry weight of weed (g/m<sup>2</sup>)**

Inside each experimental plot, a quadrat of 0.5 m x 0.5 m was placed randomly. The weeds in the quadrat were removed from each plot at 20, 40, 60, 80 DAT and at the harvesting stage. The weed samples were first sun dried and then oven dried at 60°C for 8 -10 days. After 6 days of oven drying, daily the samples were weighed till they record the constant weight. Then, the value of dry weight of weed was recorded treatment wise accordingly in gram. These weights were converted to dry weight per square meter.

#### **3.14.1.4 Weed Control Efficiency**

The weed control efficiency was calculated by using the following formula. (Gautam *et al.* 1975)

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

Where,

WCE = Weed control efficiency in percent

DWC = Dry matter weight of weed in control plot (gm).

DWT = Dry matter weight of weed in treated plot (gm).

### 3.14.1.5 Weed Index

According to Gill and Vijay Kumar (1966) weed index may be defined as the decrease in yield due to different treatments in comparison with recommended cultivation practices or the treatment which has the highest yield. It was computed by the formula given below.

$$\text{Weed Index (WI)} = \frac{X - Y}{X} \times 100$$

Where,

X = yield of bulb ( $\text{q ha}^{-1}$ ) in treatment which has highest yield.

Y = yield of bulb ( $\text{q ha}^{-1}$ ) in treatment for which weed index is to be calculated, it is expressed in percentage.

### 3.14.1.6 Phytotoxicity of herbicide

It was noted according to 0-10 scale method (Rao 1983).

**Table 7. Crop Phytotoxicity visual score rating scale (0 to10)**

| Effect   | Scale | Description of crop                        | Pytotoxicity |
|----------|-------|--------------------------------------------|--------------|
| None     | 0     | No injury, normal                          | 0%           |
| Slight   | 1     | Slight stunting, injury discoloration      | 1-10%        |
|          | 2     | Some stand loss, stunting or discoloration | 11-20%       |
|          | 3     | Injury more pronounce but not persistent   | 21-30%       |
| Moderate | 4     | Moderate injury, recovery possible         | 31-40%       |
|          | 5     | Injury more persistent, recovery doubtful  | 41-50%       |
|          | 6     | Near severe injury, no recovery possible   | 51-60%       |
| Severe   | 7     | Severe injury, stand loss surviving        | 61-70%       |
|          | 8     | Almost destroyed, a few plants surviving   | 71-80%       |
|          | 9     | Very few plants alive                      | 81-90%       |
| Complete | 10    | Complete destruction                       | 91-100%      |

### **3.14.2 Crop growth studies (Collection of data)**

#### **3.14.2.1 Initial plant population**

Twenty days later of transplanting, the plant population in each treatment plot was actually counted and compared with per plot plant population required in net plot after complete emergence. The surviving plant population was recorded as an initial plant population after transplanting.

#### **3.14.2.2 Height of onion plant (cm)**

The height of onion plants was measured from ground level to the growing tip and after computing the mean, it was recorded as height of onion plant in centimeter (cm). The height of onion plants was recorded at 20 days interval till 80 days and at the harvesting stage of the crop.

The height of the main stem of each of the five plants selected at random in the rows of net plot was recorded, from the first basal node to the base of the last unfolded leaf i.e. the height was recorded from ground level to tip of the fully opened upper most leaf and the average was expressed in cm.

#### **3.14.2.3 Number of leaves per plant**

The number of functional leaves per plant was counted on all the observational plants. After computing the mean, it was recorded as number of leaves per plant. The observations were recorded at 20 days interval till 80 days and at the harvesting stage of the crop.

#### **3.14.2.4 Weight of fresh leaves (g)**

The five representative plants were uprooted from each net plot. The leaves were separated from the bulb. These leaves were put on weighing balance then reading was taken. Periodical weight of leaves was recorded at 20 days intervals from the date of transplanting i.e., 20, 40, 60, 80 DAT and at harvest and mean value was expressed in g/plant.

#### **3.14.2.5 Weight of fresh bulb (g)**

The five representative plants were uprooted from each net plot. The leaves were separated from the bulb. These bulbs were put on

weighing balance then reading was taken. Weight of bulb was recorded at 20 days intervals from date of transplanting i.e., 20, 40, 60, 80 DAT and at harvest and means for each period was computed.

#### **3.14.2.6 Dry weight of onion plant (g)**

To get the dry matter accumulation in the plant samples, five plants were uprooted at an interval of 20 days starting from date of transplanting upto the harvesting. At each sampling, five plants were randomly selected from each net plot and component parts of plant viz., leaves and bulbs were separated and sun dried first and then dried in hot air oven at  $60^{\circ}\text{C} \pm 5^{\circ}\text{C}$  till the samples were completely dried and get constant weight.

#### **3.14.2.7 Final plant population**

Existing plants at the time of harvesting were counted and noted in each treatment plot as a final plant population.

### **3.14.3 Post -harvest study**

#### **3.14.3.1 Bulb polar diameter (mm)**

Polar diameter of bulbs was measured with the help of digital vernier caliper in mm from the junction of root plate to the top of the sample bulb.

#### **3.14.3.2 Bulb equatorial diameter(mm)**

Equatorial diameter is the maximum circumference distance between opposite sides at right angles to the polar diameter and was measured by digital vernier caliper in mm from the same samples used for measuring the polar diameter and the mean value was expressed in mm.

#### **3.14.3.3 Per plot yield of onion bulbs (kg)**

The yield of onion bulbs per plot from each treatment was recorded and expressed in kilograms (kg).

#### **3.14.3.4 Per hectare yield of onion bulbs (q)**

From the per plot yield, the yield per hectare of onion bulbs was computed and recorded accordingly in quintals (q).

### 3.14.3.5 Dry weight of onion bulb (g) at harvest

For the weight of bulb, all the observational plants were uprooted from each plot. The plants were dried under sun and then dried in the oven at 60°C till they attained constant weight and it was recorded in gram (g). The dry matter of bulb was recorded at harvest stage of the crop after cutting dried leaves.

### 3.14.4 Growth analysis

#### 3.14.4.1 Absolute growth rate (AGR)

The rate of increase in a growth variable (W) at the time (t) is called as absolute growth rate. It is measured as differential coefficient of 'W' with respect of time 't'. Absolute growth rate of total dry matter weight was calculated by following formula reported by Richards (1969) and expressed as g day<sup>-1</sup> plant<sup>-1</sup>.

$$\text{AGR (g day}^{-1} \text{ plant}^{-1}) = \frac{(W_2 - W_1)}{(t_2 - t_1)}$$

Where, W<sub>2</sub> and W<sub>1</sub> refer to the total dry matter of plant in g at t<sub>2</sub> and t<sub>1</sub> time, respectively.

#### 3.14.4.2 Relative growth rate (RGR)

Blackman (1919) pointed out that an increase in dry matter of plant is a process of continuous compound interest wherein the increment in any interval adds to the "Capital" for subsequent growth. This rate of increment is called as relative growth rate (RGR), which was worked out as per formula given by Fisher (1921) and expressed in g g<sup>-1</sup> day<sup>-1</sup> plant<sup>-1</sup>.

$$\text{RGR (g g}^{-1} \text{ day}^{-1}) = \frac{\text{Log}_e W_2 - \text{Log}_e W_1}{t_2 - t_1}$$

Where, W<sub>1</sub> and W<sub>2</sub> are the initial and final plant dry weight (g). t<sub>1</sub> and t<sub>2</sub> are the initial and final day of observation i.e. time intervals in days. Log<sub>e</sub> i.e. Natural logarithm to the base e (e = 2.3026).

### **3.14.5 Microbial Count**

Serial dilution plate technique was used for isolation and enumeration of soil fungi, actinomycetes and bacteria as described by Pahwa and prakash (1996).

### **3.14.6 Chemical study**

#### **3.14.6.1 Soil analysis**

The treatment wise required soil sample from each net plot collected before transplanting and after harvesting. These samples were used for determination of nitrogen, phosphorus and potassium. The nitrogen was estimation by (modified Kjeldahl's method), Alkaline permanganate method. Similarly available 'P' and 'K' were estimation by Olsen's method and flame photometer method, respectively.

#### **3.14.6.2 Plant Analysis**

##### **a) N P and K uptake by plant**

For estimation of nitrogen, phosphorus and potassium content in onion bulbs, a sample of 0.5 g each was taken from previously ground powder and it was used for chemical analysis. Nitrogen was estimated by Kjeldahl's method (Jackson, 1967) using Pelican make Semi Automatic NitrogenAnalyser; phosphorus by Vanadomolybdo phosphoric acid yellow colour method (di-acid extract) by using Spectrophotometer at 470 nm and potassium content was estimated (di-acid extract) by using Flame photometer (Jackson, 1967). Total nitrogen, phosphorus and potassium uptake by onion bulbs at harvest were calculated by multiplying the bulb yield of onion crop with the corresponding values of nutrient content and expressed in  $\text{kg ha}^{-1}$ .

##### **b) N P and K uptake by weed**

Weeds used for dry matter study at harvest were utilized for estimation of N, P and K content. The weeds were dried, grinded and nitrogen, phosphorus and potassium in weeds were estimated by Kjeldahls method, Vanadomolybdate phosphoric yellow colour method using spectrophotometer at 470 nm and flame photometer method

respectively (Piper, 1966). The total nutrient uptake in kg per ha was calculated by using the formula,

$$\text{Uptake by weed} = \frac{\text{Dry matter of weed (kg ha}^{-1}\text{)} \times \text{Nutrient content (\%)}}{100}$$

### **3.14.7Economic studies**

#### **3.14.7.1 Gross monetary returns (GMR)**

The gross monetary returns (₹ ha<sup>-1</sup>) were worked out by considering the onion bulb yield from different treatments and prevailing market prices in both the seasons.

#### **3.14.7.2 Net monetary returns**

The net monetary returns (₹ ha<sup>-1</sup>) were worked out by subtracting the total cost of cultivation from the gross return of the corresponding treatments.

#### **3.14.7.3 Benefit cost ratio**

It is the ratio of gross monetary returns to the cost of cultivation, which can also be expressed as returns per rupee invested. The benefit cost ratio was worked out by considering the per hectare values of gross monetary returns and cost of cultivation.

### **3.14.8 Statistical analysis and interpretation of data**

The statistical method of analysis of variance was used for analyzing the data. The data were statistically analyzed by 'Analysis of Variance' method (Panse and Sukhatme, 1967) and 'F' test of significance was used for testing the 'null hypothesis' in order to determine whether the observed treatment effects were real and discernible from chance effects. Whenever the results were found to be significant, critical difference (C.D.) was calculated for the comparison of treatment means at 5 per cent levels of significance (P = 0.05). The results have been presented in the form of summary table providing S.E. (m) in each case and C.D. at 5 per cent level. The values of C.D. have been taken into account for drawing conclusions.

## CHAPTER IV

### RESULTS AND DISCUSSION

The summarized data of the result of present field experimentation entitled “Efficacy of pre and post emergence herbicide against weed flora in onion” was conducted at AICRP Weed Management, Agronomy Farm, Dr. Panjabrao Deshmukh Krushi Vidyapith, Akola during *Rabi* season of 2018-2019 along with statistical parameters are presented and discussed in this chapter. The inferences are discussed with logical reasons wherever possible in the light of theories, past experiences and appropriate evidences.

Data pertaining to the effect of different treatments on weed parameter to each aspect are presented and discussed here under following heads. Weed studies, crop studies(plant studies and growth studies),yield studies, economic studies, microbial studies and chemical studies were subjected to statistical analysis in order to test the significance of results. The results in content to each aspect are presented and discussed here under following heads.

- 4.1 Effect of treatments on weed parameters
- 4.2 Effect of treatments on crop parameters(i.e. plant and growth studies)
- 4.3Effect of treatments on yield parameter
- 4.4 Effect of treatments on microbial count (bacteria, fungi and actinomycetes)
- 4.5 Effect of treatments on chemical parameter in soil
- 4.6Effect of treatments on economics of onion weed management

#### **Soil**

The soil of experimental site was clayey in texture with slightly alkaline in nature. The soil was low in nitrogen, medium in phosphorous and fairly rich in potash. The topography of the field was fairly uniform.

#### 4.1 Effect of treatments on weed parameters:

In this section, weed flora, weed count including monocot, dicot and its total, classification based on cotyledon basis, weed dry matter and phytotoxicity rating on onion has been studied and the results obtained for various plant parameters are placed and discussed under appropriate sub titles.

##### 4.1.1 Weed flora

In order to find out an effective measure of weed control, it is very essential to identify the weeds present in the experimental field whether it is narrow leaf, broad leaf or sedge. The correct identification helps to group them into different classes. The weed of a specific group normally responds to a particular treatment because of their morphological characteristics, genetic make up and growth similarities. Efforts were made to identify the weeds prevailing in the experimental plots. The list of weeds found in the experimental plots is given in Table 8.

Weed density recorded in experimental field plots are presented in Table 8 with their nature of cotyledon, local name, scientific name, English name and family. Among the different weed species, *Datura stramonium* was the most dominant weed, while *Parthenium hysterophorus* was second in weed density during *grabi* 2018-2019 followed by *Euphorbia hirta* L., *Commelinabenghalensis*, *Alternanatheratriandra*, *Digera arvensis* Forst., *Tridaxprocumbens* L., *Euphorbia geniculata* Orteg., *Argemone mexicana* L., *Xanthium strumarium* L., *Chenopodium album* L., *Phyllanthus niruri* L., *Portulaca oleracea* L., *Lagascamollis* and *Acalypha indic* these were dicot weeds and among monocot *Cyprus rotundus*, *Cynodon dactylon*, *Eleusin indica* L. and *Dactyloctenium aegyptium* L. were observed.

Similar findings were reported by Patel *et al.* (2011), Kalhapure *et al.* (2014) and Thakare *et al.*, (2018)

**Table 8: Weed flora observed in experimental field**

| Sr.No.                  | Local name          | Scientific name                     | English name               | Family         |
|-------------------------|---------------------|-------------------------------------|----------------------------|----------------|
| <b>A) Monocot weeds</b> |                     |                                     |                            |                |
| 1.                      | Nagar motha, Laval  | <i>Cyperus rotundus</i> L.          | Purplenut sedge            | Cyperaceae     |
| 2.                      | Hariyali            | <i>Cynodon dactylon</i>             | Bermuda grass              | Poaceae        |
| 3.                      | Silver crab grass   | <i>Eleusine indica</i>              | Goose grass                | Poaceae        |
| 4.                      | Beach wiregrass     | <i>Dactyloctenium aegyptium</i>     | Crow foot grass            | Poaceae        |
| <b>B) Dicot weeds</b>   |                     |                                     |                            |                |
| 1.                      | Kala dhotra         | <i>Datura stramonium</i>            | Thornapple                 | Solanaceae     |
| 2.                      | Gajargawat          | <i>Parthenium hysterophorus</i> L.  | Carrot grass               | Asteraceae     |
| 3.                      | Dudhani             | <i>Euphorbia hirta</i> L.           | Garden Sprung              | Euphorbiaceae  |
| 4.                      | Kena                | <i>Commelinabenghalensis</i>        | Day Flower                 | Commelinaceae  |
| 5.                      | Reshimkata          | <i>Alternanathera triandra</i> L.   | -                          | Amaranthaceae  |
| 6.                      | Kunzaru             | <i>Digera arvensis</i> F.           | Digera                     | Amaranthaceae  |
| 7.                      | Kamarmodi           | <i>Tridax procumbens</i> L.         | Coat buttons, tridax daisy | Compositae     |
| 8.                      | Mothidudhani        | <i>Euphorbia geniculata</i> Ortega. | Sprung                     | Euphorbiaceae  |
| 9.                      | Piwaladhotra        | <i>Argemone mexicana</i> L.         | Mexican poppy              | Papavaraceae   |
| 10.                     | Gokharu             | <i>Xanthium strumarium</i> L.       | Burweed                    | Asteraceae     |
| 11.                     | Bathua              | <i>Chenopodium album</i> L.         | Lambs quarter              | Chenopodiaceae |
| 12.                     | Hajardani, Jondhali | <i>Phyllanthus niruri</i> L.        | Niruri                     | Euphorbiaceae  |
| 13.                     | Ghol                | <i>Portulaca oleracea</i> L.        | Purslane                   | Portulacaceae  |
| 14.                     | Pandhariphuli       | <i>Lagascamollis</i>                | White flower               | Compositae     |
| 15.                     | Deepmal             | <i>Acalypha indica</i>              | Copper leaf                | Euphorbiaceae  |

#### 4.1.2 Effect of treatments on weed population

The weeds were classified into two major groups i.e. monocot, dicot and finally their total. The purpose was to find out the effect of different treatments on each group.

##### 4.1.2.1 Effect of treatments on monocot weeds

The perusal of data on number of monocot weed (No. m<sup>-2</sup>) recorded at interval of 20 days as influenced due to different herbicide with different pre-mix combined formulation of herbicide, other herbicide and weed management practice (Hand weeding) during the year of 2018-2019 is presented in Table 9 and graphically depicted in Fig 3.

**Table 9: Monocot weed count (no/m<sup>2</sup>) as influenced by different weed control treatments**

| Treatment                                                                        | 20 DAT          | 40 DAT            | 60 DAT            | 80 DAT            | At harvest        |
|----------------------------------------------------------------------------------|-----------------|-------------------|-------------------|-------------------|-------------------|
| T <sub>1</sub> - Pendimethalin 24% + Oxyfluorfen 4% ZE @480+82 g a.i./ha         | 3.22<br>(9.97)  | 3.87<br>(14.50)   | 4.63<br>(20.97)   | 5.67<br>(31.71)   | 6.13<br>(37.07)   |
| T <sub>2</sub> - Pendimethalin 24% + Oxyfluorfen 4% ZE @541.80+92.56 g a.i./ha   | 2.96<br>(8.47)  | 3.55<br>(12.10)   | 4.28<br>(18.00)   | 5.38<br>(28.47)   | 5.72<br>(32.20)   |
| T <sub>3</sub> - Pendimethalin 24% + Oxyfluorfen 4% ZE @600+102.5 g a.i./ha      | 2.58<br>(6.53)  | 3.31<br>(10.43)   | 3.74<br>(13.57)   | 4.51<br>(19.90)   | 5.25<br>(27.13)   |
| T <sub>4</sub> - Pendimethalin 24% + Oxyfluorfen 4% ZE @1083.60+185.12 g a.i./ha | 2.48<br>(5.83)  | 3.48<br>(11.60)   | 3.85<br>(14.40)   | 4.52<br>(20.27)   | 5.29<br>(27.63)   |
| T <sub>5</sub> - Pendimethalin 38.7% CS@ 677.25 g a.i./ha                        | 3.16<br>(9.50)  | 3.88<br>(14.57)   | 4.92<br>(23.77)   | 5.57<br>(30.60)   | 6.04<br>(36.03)   |
| T <sub>6</sub> - Oxyfluorfen 23.5% EC@ 200 g a.i./ha                             | 2.90<br>(7.97)  | 3.41<br>(11.10)   | 3.82<br>(14.13)   | 4.48<br>(20.03)   | 5.27<br>(27.27)   |
| T <sub>7</sub> - Quizalofop ethyl 5% EC@ 50 g a.i./ha                            | 6.82<br>(46.07) | 4.83<br>(24.07)   | 5.42<br>(29.53)   | 6.21<br>(38.07)   | 7.07<br>(50.53)   |
| T <sub>8</sub> - Two HW (25 & 45 DAT)                                            | 6.71<br>(44.73) | 2.50<br>(5.73)    | 2.86<br>(8.13)    | 3.65<br>(12.80)   | 3.93<br>(15.83)   |
| T <sub>9</sub> - Weedy Check                                                     | 7.05<br>(49.33) | 11.43<br>(130.43) | 13.15<br>(173.23) | 14.02<br>(198.93) | 15.12<br>(228.93) |
| S.E(m)±                                                                          | 0.27            | 0.30              | 0.34              | 0.38              | 0.41              |
| C.D. at 5%                                                                       | 0.82            | 0.92              | 1.01              | 1.15              | 1.24              |
| G.M.                                                                             | 4.21            | 4.47              | 5.19              | 6.00              | 6.65              |

Upper values are transformed value  $\sqrt{x + 0.5}$

Figures in parentheses are original values.

The data presented in Table 9 showed that number of monocot weed was affected significantly at all the periodical intervals due to different treatments. The population of monocot weed was significantly highest under weedy check (T<sub>9</sub>) as compared to chemical and cultural weed management practice i.e. herbicidal application and HW at 25 and 45 DAT respectively.

The data revealed that among the herbicidal treatment at 20 DAT, monocot weeds/m<sup>2</sup> were significantly lower in pendimethalin 24% + oxyfluorfen 4% ZE @1083.60+185.12 g a.i./ha (T<sub>4</sub>) sprayed as pre emergence, which was superior to all other treatments because of the

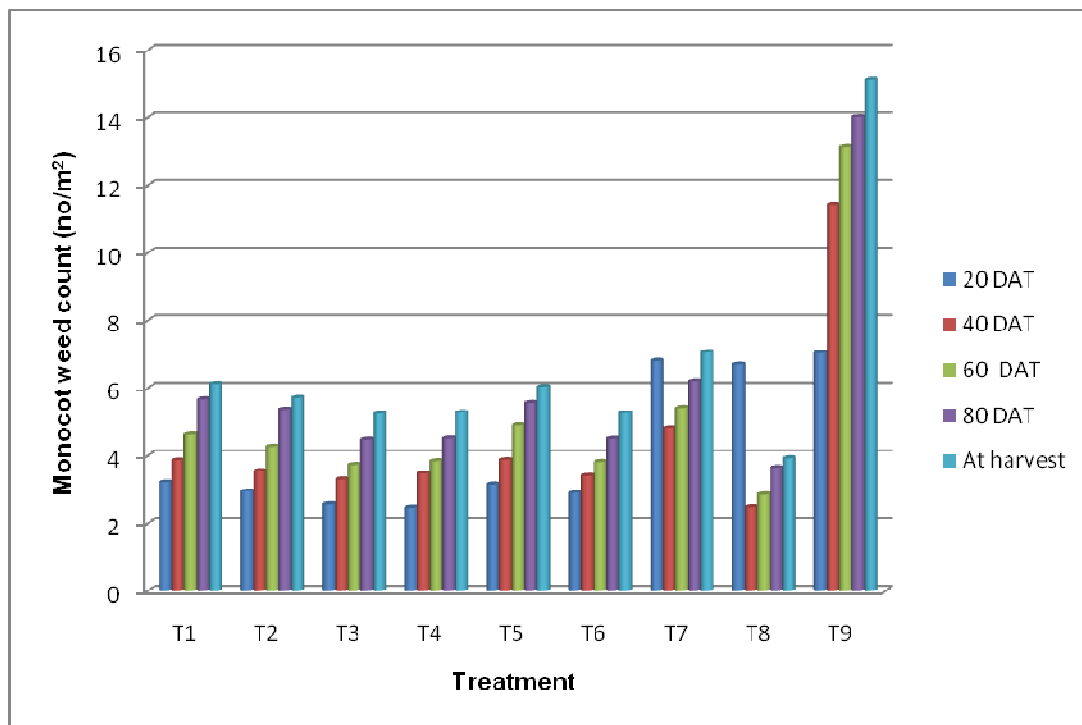


**Fig. 3 Monocot weed count (no/m<sup>2</sup>) as influenced by different weed control treatments**

reduction in weed population at initial stage. The next best treatment was pendimethalin 24% + oxyfluorfen 4% ZE @600+102.5 g a.i./ha PE (T<sub>3</sub>) followed by oxyfluorfen 23.5% EC@ 200 g a.i./ha PE (T<sub>6</sub>) however, these treatments were found highly superior over rest of the treatments and found statistically at par with each other.

At 40 DAT, lowest monocot weed flora m<sup>-2</sup> was significantly recorded in treatment with 2 hand weeding at 25 & 45 DAT i.e. weed free (T<sub>8</sub>). Among herbicidal treatments, pendimethalin 24% + oxyfluorfen 4% ZE @600+102.5 g a.i./ha as PE (T<sub>3</sub>), oxyfluorfen 23.5% EC@ 200 g a.i./ha as PE (T<sub>6</sub>) and pendimethalin 24% + oxyfluorfen 4% ZE @1083.60+185.12 g a.i./ha as PE (T<sub>4</sub>) produced lower weed count but were statistically at par with each other. These treatments further followed by treatment pendimethalin 24% + oxyfluorfen 4% ZE @541.80+92.56 g a.i./ha PE (T<sub>2</sub>), pendimethalin 24% + oxyfluorfen 4% ZE @480+82 g a.i./ha PE (T<sub>1</sub>), pendimethalin 38.7% CS@ 677.25 g a.i./ha PE (T<sub>5</sub>) and quizalofop ethyl 5% EC@ 50 g a.i./ha as post emergence (T<sub>7</sub>) but these treatments were comparable with each other. The weedy check (T<sub>9</sub>) recorded significantly higher weed population. Similar trend of monocot weed flora was observed at 60 DAT, 80 DAT and at harvest in onion crop.

Among the various weed control treatments, lowest monocot weed count /m<sup>2</sup> observed treatment in with 2 hand weeding at 25 & 45 DAT (T<sub>8</sub>) as compared to different herbicidal treatment through out the growth stages in onion with the exception of 20 DAT. At 20 DAT, lower monocots were found in treatment with pendimethalin 24% + oxyfluorfen 4% ZE @1083.60+185.12 g a.i./ha (T<sub>4</sub>). This might be due to the pre emergence application of combined formulation of pendimethalin and oxyfluorfen. Pendimethalin results in better weed control at initial stage by inhibiting weed seed germination and seedling development. Similarly, oxyfluorfen disrupt cell membrane due to lipid peroxidation. Whereas at 40 DAT, treatment pendimethalin 24% + oxyfluorfen 4% ZE @600+102.5 g a.i./ha (T<sub>3</sub>) recorded lowest monocot weed count this is because from 40 DAT & onwards, pendimethalin 24% + oxyfluorfen 4% ZE @1083.60+185.12 g a.i./ha (T<sub>4</sub>) treatment has phytotoxicity effect due to its higher

concentration of a.i. on onion plant which shows necrosis and burning tips of onion crop but treatment with application of oxyfluorfen 23.5% EC@ 200 g a.i./ha ( $T_6$ ) and pendimethalin 24% + oxyfluorfen 4% ZE @1083.60+185.12 g a.i./ha ( $T_4$ ) were statistically at par with treatment pendimethalin 24% + oxyfluorfen 4% ZE @600+102.5 g a.i./ha ( $T_3$ ). Similar trend of results were noticed at 60, 80 and at harvest stage during the experimentation. This might be due to the herbicides that have longer effect on controlling monocot weed population. The variability in weed population in different treatments can be attributed to the fact that the herbicides have different efficiency which could effectively kill most of the weeds and reduced the weed density as the field was infested by all kind of weeds. Effectiveness of various herbicides against different weed species in onion has been earlier reported by Angirias and Kumar (2005), Chinnusamy *et al.* (2006), Saini and walia (2012), Tripathy *et al.* (2013) and Kadu *et al.* (2017).

#### **4.1.2.2 Effect of treatments on dicot weeds**

The data pertaining to dicot weeds  $m^{-2}$  are presented in Table 10. A perusal of the data presented in Table 10 and graph depicted in fig 4 showed that number of dicot weeds was affected significantly at all the periodical interval due to weed control by cultural method (HW) and herbicides application.

The data revealed that number of dicot weeds was affected significantly at all the periodical intervals due to the different herbicidal treatments and weed management practices. Less number of dicot weeds/ $m^2$  were observed as compared to monocot weeds throughout growth stages. The treatment weed free ( $T_8$ ) registered significantly lowest dicot weeds population than rest of the weed management treatments during experimentation.

Initially, on 20 DAT among pre-emergence herbicides treatments, application with pendimethalin 24% + oxyfluorfen 4% ZE @1083.60+185.12 g a.i./ha ( $T_4$ ) was found superior which was at par with oxyfluorfen 23.5% EC@ 200 g a.i./ha ( $T_6$ ) followed by pendimethalin 24% + oxyfluorfen 4% ZE @600+102.5 g a.i./ha ( $T_3$ ) these treatments recorded

lowest values of dicot weeds than other herbicidal treatments. Treatment (T<sub>9</sub>) i.e. weedy check recorded highest number of dicot weed count at 20 DAT.

**Table 10: Dicot weed count (no/m<sup>2</sup>) as influenced by different weed control treatments**

| Treatment                                                                        | 20 DAT          | 40 DAT          | 60 DAT          | 80 DAT          | At harvest      |
|----------------------------------------------------------------------------------|-----------------|-----------------|-----------------|-----------------|-----------------|
| T <sub>1</sub> - Pendimethalin 24% + Oxyfluorfen 4% ZE @480+82 g a.i./ha         | 2.77<br>(7.27)  | 3.19<br>(9.70)  | 4.32<br>(19.43) | 5.00<br>(25.97) | 5.38<br>(29.17) |
| T <sub>2</sub> - Pendimethalin 24% + Oxyfluorfen 4% ZE @541.80+92.56 g a.i./ha   | 2.21<br>(4.43)  | 3.01<br>(8.53)  | 3.54<br>(12.13) | 4.14<br>(16.64) | 4.39<br>(18.83) |
| T <sub>3</sub> - Pendimethalin 24% + Oxyfluorfen 4% ZE @600+102.5 g a.i./ha      | 1.92<br>(3.20)  | 2.73<br>(7.00)  | 3.18<br>(9.87)  | 3.64<br>(12.77) | 3.87<br>(14.53) |
| T <sub>4</sub> - Pendimethalin 24% + Oxyfluorfen 4% ZE @1083.60+185.12 g a.i./ha | 1.69<br>(2.37)  | 2.93<br>(8.07)  | 3.25<br>(10.07) | 3.85<br>(14.60) | 4.07<br>(16.03) |
| T <sub>5</sub> - Pendimethalin 38.7% CS@ 677.25 g a.i./ha                        | 2.55<br>(6.00)  | 3.10<br>(9.13)  | 3.45<br>(11.57) | 4.27<br>(17.77) | 4.56<br>(20.30) |
| T <sub>6</sub> - Oxyfluorfen 23.5% EC@ 200 g a.i./ha                             | 1.85<br>(2.93)  | 2.86<br>(7.70)  | 3.23<br>(10.00) | 3.88<br>(14.67) | 4.02<br>(16.10) |
| T <sub>7</sub> - Quizalofop ethyl 5% EC@ 50 g a.i./ha                            | 3.37<br>(10.90) | 5.32<br>(28.23) | 6.41<br>(40.70) | 6.83<br>(46.10) | 7.38<br>(53.93) |
| T <sub>8</sub> - Two HW (25 & 45 DAT)                                            | 3.24<br>(10.33) | 2.45<br>(5.50)  | 2.66<br>(6.67)  | 2.95<br>(8.20)  | 3.12<br>(9.40)  |
| T <sub>9</sub> - Weedy Check                                                     | 3.52<br>(11.97) | 6.39<br>(40.83) | 7.29<br>(52.60) | 8.05<br>(64.27) | 8.33<br>(69.47) |
| S.E(m)±                                                                          | 0.20            | 0.24            | 0.29            | 0.32            | 0.35            |
| C.D. at 5%                                                                       | 0.60            | 0.71            | 0.87            | 0.97            | 1.06            |
| G.M.                                                                             | 2.57            | 3.55            | 4.15            | 4.74            | 5.01            |

Upper values are transformed value  $\sqrt{x + 0.5}$

Figures in parentheses are original values.

From 40 DAT to harvest, treatment weed free (T<sub>8</sub>) noticed lowest dicot weed population and showed significantly least weed count over rest of the treatments. Treatment with application of pendimethalin 24% + oxyfluorfen 4% ZE @600+102.5 g a.i./ha (T<sub>3</sub>) stood second by recording lower number of dicot weeds which was followed by oxyfluorfen 23.5% EC@ 200 g a.i./ha (T<sub>6</sub>) and pendimethalin 24% + oxyfluorfen 4% ZE @1083.60+185.12 g a.i./ha (T<sub>4</sub>). Treatment T<sub>3</sub>, T<sub>4</sub> and T<sub>6</sub> were statistically

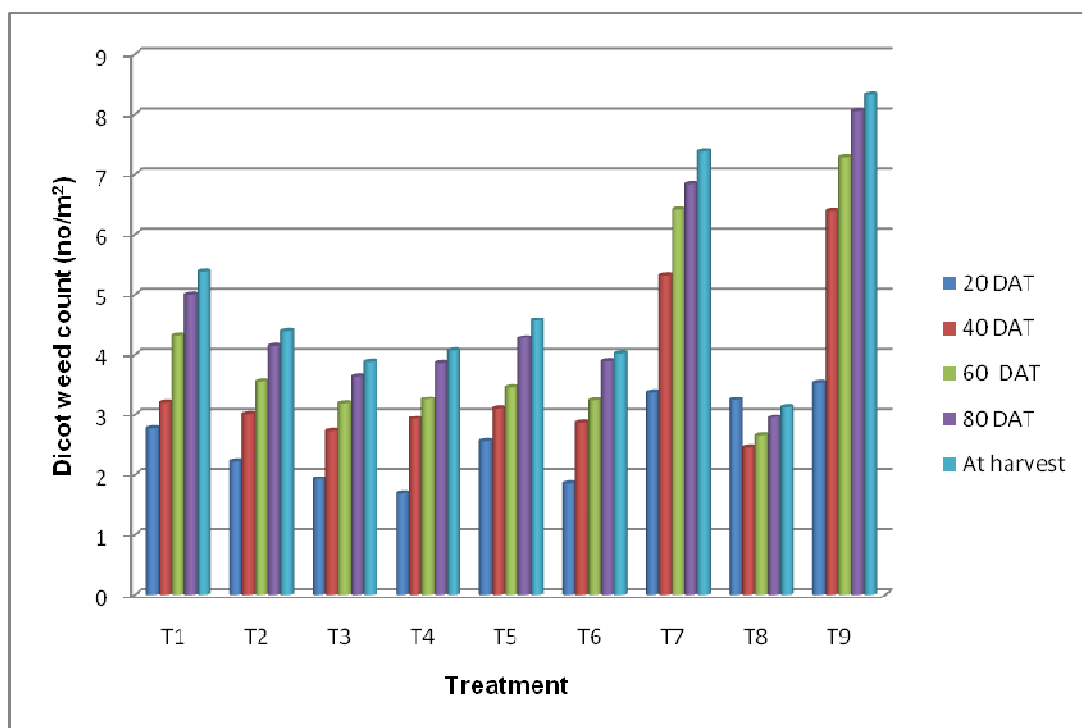


**Fig. 4 Dicot weed count (no/m<sup>2</sup>) as influenced by different weed control treatments**

at par with each other. Quizalofop ethyl 5% EC@ 50 g a.i./ha as post emergence application (T<sub>7</sub>) showed less effect on dicot weeds. Naturally, weedy check (T<sub>9</sub>) recorded highest dicot weed population. This could be due to non-removal of weeds which produced seeds and act as weed seed bank, which result in increased weed germination and thereby increased total number of weeds. Similar trend herbicide effect on dicot weed flora was observed at 60, 80 and at harvest.

Among the various treatments, lowest dicot weed count/m<sup>2</sup> was observed at pendimethalin 24% + oxyfluorfen 4% ZE @1083.60+185.12 g a.i./ha (T<sub>4</sub>) at 20 DAT, this might be due to the pre emergence application of pendimethalin and oxufluorfen in combined formulation which gave better weed control at initial stage by inhibiting weeds seed germination and seedling development for longer period during initial stage but as crop grow its higher concentration somewhere restrict the plant growth, reduces competating ability of crop with weed flora. Hence treatment pendimethalin 24% + oxyfluorfen 4% ZE @600+102.5 g a.i./ha(T<sub>3</sub>)proved superior overpendimethalin 24% + oxyfluorfen 4% ZE @1083.60+185.12 g a.i./ha (T<sub>4</sub>). From 40 DAT and onwards treatment T<sub>3</sub> (Pendimethalin 24% + Oxyfluorfen 4% ZE @600+102.5 g a.i./ha) showed its superiority by recording least dicot weed count . Treatment with application of pendimethalin 24% + oxyfluorfen 4% ZE @600+102.5 g a.i./ha(T<sub>3</sub>), pendimethalin 24% + oxyfluorfen 4% ZE @1083.60+185.12 g a.i./ha(T<sub>4</sub>) and oxyfluorfen 23.5% EC@ 200 g a.i./ha (T<sub>6</sub>) were comparable with each other. The variability of weed population in different treatments can be attributed to fact that herbicides which could effectively kill most of the germinating weed seed hence, reduced weed density. This may be due to longer effect of applied herbicide shows better control on weed at critical growth stages by reducing the density of dicot weed. Dicot weed population was reduced significantly due to various weed control treatments at all growth stages due to herbicidal treatments. The results confirm the finding with Bharathi *et al.* (2011), Shinde *et al.* (2013), Tripathi *et al.* (2013) and Sankar *et al.* (2015).

#### 4.1.2.3 Effect of treatments on total weeds

Data pertaining to total weed count per m<sup>2</sup> are presented in Table 11 and graphically showed in Fig.5.

Significant differences were observed between weed management i.e. cultural treatment and herbicidal application at all the periodical intervals with respect to total weed count (Table 11) which gives evidence that treatments are significantly influenced due to different herbicidal application. The treatment T<sub>8</sub> i.e. twohandweeding (25 & 45 DAT) recorded significantly lower number of total weed count over rest of the treatments.

**Table11: Total weed count no/m<sup>2</sup> as influenced by different weed control treatments**

| Treatment                                                                        | 20 DAT          | 40 DAT            | 60 DAT            | 80 DAT            | At harvest        |
|----------------------------------------------------------------------------------|-----------------|-------------------|-------------------|-------------------|-------------------|
| T <sub>1</sub> - Pendimethalin 24% + Oxyfluorfen 4% ZE @480+82 g a.i./ha         | 4.21<br>(17.23) | 4.97<br>(24.20)   | 6.36<br>(40.40)   | 7.59<br>(57.67)   | 8.14<br>(66.23)   |
| T <sub>2</sub> - Pendimethalin 24% + Oxyfluorfen 4% ZE @541.80+92.56 g a.i./ha   | 3.62<br>(12.90) | 4.60<br>(20.63)   | 5.51<br>(30.13)   | 6.75<br>(45.11)   | 7.18<br>(51.03)   |
| T <sub>3</sub> - Pendimethalin 24% + Oxyfluorfen 4% ZE @600+102.5 g a.i./ha      | 3.06<br>(9.07)  | 4.23<br>(17.43)   | 4.89<br>(23.43)   | 5.75<br>(32.80)   | 6.49<br>(41.67)   |
| T <sub>4</sub> - Pendimethalin 24% + Oxyfluorfen 4% ZE @1083.60+185.12 g a.i./ha | 3.03<br>(8.90)  | 4.38<br>(19.67)   | 4.99<br>(24.47)   | 5.92<br>(34.87)   | 6.64<br>(43.67)   |
| T <sub>5</sub> - Pendimethalin 38.7% CS@ 677.25 g a.i./ha                        | 4.00<br>(15.50) | 4.92<br>(23.70)   | 5.90<br>(34.67)   | 6.64<br>(43.70)   | 7.54<br>(56.33)   |
| T <sub>6</sub> - Oxyfluorfen 23.5% EC@ 200 g a.i./ha                             | 3.37<br>(10.90) | 4.39<br>(18.80)   | 4.96<br>(24.13)   | 5.91<br>(34.57)   | 6.61<br>(43.37)   |
| T <sub>7</sub> - Quizalofop ethyl 5% EC@ 50 g a.i./ha                            | 7.58<br>(56.97) | 7.26<br>(52.30)   | 8.36<br>(70.23)   | 9.20<br>(84.17)   | 10.17<br>(104.47) |
| T <sub>8</sub> - Two HW (25 & 45 DAT)                                            | 7.45<br>(55.07) | 3.43<br>(11.23)   | 3.86<br>(14.80)   | 4.35<br>(18.67)   | 4.81<br>(22.88)   |
| T <sub>9</sub> - Weedy Check                                                     | 7.86<br>(61.30) | 13.06<br>(171.27) | 15.03<br>(225.83) | 16.18<br>(263.20) | 17.04<br>(291.73) |
| S.E(m)±                                                                          | 0.23            | 0.27              | 0.40              | 0.46              | 0.50              |
| C.D. at 5%                                                                       | 0.70            | 0.83              | 1.21              | 1.39              | 1.51              |
| G.M.                                                                             | 4.91            | 5.69              | 6.65              | 7.59              | 8.29              |

Upper values are transformed value  $\sqrt{x + 0.5}$

Figures in parentheses are original values

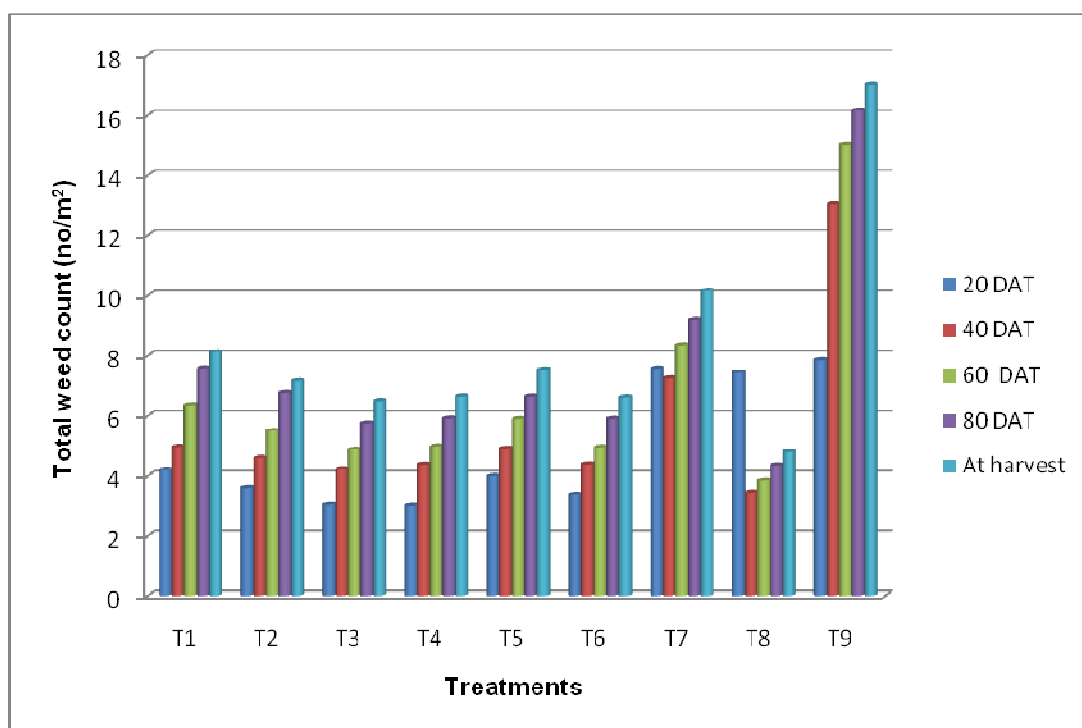


**Fig. 5 Total weed count (no/m<sup>2</sup>) as influenced by different weed control treatments**

The result indicated that there was significant difference in the total weed population due to various weed management practices at 20 DAT. Significantly lower weed population was recorded under treatment pendimethalin 24% + oxyfluorfen 4% ZE @1083.60+185.12 g a.i./ha (T<sub>4</sub>) which was at par with treatments of as pre-emergence application of pendimethalin 24% + oxyfluorfen 4% ZE @600+102.5 g a.i./ha (T<sub>3</sub>) followed by oxyfluorfen 23.5% EC@ 200 g a.i./ha (T<sub>6</sub>). This was mainly due to lower weeds during initial stage by pre-emergence application of pendimethalin and effective control of later emerged weed through oxyfluorfen due to its higher persistency which ultimately provided weeds free environment to onion. These findings are in line with those of Ghadage *et al.* (2006), Patel *et al.* (2011) and Kadu *et al.* (2017). Significantly the highest total weed population was recorded under treatment of weedy check (T<sub>9</sub>) i.e. 61.30. Highest total weed population was recorded in weedy check as no weed management measures were undertaken due to which weeds grow vigorously.

At 40 DAT, significantly the lowest total weed population was recorded under treatment with 2 HW at 25 and 45 DAT (T<sub>8</sub>). Control of total weeds might be due to manual removal of weed through *khurpi* at 25 DAT. Whereas, pendimethalin 24% + oxyfluorfen 4% ZE @600+102.5 g a.i./ha (T<sub>3</sub>) showed second best treatment by recording lower total weed population which was followed by oxyfluorfen 23.5% EC@ 200 g a.i./ha as pre emergence (T<sub>6</sub>) and pendimethalin 24% + oxyfluorfen 4% ZE @1083.60+185.12 g a.i./ha PE (T<sub>4</sub>). Effective control of weeds under application of pendimethalin and oxyfluorfen combination might be due to disruption of cell division and cell elongation in shoot and root meristems of susceptible weed plants. Oxyfluorfen applied as pre-emergence was effective to control weeds. This result supported by the findings of Kalasaree *et al.* (2014).

At 60 and at 80 DAT, significant reduction in total weeds count was in treatment with 2 HW at 25 and 45 DAT (T<sub>8</sub>). Among the different herbicidal treatment, pendimethalin 24% + oxyfluorfen 4% ZE @600+102.5 g a.i./ha (T<sub>3</sub>), oxyfluorfen 23.5% EC@ 200 g a.i./ha (T<sub>6</sub>) and

pendimethalin 24% + oxyfluorfen 4% ZE @1083.60+185.12 g a.i./ha (T<sub>4</sub>) as pre emergence showed effective control on weed than rest of the herbicidal treatments and at par with each other.

At harvest, significantly lower total weed density was recorded under treatment of 2HW at 25 and 45 DAT (T<sub>8</sub>), which remained at par with treatment as pre-emergence application pendimethalin 24% + oxyfluorfen 4% ZE @600+102.5 g a.i./ha (T<sub>3</sub>), oxyfluorfen 23.5% EC@ 200 g a.i./ha (T<sub>6</sub>) and pendimethalin 24% + oxyfluorfen 4% ZE @1083.60+185.12 g a.i./ha (T<sub>4</sub>). The effectiveness in reducing weed density under herbicidal treatment might be due to their herbicidal action of herbicide, while in hand weeded plots, newly emerged weeds were removed manually at 25 and 45 DAT through *khurpi* which disrupt the germination of weed seed. Significantly the highest total weed density (291.73m<sup>-2</sup>) was recorded in weedy check (T<sub>9</sub>). The result are in accordance with findings of Bhat and Bhushan (2005) and Patel *et al.* (2011).

Among the various treatments, treatment (T<sub>8</sub>) 2hand weeding 25 & 45 DAT recorded significantly lowest weed count at 40, 60, 80 and at harvest with the exception of 20DAT because hand weeding operation was performed at 25 DAT. The reduction in total weed density in treatment (T<sub>8</sub>) might be due to keeping weed free environment. But among herbicidal treatments, the lowest dicot weed count m<sup>-2</sup> was observed in treatment with application of pendimethalin 24% + oxyfluorfen 4% ZE @1083.60+185.12 g a.i./ha (T<sub>4</sub>) up to 20 DAT, this might be due to the pre emergence application of pendimethalin 24% + oxyfluorfen 4% ZE @1083.60+185.12 g a.i./ha, which results in better weed control at initial stage. The treatment pendimethalin 24% + oxyfluorfen 4% ZE @600+102.5 g a.i./ha (T<sub>3</sub>), oxyfluorfen 23.5% EC@ 200 g a.i./ha (T<sub>6</sub>) and pendimethalin 24% + oxyfluorfen 4% ZE @1083.60+185.12 g a.i./ha (T<sub>4</sub>) showed its superiority by recording least dicot weed count at 40, 60, 80 and at harvest. This might be due to combined formulation of both herbicides that have longer effect on controlling weed population. The application of herbicide quizalofop ethyl 5% EC@ 50 g a.i./ha as post emergence showed better effect on

many monocot weed. Total weed population was reduced significantly due to various weed control treatments at all stages of crop growth. This might be due to the potent effect of herbicidal application alone and in combination which were effective in timely reducing total weed population. Similar results were reported by Mondal *et al.* (2005), Kolseet *et al.* (2010) Sable *et al.* (2013) and Gupta *et al.* (2019).

#### **4.1.3 Effect of treatments on dry matter production by weeds**

The total dry weight of weeds as influenced by different herbicidal treatments and weed management practice in onion at 20, 40, 60, 80 and at harvest differed significantly are illustrated in Table 12. and graphically depicted in Fig.6. Irrespective of growth stages the weed dry weight was lower in 2HW 25 & 45 DAT(T<sub>8</sub>) as compared to all other treatments throughout the growth period of onion. Weed dry weight was recorded prior to implementation of weed control cultural measure. In general, the dry matter of weed was lowest at 20 DAT and was gradually increasing trend and reached up to maximum at harvest.

At 20 DAT, treatment with application of pendimethalin 24% + oxyfluorfen 4% ZE @1083.60+185.12 g a.i./ha (T<sub>4</sub>) has lowest dry matter accumulation of weed and it was closely followed by and at par with treatment T<sub>3</sub> (pendimethalin 24% + oxyfluorfen 4% ZE @600+102.5 g a.i./ha) followed by other treatments i.e. oxyfluorfen 23.5% EC@ 200 g a.i./ha(T<sub>6</sub>), pendimethalin 24% + oxyfluorfen 4% ZE @541.80+92.56 g a.i./ha(T<sub>2</sub>) and pendimethalin 38.7% CS@ 677.25 g a.i./ha (T<sub>5</sub>). Treatment T<sub>9</sub> (Weedy check) recorded significantly higher weed biomass accumulation.

At 40, 60, 80 DAT and at harvest, significantly the lowest dry weight of weeds was observed under treatment HW carried out at 25 and 45 DAT (T<sub>8</sub>). Among the herbicidal treatments, the result of pendimethalin 24% + oxyfluorfen 4% ZE @600+102.5 g a.i./ha (T<sub>3</sub>) showed the lower total dry weight of weeds which was remained at par with oxyfluorfen 23.5% EC@ 200 g a.i./ha (T<sub>6</sub>) and pendimethalin 24% + oxyfluorfen 4% ZE @1083.60+185.12 g a.i./ha (T<sub>4</sub>) during experimentation. This indicated that the effectiveness of herbicides not only in controlling weeds but also

reduces the dry weight. These findings are also in close agreement with Poddar *et al.* (2014) and Borseet *al.* (2015). Significantly, the highest total weed dry weight was recorded under weedy check (T<sub>9</sub>).

**Table 12: Total dry matter accumulations of weeds (g/m<sup>2</sup>) as influenced by different weed control treatments**

| Treatment                                                                           | 20 DAT          | 40 DAT          | 60 DAT          | 80 DAT          | At Harvest      |
|-------------------------------------------------------------------------------------|-----------------|-----------------|-----------------|-----------------|-----------------|
| T <sub>1</sub> - Pendimethalin 24% + Oxyfluorfen 4% ZE @480+82 g a.i./ha PE         | 2.93<br>(8.08)  | 3.27<br>(10.31) | 3.63<br>(12.69) | 3.88<br>(14.70) | 4.28<br>(17.93) |
| T <sub>2</sub> - Pendimethalin 24% + Oxyfluorfen 4% ZE @541.80+92.56 g a.i./ha PE   | 2.61<br>(6.52)  | 2.93<br>(8.13)  | 3.27<br>(10.30) | 3.58<br>(12.37) | 4.04<br>(15.83) |
| T <sub>3</sub> - Pendimethalin 24% + Oxyfluorfen 4% ZE @600+102.5 g a.i./ha PE      | 2.28<br>(5.00)  | 2.53<br>(6.03)  | 2.82<br>(7.47)  | 3.23<br>(9.96)  | 3.72<br>(13.37) |
| T <sub>4</sub> - Pendimethalin 24% + Oxyfluorfen 4% ZE @1083.60+185.12 g a.i./ha PE | 2.22<br>(4.50)  | 2.58<br>(6.27)  | 2.84<br>(7.60)  | 3.27<br>(10.17) | 3.85<br>(14.33) |
| T <sub>5</sub> - Pendimethalin 38.7% CS@ 677.25 g a.i./ha PE                        | 2.86<br>(7.70)  | 3.07<br>(8.94)  | 3.47<br>(11.51) | 3.76<br>(13.64) | 4.44<br>(19.23) |
| T <sub>6</sub> - Oxyfluorfen 23.5% EC@ 200 g a.i./ha PE                             | 2.35<br>(5.34)  | 2.57<br>(6.10)  | 2.85<br>(7.72)  | 3.24<br>(10.00) | 3.75<br>(13.80) |
| T <sub>7</sub> - Quizalofop ethyl 5% EC@ 50 g a.i./ha PoE                           | 4.42<br>(19.23) | 3.32<br>(11.11) | 3.92<br>(15.26) | 4.49<br>(19.77) | 5.02<br>(26.27) |
| T <sub>8</sub> - Two HW (25 & 45 DAT)                                               | 3.98<br>(15.37) | 2.26<br>(4.73)  | 2.80<br>(7.33)  | 2.98<br>(8.36)  | 3.35<br>(10.80) |
| T <sub>9</sub> - Weedy Check                                                        | 6.67<br>(44.03) | 7.89<br>(62.27) | 8.65<br>(75.30) | 9.06<br>(83.53) | 9.68<br>(93.86) |
| S.E(m)±                                                                             | 0.23            | 0.26            | 0.30            | 0.34            | 0.39            |
| C.D. at 5%                                                                          | 0.69            | 0.80            | 0.92            | 1.02            | 1.17            |
| G.M.                                                                                | 3.37            | 3.38            | 3.81            | 4.16            | 4.68            |

Upper values are transformed value  $\sqrt{x + 0.5}$

Figures in parentheses are original values.

Among chemical weed control with the application of herbicide, highest reduction of weed dry matter was found in treatment T<sub>3</sub> (pendimethalin 24% + oxyfluorfen 4% ZE @600+102.5 g a.i./ha as PE). This might be due to the formulation of herbicidal combination i.e. pendimethalin + oxyfluorfen. Pendimethalin inhibits the germination of weed seed and oxyfluorfen have longer effect on controlling weed population and brought significant reduction in weed dry matter as

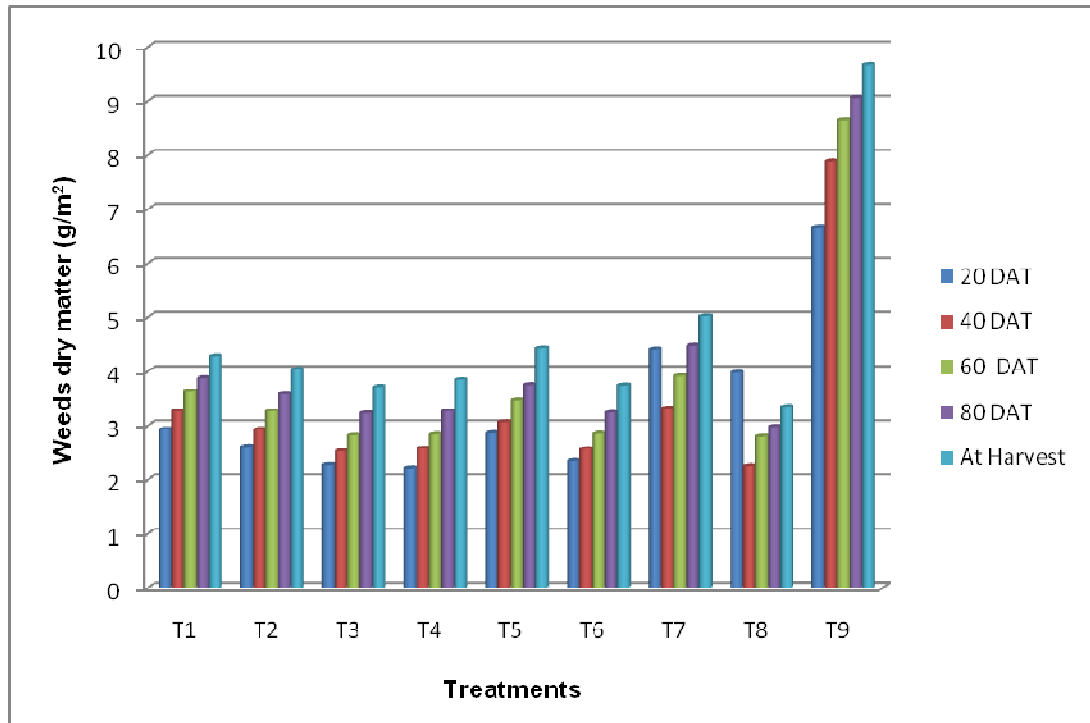


**Fig. 6 Weeds dry matter ( $\text{g/m}^2$ ) as influenced by different weed control treatments**

compared to weedy check. These results are in accordance with the results reported by Saraf (2007), Rajkumara and Palled (2009), Vashi *et al.* (2011) and Abbas Abbaszadehet *al.* (2014). Due to more weed intensity and its dominance which utilized the sunlight, nutrient, moisture, CO<sub>2</sub>, etc. over crop plant and resulted into higher growth and ultimately the higher weed biomass in weedy check. Similar result was reported by Waradeet *al.* (2006), Chopra and Chopra (2007), Patel *et al.* (2012) and Sinareet *al.* (2014).

#### 4.1.4 Weed control efficiency

Weed control efficiency as influenced by different weed control treatments are presented in Table 13. and graph depicted in fig.7a & 7b.

The highest weed control efficiency was observed in treatment weed free (T<sub>8</sub>) from 40 DAT up to at harvest, because of keeping weed free environment and found superior over rest of all herbicidal treatments.

At 20 DAT, it was clear from the data that treatment with application of pendimethalin 24% + oxyfluorfen 4% ZE @1083.60+185.12 g a.i./ha as pre-emergence (T<sub>4</sub>) had the maximum weed control efficiency followed by pendimethalin 24% + oxyfluorfen 4% ZE @600+102.5 g a.i./ha PE (T<sub>3</sub>) and oxyfluorfen 23.5% EC@ 200 g a.i./ha PE (T<sub>6</sub>). Weed control efficacy ranged between 89.77 to 56.32 % at 20 DAT.

At 40 DAT, maximum weed control efficacy of 92.40% was observed under treatment of HW at 25 and 45 DAT (T<sub>8</sub>) followed by treatments of withpendimethalin 24% + oxyfluorfen 4% ZE @600+102.5 g a.i./ha as pre emergence (T<sub>3</sub>) i.e. 90.31%, oxyfluorfen 23.5% EC@ 200 g a.i./ha PE (T<sub>6</sub>) i.e. 90.20, pendimethalin 24% + oxyfluorfen 4% ZE @1083.60+185.12 g a.i./ha PE (T<sub>4</sub>)(89.77) and pendimethalin 24% + oxyfluorfen 4% ZE @541.80+92.56 g a.i./haPE (T<sub>2</sub>). Weedy check (T<sub>9</sub>) recorded minimum weed control efficiency owing to uncontrolled conditions favoured luxurious weed growth leading to increased weed dry matter. These findings are also supported by Poddar *et al.* (2014). Similar trend of weed control efficiency was observed at 60 DAT, 80 DAT and at harvest.

Maximum weed control efficiency was registered under the treatments of HW at 25 and 45 DAT (T<sub>8</sub>) followed by pendimethalin 24% + oxyfluorfen 4% ZE @600+102.5 g a.i./ha as pre emergence (T<sub>3</sub>), oxyfluorfen 23.5% EC@ 200 g a.i./ha PE (T<sub>6</sub>) and pendimethalin 24% + oxyfluorfen 4% ZE @1083.60+185.12 g a.i./ha PE (T<sub>4</sub>). The well-developed crop canopy, intercepting solar energy effectively by crop covered the ground area which reduced the weed emergence and increased the weed control efficiency. The herbicides that have longer effect on controlling the monocot as well as dicot weeds population and thereby increasing weed control efficiency. These results are in accordance with those reported by Kolseet *et al.* (2010), Shinde *et al.* (2012) and Jangreet *et al.* (2014) and Sable *et al.* (2015). Lower weed control efficacy was recorded under treatment of quizalofop ethyl 5% EC@ 50 g a.i./ha applied as post emergence (T<sub>7</sub>).

**Table 13: Weed control efficiency (%) and weed index (%) as Influenced by different weed control treatments**

| Treatment                                                                           | Weed control efficiency (%) |        |        |        |            | Weed index (%) |
|-------------------------------------------------------------------------------------|-----------------------------|--------|--------|--------|------------|----------------|
|                                                                                     | 20 DAT                      | 40 DAT | 60 DAT | 80 DAT | At Harvest |                |
| T <sub>1</sub> - Pendimethalin 24% + Oxyfluorfen 4% ZE @480+82 g a.i./ha PE         | 81.64                       | 83.44  | 83.14  | 82.40  | 80.89      | 25.30          |
| T <sub>2</sub> - Pendimethalin 24% + Oxyfluorfen 4% ZE @541.80+92.56 g a.i./ha PE   | 85.19                       | 86.94  | 86.32  | 83.53  | 83.13      | 22.53          |
| T <sub>3</sub> - Pendimethalin 24% + Oxyfluorfen 4% ZE @600+102.5 g a.i./ha PE      | 88.64                       | 90.31  | 90.07  | 88.70  | 85.86      | 4.29           |
| T <sub>4</sub> - Pendimethalin 24% + Oxyfluorfen 4% ZE @1083.60+185.12 g a.i./ha PE | 89.77                       | 89.77  | 89.90  | 87.82  | 84.73      | 14.78          |
| T <sub>5</sub> - Pendimethalin 38.7% CS@ 677.25 g a.i./ha PE                        | 82.51                       | 85.64  | 84.71  | 83.67  | 79.51      | 33.35          |
| T <sub>6</sub> - Oxyfluorfen 23.5% EC@ 200 g a.i./ha PE                             | 87.87                       | 90.20  | 89.74  | 88.02  | 85.29      | 12.25          |
| T <sub>7</sub> - Quizalofop ethyl 5% EC@ 50 g a.i./ha PoE                           | 56.32                       | 82.15  | 79.73  | 76.33  | 72.01      | 27.93          |
| T <sub>8</sub> - Two HW (25 & 45 DAT)                                               | 65.09                       | 92.40  | 90.26  | 89.99  | 88.49      | -              |
| T <sub>9</sub> - Weedy Check                                                        | -                           | -      | -      | -      | -          | 54.33          |

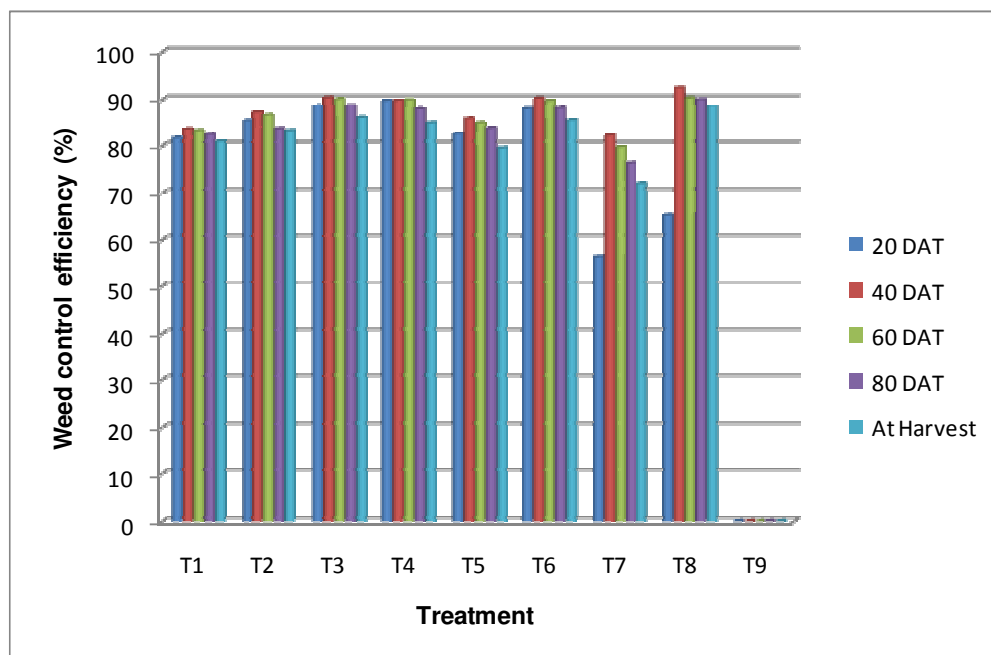


**Fig. 7a Weed control efficiency (%) as Influenced by different weed control treatments**

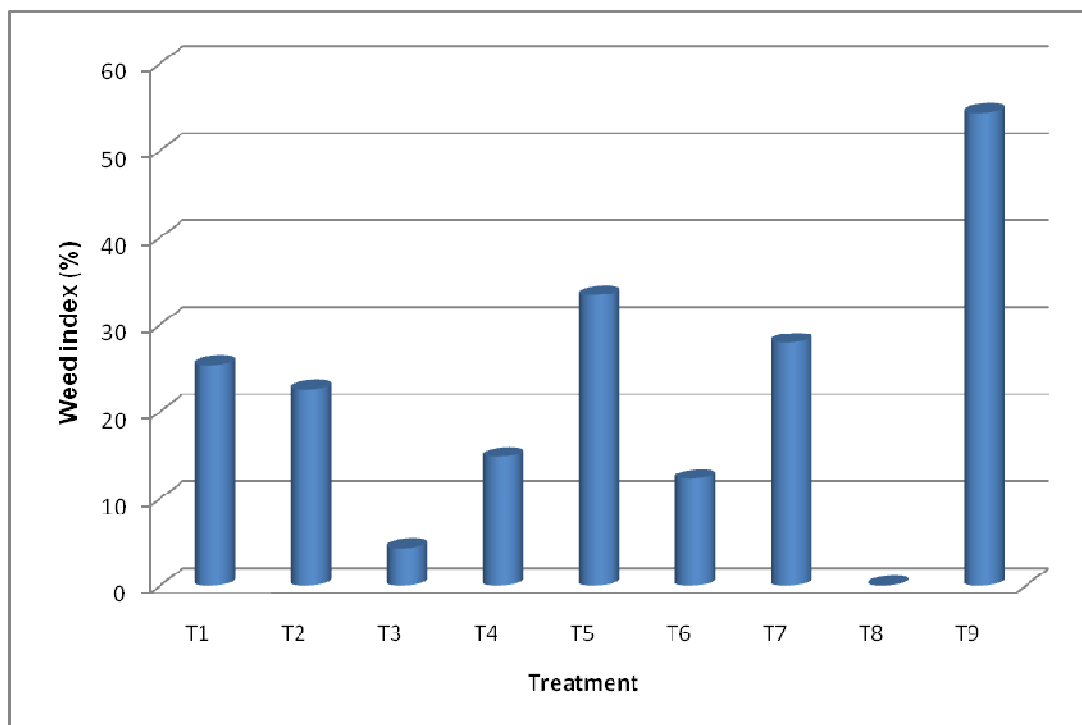


**Fig. 7b Weed index (%) as Influenced by different weed control treatments**

#### **4.1.5 Weed Index**

Data pertaining to weed index (%) are presented in Table 13 and depicted in fig 7b. Weed index was computed as the yield reduction comparative to highest yielding treatment i.e. Weed free (T<sub>9</sub>).

Data presented in the Table 13 showed that effect of weed management practices on the weed index. Weedy check (T<sub>9</sub>) showed the highest weed index 54.33 per cent while the lowest weed index (4.29) was recorded in pendimethalin 24% + oxyfluorfen 4% ZE @600+102.5 g a.i./ha PE (T<sub>3</sub>) during experimentation. Similarly, application of oxyfluorfen 23.5% EC@ 200 g a.i./ha PE (T<sub>6</sub>), pendimethalin 24% + oxyfluorfen 4% ZE @1083.60+185.12 g a.i./ha PE (T<sub>4</sub>) and pendimethalin 24% + oxyfluorfen 4% ZE @541.80+92.56 g a.i./ha PE (T<sub>2</sub>) are the next best treatments, with regards to recording lower weed index.

Treatment T<sub>9</sub>(weedy check) recorded maximum weed index i.e. 54.33% indicating the reduction in onion bulb yield due to presence of weeds throughout crop growth period. Lower the weed index better the weed control efficiency of that herbicides.

Lower weed index in chemical treatments alone and mechanical weed control practices might be due to better weed control which provided favourable conditions for crop growth which ultimately increased the bulb yield of onion crop as compared to weedy check treatment. Similar results were also reported by Kolseet *al.* (2010), and Sable *et al.* (2010).

#### **4.1.6 Crop phytotoxicity**

Phytotoxicity symptoms due to herbicides on crop were recorded by using a visual score scale of 0-10. Visual assessment of herbicide toxicity on crop was recorded 10 days after application of herbicide in respective treatment.

**Table 14: Phytotoxicity symptoms on onion crop (score 0-10 scale)**

| Treatment                                                                           | Phytotoxicity parameters observed*<br>(mean observations recorded at 10 day after herbicide application) |                    |          |                         |           |         |
|-------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------|--------------------|----------|-------------------------|-----------|---------|
|                                                                                     | Leaf injury on tips/surface                                                                              | Necrosis/scorching | Epinasty | Vein Clearing/yellowing | Hyponasty | Wilting |
| T <sub>1</sub> - Pendimethalin 24% + Oxyfluorfen 4% ZE @480+82 g a.i./ha PE         | 0                                                                                                        | 0                  | 0        | 0                       | 0         | 0       |
| T <sub>2</sub> - Pendimethalin 24% + Oxyfluorfen 4% ZE @541.80+92.56 g a.i./ha PE   | 0                                                                                                        | 0                  | 0        | 0                       | 0         | 0       |
| T <sub>3</sub> - Pendimethalin 24% + Oxyfluorfen 4% ZE @600+102.5 g a.i./ha PE      | 0                                                                                                        | 0                  | 0        | 0                       | 0         | 0       |
| T <sub>4</sub> - Pendimethalin 24% + Oxyfluorfen 4% ZE @1083.60+185.12 g a.i./ha PE | 1                                                                                                        | 1                  | 0        | 0                       | 0         | 0       |
| T <sub>5</sub> - Pendimethalin 38.7% CS@ 677.25 g a.i./ha PE                        | 0                                                                                                        | 0                  | 0        | 0                       | 0         | 0       |
| T <sub>6</sub> - Oxyfluorfen 23.5% EC@ 200 g a.i./ha PE                             | 0                                                                                                        | 0                  | 0        | 0                       | 0         | 0       |
| T <sub>7</sub> - Quizalofop ethyl 5% EC@ 50 g a.i./ha PoE                           | 0                                                                                                        | 0                  | 0        | 0                       | 0         | 0       |
| T <sub>8</sub> - Two HW (25 & 45 DAT)                                               | 0                                                                                                        | 0                  | 0        | 0                       | 0         | 0       |
| T <sub>9</sub> - Weedy Check                                                        | 0                                                                                                        | 0                  | 0        | 0                       | 0         | 0       |

The data presented in Table 14. revealed that none of the herbicides under study shown any phytotoxicity symptoms on crop growth during the experimentation only with the exception of treatment (T<sub>4</sub>) pendimethalin 24% + oxyfluorfen 4% ZE @1083.60+185.12 g a.i./ha as PE where leaf injury on tips and necrosis observed which was upto the easily recoverable extent was observed. The phytotoxicity was seen initially but the onion plants that were injured was recovered upto harvest. The results are in accordance with the finding of Yadav *et al.* (2009) and Uygure *et al.* (2010).

#### 4.2 Effect of treatments on crop parameter

The section of effect on crop parameter include plant studies (initial and final plant population) and under growth studies plant height, no. of leaves, fresh bulb weight, fresh leaf weight and dry matter of plant in onion has been studied and the results obtained for various plant parameters are placed and discussed under appropriate sub titles.

#### 4.2.1 Effect of herbicides on plant population

Data pertaining to initial plant stand of onion at 20 days after transplanting and final plant stand at harvest per net plot as influenced by different treatments during 2018-2019 are presented in Table 15.

**Table 15: Plant population of onion per net plot as influenced by different weed control treatments**

| Treatment                                                                           | Initial plant stand                |               | Final plant stand                  |               |
|-------------------------------------------------------------------------------------|------------------------------------|---------------|------------------------------------|---------------|
|                                                                                     | Plant count net plot <sup>-1</sup> | Percent count | Plant count net plot <sup>-1</sup> | Percent count |
| T <sub>1</sub> - Pendimethalin 24% + Oxyfluorfen 4% ZE @480+82 g a.i./ha PE         | 1392                               | 99.30         | 1366                               | 97.36         |
| T <sub>2</sub> - Pendimethalin 24% + Oxyfluorfen 4% ZE @541.80+92.56 g a.i./ha PE   | 1383                               | 98.57         | 1355                               | 96.57         |
| T <sub>3</sub> - Pendimethalin 24% + Oxyfluorfen 4% ZE @600+102.5 g a.i./ha PE      | 1379                               | 98.28         | 1349                               | 96.15         |
| T <sub>4</sub> - Pendimethalin 24% + Oxyfluorfen 4% ZE @1083.60+185.12 g a.i./ha PE | 1366                               | 97.36         | 1307                               | 93.15         |
| T <sub>5</sub> - Pendimethalin 38.7% CS@ 677.25 g a.i./ha PE                        | 1385                               | 98.70         | 1343                               | 95.72         |
| T <sub>6</sub> - Oxyfluorfen 23.5% EC@ 200 g a.i./ha PE                             | 1375                               | 98.00         | 1347                               | 96.00         |
| T <sub>7</sub> - Quizalofop ethyl 5% EC@ 50 g a.i./ha PoE                           | 1381                               | 98.43         | 1351                               | 96.29         |
| T <sub>8</sub> - Two HW (25 & 45 DAT)                                               | 1384                               | 98.78         | 1360                               | 96.93         |
| T <sub>9</sub> - Weedy Check                                                        | 1386                               | 98.64         | 1371                               | 97.71         |
| S.E(m)±                                                                             | 68.39                              | 4.94          | 89.62                              | 4.87          |
| C.D. at 5%                                                                          | NS                                 | NS            | NS                                 | NS            |
| G.M.                                                                                | 1381                               | 98.45         | 1355                               | 96.21         |

The mean initial and final stand during the year 2018-2019 was 1381 and 1355 per net plot respectively. The mean per cent initial count and final stand during the year 2018-2019 was 98.45 and 96.21 per cent, respectively; giving rise to a conclusion that plant population was not a variable factor. It also indicate that the variation in various plant parameters (which are presented and discussed here after) were emerged due to the treatment differences and not due to variation caused by differing plant population, either at initial or harvest stage. Even the phytotoxicity of herbicide in one of the treatment i.e. pendimethalin 24% + oxyfluorfen 4%

ZE @1083.60+185.12 g a.i./ha (T<sub>4</sub>) did not change plant population at harvest.

The effect of herbicide and weed management practices was found non-significant. This indicated uniform plant population under all treatments, its persistence throughout the crop growth period and no any adverse effect of different herbicides applied to the onion crop. The treatment differences therefore on different parameters under study were treatment effect and plant population was not a variable factor. Similar results were reported by Waradeet *al.* (2008) and Kolseet *al.* (2010).

#### **4.2.2 Growth studies**

Growth is a multidimensional web of many parameters. It is a phenotypic expression with respect to nutrient status, provided all other conditions are favorable. The different growth parameters are studied and the results are discussed herewith.

#### **4.2.3 Plant height (cm)**

The apical meristem is responsible for vertical growth, organ increase in length of a stem i.e. modified leaf in case of onion. These cells in the apical meristem undergo mitosis reflecting in increased plant height. Any imbalance between the resources of the soil and the plant needs causes variations in the plant height and ultimately in its overall growth. Availability of soil resources for the plant growth depends largely on the factors which influences the physical status of soil, apart from its chemical and biological circumstances. Hence, it becomes certain to observe the plant height at a periodical interval, so as to distinguish the treatment effects, if any.

Data on plant height as influenced by different weed management treatments recorded at 20 days interval are given in Table 16 and graphically depicted in Fig.8. The height of the plant was increased subsequently at the growth stages i.e. 20, 40, 60 and 80 DAT, but it was decreased at the harvesting stage during the experimentation due to leaf fall by the senescence. Mean plant height increased from 28.17 to 72.95 cm from 20 DAT to 80 DAT and at harvesting stage it decreases upto 35.36cm. The rate of increase in plant height was quite rapid during 20 to 40

DAT, moderate between 40 to 60 DAT and subsequently the rate of increase was much lesser towards the crop harvest stage.

**Table 16: Plant height (cm) at periodical growth stages as influenced by different weed control treatments**

| Treatment                                                                          | 20<br>DAT | 40<br>DAT | 60<br>DAT | 80<br>DAT | At<br>Harvest |
|------------------------------------------------------------------------------------|-----------|-----------|-----------|-----------|---------------|
| T <sub>1</sub> - Pendimethalin 24% + Oxyfluorfen 4% ZE @480+82 g a.i./ha PE        | 26.50     | 51.17     | 56.73     | 67.93     | 31.10         |
| T <sub>2</sub> - Pendimethalin 24% + Oxyfluorfen 4% ZE @541.80+92.56 g a.i./ha PE  | 27.73     | 52.27     | 61.33     | 72.77     | 33.27         |
| T <sub>3</sub> - Pendimethalin 24% + Oxyfluorfen 4% ZE @600+102.5 g a.i./ha PE     | 29.03     | 57.00     | 72.60     | 77.87     | 40.97         |
| T <sub>4</sub> - Pendimethalin 24% + Oxyfluorfen 4% ZE @1836.0+185.12 g a.i./ha PE | 28.17     | 55.13     | 68.83     | 75.80     | 36.33         |
| T <sub>5</sub> - Pendimethalin 38.7% CS@ 677.25 g a.i./ha PE                       | 26.23     | 52.17     | 61.53     | 70.53     | 31.97         |
| T <sub>6</sub> - Oxyfluorfen 23.5% EC@ 200 g a.i./ha PE                            | 28.60     | 56.17     | 69.67     | 76.43     | 41.67         |
| T <sub>7</sub> - Quizalofop ethyl 5% EC@ 50 g a.i./ha PoE                          | 27.37     | 51.30     | 60.43     | 71.23     | 31.77         |
| T <sub>8</sub> - Two HW (25 & 45 DAT)                                              | 30.53     | 59.23     | 73.23     | 80.60     | 43.67         |
| T <sub>9</sub> - Weedy Check                                                       | 29.37     | 36.50     | 51.00     | 60.03     | 27.47         |
| S.E(m)±                                                                            | 1.5       | 2.58      | 3.53      | 3.77      | 2.4           |
| C.D. at 5%                                                                         | NS        | 7.73      | 10.58     | 11.33     | 7.2           |
| G.M.                                                                               | 28.17     | 52.33     | 63.93     | 72.95     | 35.36         |

The plant height of onion was significantly influenced due to different treatments at all the growth stages, except at 20 DAT. The non significant effects at 20 DAT might be due to less improvement in growth. For stimulation of plant growth hormones, supply of water and nutrients through the ideal root system becomes inevitable and from 20DAT onwards and hence root system more developed due to proper fixation of roots. Hence 20DAT onwards upto harvest at all the stages of crop growth was in continuous increasing trend in plant height.

The maximum plant height was recorded at two HW (25 & 45 DAT) (T<sub>8</sub>) which was closely followed and found at par with pendimethalin 24% + oxyfluorfen 4% ZE @600+102.5 g a.i./ha (T<sub>3</sub>), oxyfluorfen 23.5% EC@ 200 g a.i./ha (T<sub>6</sub>), pendimethalin 24% + oxyfluorfen 4% ZE @1836.0+185.12 g a.i./ha (T<sub>4</sub>), pendimethalin 24% + oxyfluorfen 4% ZE

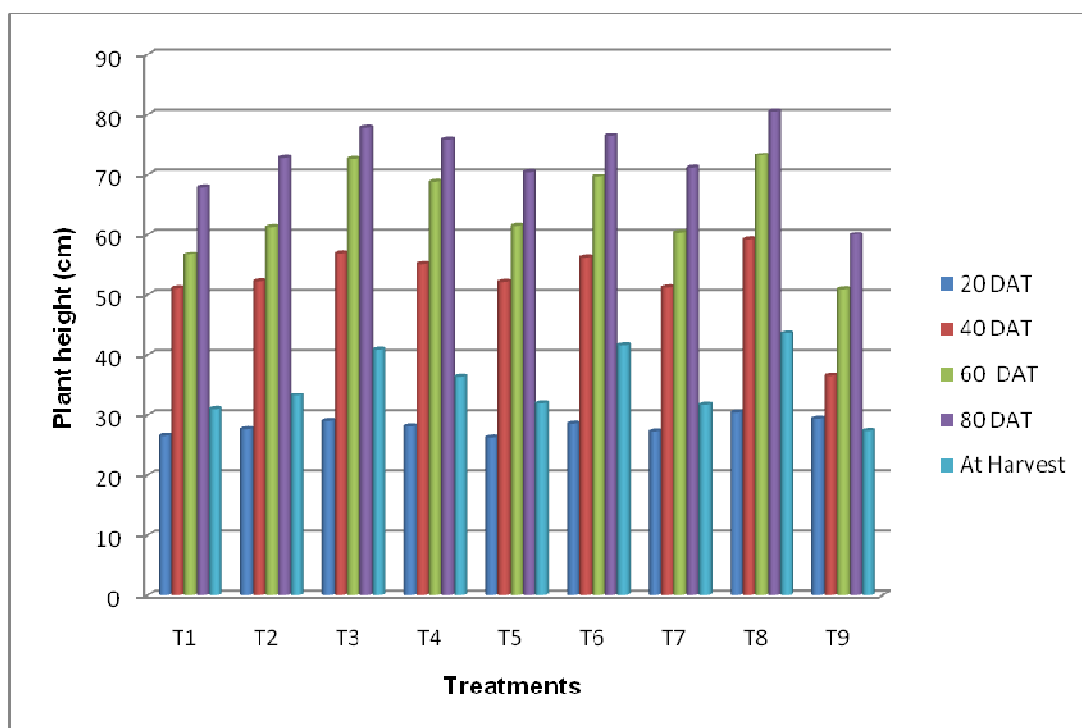


**Fig. 8 Plant height (cm) at periodical growth stages as influenced by different weed control treatments**

@541.80+92.56 g a.i./ha (T<sub>2</sub>) pendimethalin 38.7% CS@ 677.25 g a.i./ha (T<sub>5</sub>) at all the growth stages during experimentation and was found significantly superior over rest of the treatments of herbicide.

The increase in plant height of onion under treatment Two HW (25 & 45 DAT)(T<sub>8</sub>) and treatment pendimethalin 24% + oxyfluorfen 4% ZE @600+102.5 g a.i./ha (T<sub>3</sub>) might be due to the least weed population observed in the treatments, which reduced the crop weed competition. Significant reduction in plant height was noticed in unweeded control treatment at all the growth stages of the crop. Decrease in plant height might be due to the fact that weeds suppressed the vegetative growth of plants by the competition between crop and weeds for soil moisture, plant nutrients, solar radiation and space during active growth period. These results are in accordance with the findings reported by Saraf (2007) and Kolse *et al.* (2010).

#### **4.2.4 Number of Leaves plant<sup>-1</sup>**

Leaves are complex plant organs upon which plant life depend. They are highly efficient solar energy converters. Their number over plant directly indicates the behavioral adaptation due to changes in the nutritional supply capacity of the soil, keeping all the other factors constant. Hence, during the present investigation the number of leaves per plant of onion was counted to record the variations due to various herbicide treatments.

Numbers of leaves per plant at different growth stages of onion as influenced due to different treatments are presented in Table 17 .

Effect of various herbicidal treatments on functional leaves was found to be significant during all the periodical crop growth stages, except at 20 DAT, where the leaf production rate was much similar among the treatments. Significantly maximum number of functional leaves (4.33, 7.67, 9.53, 10 and 4.40) at 20, 40, 60, 80 DAT and harvest during the experimentation, respectively was registered with treatment 2 HW 25 & 45 DAT (T<sub>8</sub>).

**Table 17: Number of leaves plant<sup>-1</sup> as influenced by different weed control treatments**

| Treatment                                                                           | 20 DAT | 40 DAT | 60 DAT | 80 DAT | At Harvest |
|-------------------------------------------------------------------------------------|--------|--------|--------|--------|------------|
| T <sub>1</sub> - Pendimethalin 24% + Oxyfluorfen 4% ZE @480+82 g a.i./ha PE         | 3.83   | 6.23   | 7.57   | 8.90   | 3.70       |
| T <sub>2</sub> - Pendimethalin 24% + Oxyfluorfen 4% ZE @541.80+92.56 g a.i./ha PE   | 3.93   | 6.41   | 7.97   | 8.53   | 3.63       |
| T <sub>3</sub> - Pendimethalin 24% + Oxyfluorfen 4% ZE @600+102.5 g a.i./ha PE      | 4.13   | 7.27   | 8.63   | 9.83   | 4.03       |
| T <sub>4</sub> - Pendimethalin 24% + Oxyfluorfen 4% ZE @1083.60+185.12 g a.i./ha PE | 4.10   | 6.70   | 8.10   | 9.27   | 3.93       |
| T <sub>5</sub> - Pendimethalin 38.7% CS@ 677.25 g a.i./ha PE                        | 3.50   | 6.07   | 7.53   | 8.20   | 3.60       |
| T <sub>6</sub> - Oxyfluorfen 23.5% EC@ 200 g a.i./ha PE                             | 4.03   | 6.83   | 8.30   | 9.53   | 4.00       |
| T <sub>7</sub> - Quizalofop ethyl 5% EC@ 50 g a.i./ha PoE                           | 3.23   | 6.30   | 7.77   | 8.07   | 3.57       |
| T <sub>8</sub> - Two HW (25 & 45 DAT)                                               | 4.33   | 7.67   | 9.53   | 10.00  | 4.40       |
| T <sub>9</sub> -Weedy Check                                                         | 3.40   | 5.93   | 6.57   | 7.01   | 2.93       |
| S.E(m)±                                                                             | 0.21   | 0.35   | 0.38   | 0.52   | 0.24       |
| C.D. at 5%                                                                          | NS     | 1.05   | 1.16   | 1.58   | 0.74       |
| G.M.                                                                                | 3.83   | 6.60   | 8.00   | 8.82   | 3.76       |

At 20 DAT stage mean number of leaves per plant were 3.83. By 80 DAT, mean number of leaves were maximum with 8.82. Subsequently towards harvest stage number of leaves decreased due to senescence of leaves which occurred during investigation.

At all the stages of crop growth leaves per plant were affected significantly due to decreased in crop weed competition through herbicide application at 40 DAT and onwards where number of leaves were influenced due to different herbicide concentration. Two HW (25 & 45 DAT) (T<sub>8</sub>) registered maximum number of leaves which was closely followed by pendimethalin 24% + oxyfluorfen 4% ZE @600+102.5 g a.i./ha (T<sub>3</sub>) and were found at par at oxyfluorfen 23.5% EC@ 200 g a.i./ha (T<sub>6</sub>) and pendimethalin 24% + oxyfluorfen 4% ZE @1083.60+185.12 g a.i./ha (T<sub>4</sub>) and other treatments followed by above treatments. Lower number of leaves plant<sup>-1</sup> was recorded in treatment (T<sub>9</sub>)(Weedy check). Similar results were reported by Bharti *et al.* (2011).

#### 4.2.5 Influence of herbicides on fresh leaves weight of onion plant (g)

The variation in weight of green leaves indicates the biomass production capacity of the onion plant due to effect of herbicide in crop weed competition through application in different concentration. Data pertaining to mean weight of leaves per plant as influenced by various treatments at different growth stages are presented in Table 18 and graphically depicted fig9. The mean weight of green leaves per plant was significantly influenced by the herbicidal treatments at 40, 60 and 80 DAT and later on it was decreased at harvesting stage during the years of experimentation.

The weight of fresh leaves was influenced significantly by various herbicidal treatments at all the growth stages except at 20 DAT. From 40 DAT & onward significantly higher weight of leaves per plant was recorded in treatment with 2 HW (25 & 45 DAT) ( $T_8$ ) when compared with all other remaining treatment. However, pendimethalin 24% + oxyfluorfen 4% ZE @ 600+102.5 g a.i./ha ( $T_3$ ) was significantly at par with oxyfluorfen 23.5% EC @ 200 g a.i./ha ( $T_6$ ) and pendimethalin 24% + oxyfluorfen 4% ZE @ 1083.60+185.12 g a.i./ha ( $T_4$ ).

Similar trend of leaf weight was observed in treatment with herbicide application on 60 DAT, 80 DAT & at harvest as observed on 40 DAT. This is because very close difference was noticed among these treatments indicative of the fact that response of herbicides in minimizing weed population in onion. Minimum number of fresh leaves weight plant<sup>-1</sup> was recorded in treatment ( $T_9$ ) i.e. weedy check. The higher weight of green leaves might be due to increased plant height and number of leaves due to decrease in competition for nutrient, space, water, sunlight between onion crop and weed. Similar results were reported by Saini and Walia (2012).

**Table 18: Fresh leaves weight (g) as influenced by different weed control treatments**

| Treatment | 20 | 40 | 60 | 80 | At |
|-----------|----|----|----|----|----|
|-----------|----|----|----|----|----|

|                                                                                     | DAT  | DAT   | DAT   | DAT   | Harvest |
|-------------------------------------------------------------------------------------|------|-------|-------|-------|---------|
| T <sub>1</sub> - Pendimethalin 24% + Oxyfluorfen 4% ZE @480+82 g a.i./ha PE         | 3.10 | 14.13 | 20.13 | 52.60 | 31.37   |
| T <sub>2</sub> - Pendimethalin 24% + Oxyfluorfen 4% ZE @541.80+92.56 g a.i./ha PE   | 3.50 | 15.30 | 23.97 | 54.53 | 34.07   |
| T <sub>3</sub> - Pendimethalin 24% + Oxyfluorfen 4% ZE @600+102.5 g a.i./ha PE      | 3.97 | 20.87 | 29.93 | 61.17 | 39.23   |
| T <sub>4</sub> - Pendimethalin 24% + Oxyfluorfen 4% ZE @1083.60+185.12 g a.i./ha PE | 3.77 | 19.60 | 28.53 | 59.10 | 37.97   |
| T <sub>5</sub> - Pendimethalin 38.7% CS@ 677.25 g a.i./ha PE                        | 3.37 | 14.30 | 19.97 | 53.30 | 28.83   |
| T <sub>6</sub> - Oxyfluorfen 23.5% EC@ 200 g a.i./ha PE                             | 3.83 | 19.63 | 28.90 | 60.40 | 38.40   |
| T <sub>7</sub> - Quizalofop ethyl 5% EC@ 50 g a.i./ha PoE                           | 3.50 | 18.30 | 20.63 | 56.47 | 31.37   |
| T <sub>8</sub> - Two HW (25 & 45 DAT)                                               | 4.07 | 22.20 | 30.87 | 65.00 | 40.27   |
| T <sub>9</sub> - Weedy Check                                                        | 3.57 | 8.93  | 13.60 | 43.77 | 21.83   |
| S.E(m)±                                                                             | 0.30 | 1.10  | 1.39  | 3.17  | 2.2     |
| C.D. at 5%                                                                          | NS   | 3.30  | 4.19  | 9.52  | 6.6     |
| G.M.                                                                                | 3.63 | 17.03 | 24.06 | 56.26 | 33.70   |

#### 4.2.6 Influence of herbicides on fresh bulb weight of onion plant (g)

The data on fresh bulb weight at different growth stages i.e. 20, 40, 60, 80 and at harvest were recorded during investigation, presented in Table 19 and graphically depicted (at harvest stage) in Fig 10. showed progressive increase in fresh bulb weight as influenced by various herbicidal treatments at every stages of crop growth up to maturity by the herbicidal treatments. Initially, the mean bulb fresh weight was 2.29 g which increases upto 89.14 g at the harvesting stage during the years of experimentation.

The fresh bulb weight of onion recorded at 20 DAT in different herbicidal treatment with different concentration are presented in Tables 19 and revealed that fresh bulb weight at all growth stages were significantly the highest under treatment with 2 hand weeding at 25 and 45 DAT (T<sub>8</sub>) i.e. weed free and lowest in weedy check (T<sub>9</sub>) treatment while among he

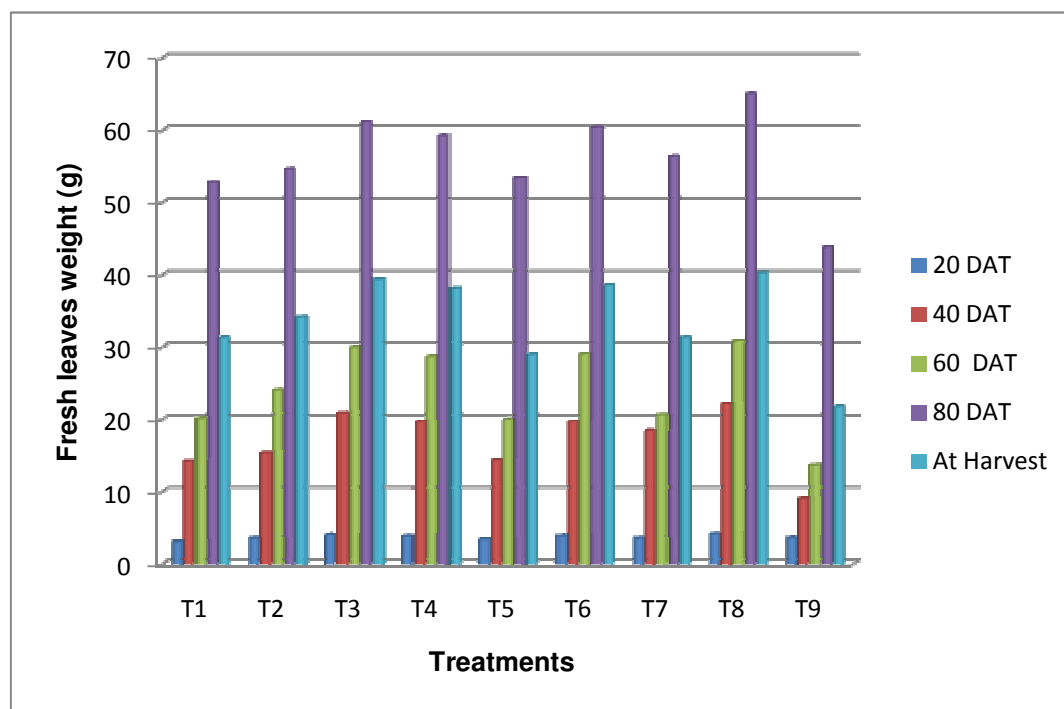


**Fig. 9 Fresh leaves weight (g) as influenced by different weed control treatments**

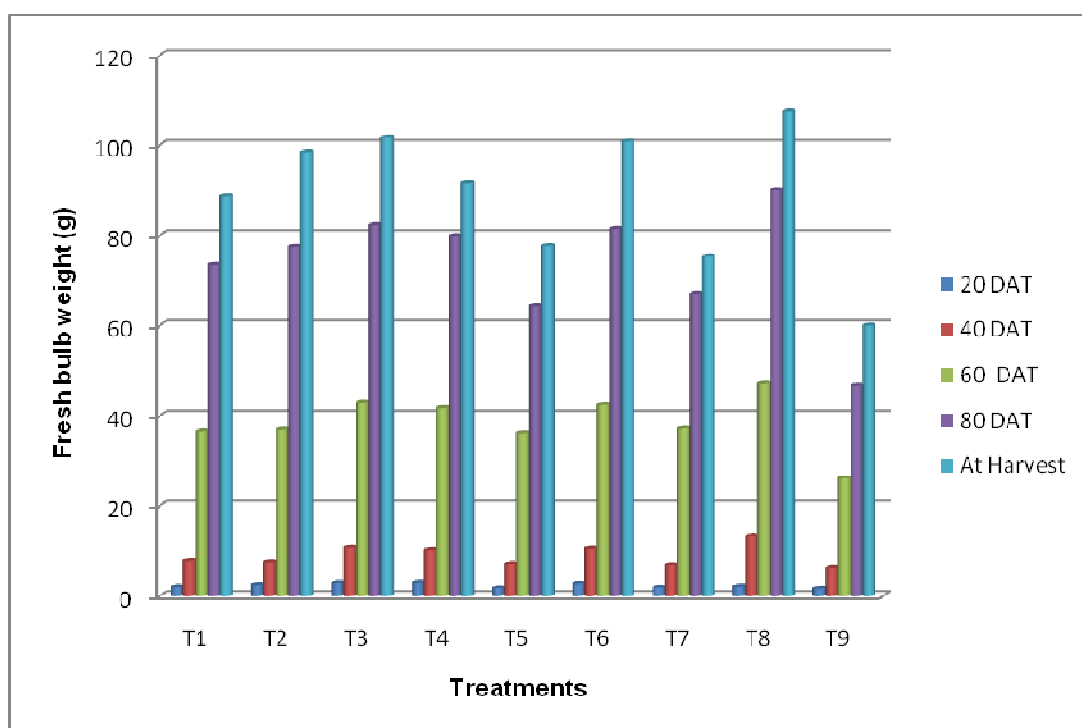


**Fig. 10 Fresh bulb weight (g) as influenced by different weed control treatments**

herbicidal treatment, treatment with application of pendimethalin 24% + oxyfluorfen 4% ZE @600+102.5 g a.i./ha (T<sub>3</sub>), oxyfluorfen 23.5% EC@ 200 g a.i./ha (T<sub>6</sub>) and pendimethalin 24% + oxyfluorfen 4% ZE @541.80+92.56 g a.i./ha (T<sub>2</sub>) were statistically at par with each other. This might be due to favourable effect of herbicidal application to improved competing potential of crop with weed which decreased weed population and helps to utilize supplied nutrients to crops hence improve fresh bulb weight initially.

At 40 DAT, treatment with 2 HW 25& 45 DAT (T<sub>8</sub>) recorded maximum fresh bulb weight of onion (22.20 g) than that of weedy check (T<sub>9</sub>) (8.93g) which was statistically at par with treatment (T<sub>3</sub>) i.e. pendimethalin 24% + oxyfluorfen 4% ZE @600+102.5 g a.i./ha, (T<sub>6</sub>) i.e. oxyfluorfen 23.5% EC@ 200 g a.i./ha and (T<sub>4</sub>) i.e. pendimethalin 24% + oxyfluorfen 4% ZE @1083.60+185.12 g a.i./ha. These treatments are at par to weed free(T<sub>8</sub>) treatment. The results clearly indicated that there was a significant difference as influenced by different herbicide treatments on fresh bulb weight at all the growth stages. Similar trend of bulb leaf weight was observed at 60 DAT, 80 DAT and at harvest.

Among the treatments,during experimentation two HW (25 & 45 DAT) (T<sub>8</sub>) registered significantly the highest fresh bulb weight of 2.13, 13.40, 47.20, 90.13, and 107.60g at 20, 40, 60, 80 and at harvest respectively during the experimentation. Initially, at first observation weight of bulb was not highest this is because HW was conducted at 25 DAT and observation was recorded at 20DAT. It was closely followed and statistically similar with treatmentpendimethalin 24% + oxyfluorfen 4% ZE @600+102.5 g a.i./ha (T<sub>3</sub>), oxyfluorfen 23.5% EC@ 200 g a.i./ha (T<sub>6</sub>), pendimethalin 24% + oxyfluorfen 4% ZE @1083.60+185.12 g a.i./ha (T<sub>4</sub>) at all the growth stages. The lower bulb weight was registered in treatmentweedy check (T<sub>9</sub>) because of presence higher number of weed population which compete with onion and create problem of low chlorophyll content and photosynthetic rates due to unchecked weed growth, there by reduction in the availability of moisture, light and nutrient to the crop resulted in loss of weight. Similar results were reported by Bhutia *et al.* (2005) and Saini and walia (2012).

**Table 19: Fresh bulb weight (g) as influenced by different weed control treatments**

| Treatment                                                                           | 20<br>DAT | 40<br>DAT | 60<br>DAT | 80<br>DAT | At<br>Harvest |
|-------------------------------------------------------------------------------------|-----------|-----------|-----------|-----------|---------------|
| T <sub>1</sub> - Pendimethalin 24% + Oxyfluorfen 4% ZE @480+82 g a.i./ha PE         | 2.07      | 7.80      | 36.65     | 73.53     | 88.87         |
| T <sub>2</sub> - Pendimethalin 24% + Oxyfluorfen 4% ZE @541.80+92.56 g a.i./ha PE   | 2.47      | 7.47      | 37.05     | 77.53     | 98.50         |
| T <sub>3</sub> - Pendimethalin 24% + Oxyfluorfen 4% ZE @600+102.5 g a.i./ha PE      | 2.90      | 10.80     | 42.90     | 82.33     | 101.77        |
| T <sub>4</sub> - Pendimethalin 24% + Oxyfluorfen 4% ZE @1083.60+185.12 g a.i./ha PE | 2.93      | 10.27     | 41.77     | 79.97     | 91.60         |
| T <sub>5</sub> - Pendimethalin 38.7% CS@ 677.25 g a.i./ha PE                        | 1.80      | 7.12      | 36.30     | 64.37     | 77.70         |
| T <sub>6</sub> - Oxyfluorfen 23.5% EC@ 200 g a.i./ha PE                             | 2.77      | 10.63     | 42.47     | 81.53     | 100.87        |
| T <sub>7</sub> - Quizalofop ethyl 5% EC@ 50 g a.i./ha PoE                           | 1.93      | 6.90      | 37.27     | 67.13     | 75.37         |
| T <sub>8</sub> - Two HW (25 & 45 DAT)                                               | 2.13      | 13.40     | 47.20     | 90.13     | 107.60        |
| T <sub>9</sub> - Weedy Check                                                        | 1.70      | 6.30      | 26.17     | 46.70     | 60.03         |
| S.E(m)±                                                                             | 0.17      | 0.47      | 1.60      | 3.67      | 4.45          |
| C.D. at 5%                                                                          | 0.51      | 1.4       | 4.81      | 11.02     | 13.34         |
| G.M.                                                                                | 2.30      | 8.96      | 38.64     | 73.69     | 89.14         |

#### 4.2.7 Dry matter accumulation plant<sup>-1</sup>

Dry matter is a function of vegetative and reproductive development of plant body. It is not necessary that the plant which possesses ability to develop vegetatively, also bear the capacity to convert it in developing reproductive plant parts. Under such circumstances, it may happen to that luxurious vegetative growth superseding the reproductive growth, especially under the conditions of imbalanced supply of food material due to crop weed competition. Hence any external influence which alters the capability of the soil to provide essential nutrients by way of management practices, directly affect the production plant dry matter. Hence, it is inevitable to measure the accumulation of plant dry matter to test the treatment differences, if any, periodical estimation of plant dry matter accumulation was done during the period of present investigation.

The accumulation of dry matter per plant is the best index of growth put forth by the crop. Relevant data on the dry matter accumulation recorded periodically are given in Table 20. Progressive increase in the total dry matter accumulation per plant as influenced by various herbicidal treatments have been illustrated in Fig.11. The dry matter accumulation reached to its maximum of 15.74 g at harvest during present investigation. During the crop growth period, increase in dry matter per plant (g) was continuous upto harvest. The rate of increase was slow upto 40 DAT, but during 40 DAT to 80 DAT the rate accelerated.

All the weed control treatments significantly influenced the dry matter accumulation plant<sup>-1</sup> at all the growth stages of crop except at 20 DAT. At 40 DAT, treatment with two HW (25 & 45 DAT) (T<sub>8</sub>) was accumulated significantly higher plant dry matter over treatment T<sub>9</sub> (weedy check). Treatment with application of pendimethalin 24% + oxyfluorfen 4% ZE @600+102.5 g a.i./ha (T<sub>3</sub>), oxyfluorfen 23.5% EC@ 200 g a.i./ha (T<sub>6</sub>), pendimethalin 24% + oxyfluorfen 4% ZE @1083.60+185.12 g a.i./ha (T<sub>4</sub>) were statistically at par with each other.

At 60 DAT, treatment T<sub>8</sub> (weed free with 2 HW 25 & 45 DAT) was comparable with treatments pendimethalin 24% + oxyfluorfen 4% ZE @600+102.5 g a.i./ha (T<sub>3</sub>) and oxyfluorfen 23.5% EC@ 200 g a.i./ha (T<sub>6</sub>) which was at par with each other and recorded significantly higher dry matter over treatments pendimethalin 24% + oxyfluorfen 4% ZE @480+82 g a.i./ha (T<sub>1</sub>), pendimethalin 24% + oxyfluorfen 4% ZE @541.80+92.56 g a.i./ha (T<sub>2</sub>), pendimethalin 38.7% CS@ 677.25 g a.i./ha (T<sub>5</sub>) and quizalofop ethyl 5% EC@ 50 g a.i./ha (T<sub>7</sub>) which were comparable with each other. Treatment T<sub>9</sub> (weedy check) recorded significantly lower plant dry matter due to more competition of crop with weed for moisture and nutrients hence less dry matter production in weedy check plot. Similar trend was of plant dry matter accumulation was observed at harvest.

**Table 20: Total dry matter accumulation plant<sup>-1</sup> (g) as influenced by different weed control treatments**

| Treatment                                                                           | 20<br>DAT | 40<br>DAT | 60<br>DAT | 80<br>DAT | At<br>Harvest |
|-------------------------------------------------------------------------------------|-----------|-----------|-----------|-----------|---------------|
| T <sub>1</sub> - Pendimethalin 24% + Oxyfluorfen 4% ZE @480+82 g a.i./ha PE         | 1.80      | 3.60      | 7.23      | 12.07     | 13.67         |
| T <sub>2</sub> - Pendimethalin 24% + Oxyfluorfen 4% ZE @541.80+92.56 g a.i./ha PE   | 1.83      | 3.73      | 7.73      | 12.97     | 14.70         |
| T <sub>3</sub> - Pendimethalin 24% + Oxyfluorfen 4% ZE @600+102.5 g a.i./ha PE      | 2.00      | 4.23      | 8.83      | 16.40     | 18.87         |
| T <sub>4</sub> - Pendimethalin 24% + Oxyfluorfen 4% ZE @1083.60+185.12 g a.i./ha PE | 1.87      | 4.07      | 8.37      | 14.40     | 16.57         |
| T <sub>5</sub> - Pendimethalin 38.7% CS@ 677.25 g a.i./ha PE                        | 1.85      | 3.77      | 7.57      | 12.57     | 13.93         |
| T <sub>6</sub> - Oxyfluorfen 23.5% EC@ 200 g a.i./ha PE                             | 2.07      | 4.17      | 8.73      | 15.43     | 17.60         |
| T <sub>7</sub> - Quizalofop ethyl 5% EC@ 50 g a.i./ha PoE                           | 2.00      | 4.00      | 7.67      | 12.40     | 14.00         |
| T <sub>8</sub> - Two HW (25 & 45 DAT)                                               | 2.03      | 4.47      | 9.63      | 16.93     | 19.97         |
| T <sub>9</sub> - Weedy Check                                                        | 1.77      | 3.57      | 6.97      | 11.10     | 12.33         |
| S.E(m)±                                                                             | 0.10      | 0.27      | 0.48      | 0.75      | 0.97          |
| C.D. at 5%                                                                          | NS        | 0.83      | 1.45      | 2.26      | 2.92          |
| G.M.                                                                                | 1.89      | 3.96      | 8.08      | 13.81     | 15.74         |

The higher dry matter accumulation was recorded in treatment weed free (T<sub>8</sub>) i.e. 2 HW 25 & 45 DAT due to favourable environment via clean cultivation resulting in more absorption of solar radiation and absorption of more nutrients. Among herbicidal treatment, higher dry matter accumulation was observed in pendimethalin 24% + oxyfluorfen 4% ZE @600+102.5 g a.i./ha (T<sub>3</sub>), oxyfluorfen 23.5% EC@ 200 g a.i./ha (T<sub>6</sub>) and pendimethalin 24% + oxyfluorfen 4% ZE @1083.60+185.12 g a.i./ha (T<sub>4</sub>) might be due to less weed competition, thereby facilitating luxurious crop growth resulting in more dry matter production plant<sup>-1</sup> as compared to unweeded control treatment and other treatment. These results are in accordance with the findings of Saraf (2007).

#### 4.2.8 Growth analysis studies

Data on total dry matter are subjected to growth function nearly AGR and RGR at various growth stages of onion crop.

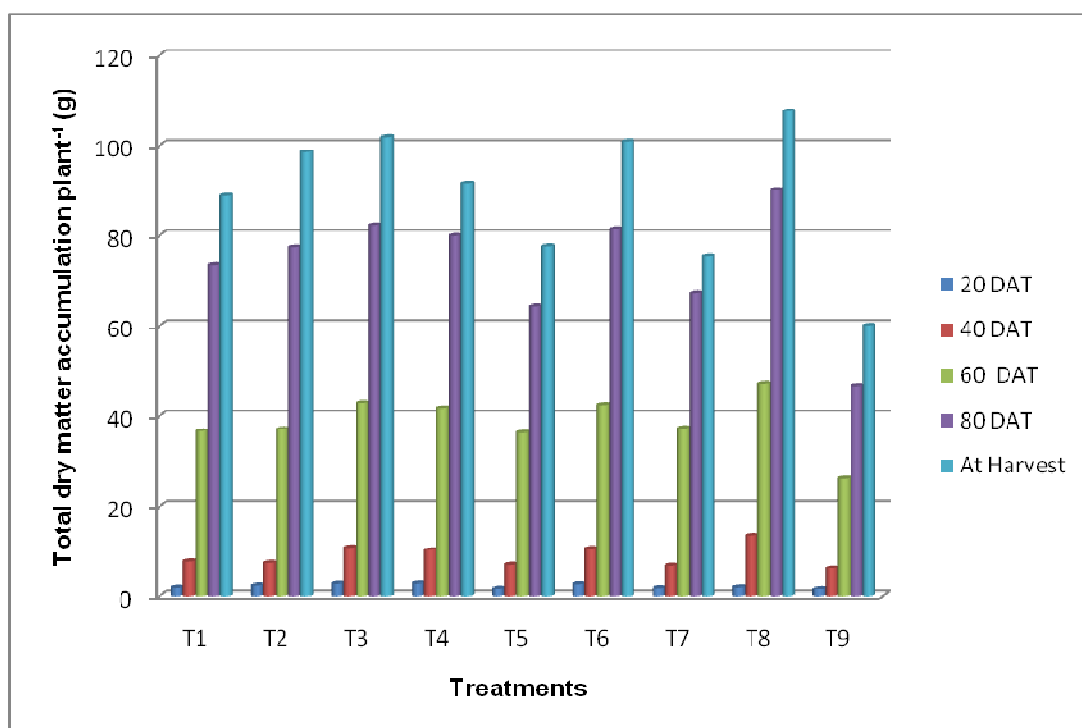


**Fig. 11 Total dry matter accumulation plant<sup>-1</sup> (g) as influenced by different weed control treatments**

#### 4.2.8.1 Absolute Growth rate for dry matter

Absolute growth rate (AGR) of dry matter denotes the amount of dry matter weight gained on the basis of unit area of crop in unit time. Data relating to AGR of dry matter weight per plant ( $\text{g day}^{-1}$ ) as periodically influenced by various weed management treatments have been presented in Table 21.

Data revealed that mean AGR per plant for dry matter increased progressively between 20-40 DAT, 40-60 and 60-80 day's interval with all the treatments, thereafter it subsequently declined at 80 DAT to harvest stage interval. The mean AGR calculated at 60-80 DAT was  $0.286 \text{ g day}^{-1} \text{ plant}^{-1}$ .

**Table 21: Absolute growth rate( $\text{g day}^{-1} \text{ plant}^{-1}$ ) for plant dry matter as influenced by different weed control treatments**

| Treatment                                                                           | 20-40 DAT | 40-60 DAT | 60-80 DAT | 80-At harvest DAT |
|-------------------------------------------------------------------------------------|-----------|-----------|-----------|-------------------|
| T <sub>1</sub> - Pendimethalin 24% + Oxyfluorfen 4% ZE @480+82 g a.i./ha PE         | 0.090     | 0.182     | 0.242     | 0.080             |
| T <sub>2</sub> - Pendimethalin 24% + Oxyfluorfen 4% ZE @541.80+92.56 g a.i./ha PE   | 0.095     | 0.200     | 0.262     | 0.087             |
| T <sub>3</sub> - Pendimethalin 24% + Oxyfluorfen 4% ZE @600+102.5 g a.i./ha PE      | 0.112     | 0.230     | 0.378     | 0.123             |
| T <sub>4</sub> - Pendimethalin 24% + Oxyfluorfen 4% ZE @1083.60+185.12 g a.i./ha PE | 0.110     | 0.215     | 0.302     | 0.104             |
| T <sub>5</sub> - Pendimethalin 38.7% CS@ 677.25 g a.i./ha PE                        | 0.095     | 0.190     | 0.250     | 0.068             |
| T <sub>6</sub> - Oxyfluorfen 23.5% EC@ 200 g a.i./ha PE                             | 0.105     | 0.228     | 0.335     | 0.108             |
| T <sub>7</sub> - Quizalofop ethyl 5% EC@ 50 g a.i./ha PoE                           | 0.100     | 0.183     | 0.237     | 0.080             |
| T <sub>8</sub> - Two HW (25 & 45 DAT)                                               | 0.122     | 0.258     | 0.365     | 0.152             |
| T <sub>9</sub> - Weedy Check                                                        | 0.090     | 0.170     | 0.207     | 0.062             |
| G.M.                                                                                | 0.102     | 0.206     | 0.286     | 0.096             |

Significant variation was observed in AGR due to different herbicide application treatment when compared to weedy check during 20-40, 40-60, 60-80, 80 DAT and at harvest. Among the various treatments, weed free with 2 HW 25 & 45 DAT registered higher AGR values than rest of the herbicidal treatment which was followed by (T<sub>3</sub>)

pendimethalin 24% + 04% ZE @600+102.5 g a.i./ha, (T<sub>6</sub>) oxyfluorfen 23.5% EC@ 200 g a.i./ha and (T<sub>4</sub>) pendimethalin 24% + oxyfluorfen 4% ZE @1083.60+185.12 g a.i./ha. Lowest rate of growth was recorded weedy check (T<sub>9</sub>), whereas other treatment were comparable with each other due less difference in dry matter among various treatments. AGR is positively correlated with dry matter accumulation AGR increased with increase in dry matter in all the treatments and lower values of AGR at initial stages of growth was the result of lower dry matter accumulation of plant.

#### 4.2.8.2 Relative growth rate ( $\text{g g}^{-1} \text{ day}^{-1}$ )

Relative growth rate ( $\text{g g}^{-1} \text{ day}^{-1}$ ) as an index of rate of increase in biomass unit<sup>-1</sup> of existing biomass was computed from dry matter accumulation per plant obtained at various growth stages and the relevant data are presented in Table 22. Mean RGR  $0.0362 \text{ g g}^{-1} \text{ day}^{-1}$  was maximum during 20-40 DAT phase during investigation. Thereafter it declined gradually till harvest stage.

**Table 22: Relative growth rate ( $\text{g g}^{-1} \text{ day}^{-1}$ ) for dry matter as influenced by different weed control treatments**

| Treatment                                                                           | 20-40<br>DAT | 40-60<br>DAT | 60-80<br>DAT | 80-At<br>Harvest<br>DAT |
|-------------------------------------------------------------------------------------|--------------|--------------|--------------|-------------------------|
| T <sub>1</sub> - Pendimethalin 24% + Oxyfluorfen 4% ZE @480+82 g a.i./ha PE         | 0.03503      | 0.03487      | 0.02523      | 0.00634                 |
| T <sub>2</sub> - Pendimethalin 24% + Oxyfluorfen 4% ZE @541.80+92.56 g a.i./ha PE   | 0.03632      | 0.03624      | 0.02617      | 0.00637                 |
| T <sub>3</sub> - Pendimethalin 24% + Oxyfluorfen 4% ZE @600+102.5 g a.i./ha PE      | 0.03747      | 0.03662      | 0.03109      | 0.00703                 |
| T <sub>4</sub> - Pendimethalin 24% + Oxyfluorfen 4% ZE @1083.60+185.12 g a.i./ha PE | 0.03992      | 0.03594      | 0.02727      | 0.00641                 |
| T <sub>5</sub> - Pendimethalin 38.7% CS@ 677.25 g a.i./ha PE                        | 0.03509      | 0.03441      | 0.02536      | 0.00556                 |
| T <sub>6</sub> - Oxyfluorfen 23.5% EC@ 200 g a.i./ha PE                             | 0.03494      | 0.03680      | 0.02854      | 0.00682                 |
| T <sub>7</sub> - Quizalofop ethyl 5% EC@ 50 g a.i./ha PoE                           | 0.03384      | 0.03330      | 0.02407      | 0.00587                 |
| T <sub>8</sub> - Two HW (25 & 45 DAT)                                               | 0.03827      | 0.03859      | 0.02817      | 0.00816                 |
| T <sub>9</sub> - Weedy Check                                                        | 0.03519      | 0.03349      | 0.02352      | 0.00535                 |
| G.M.                                                                                | 0.03623      | 0.03559      | 0.02660      | 0.00643                 |

RGR had a significant influence due to various herbicidal treatments in the initial stage of crop growth i.e. during 20-40 DAT phase. The differences in RGR were comparable at all other crop growth stages. At 20-40 DAT phase, maximum RGR was registered in the treatment (T<sub>4</sub>) pendimethalin 24% + oxyfluorfen 4% ZE @1083.60+185.12 g a.i./ha which was higher than other herbicidal treatment. From 40 DAT & onwards, maximum RGR was observed in weed free treatment with 2 HW while among herbicidal treatment application of pendimethalin 24% + oxyfluorfen 4% ZE @600+102.5 g a.i./ha (T<sub>3</sub>) followed by, T<sub>6</sub> (oxyfluorfen 23.5% EC@ 200 g a.i./ha) and T<sub>4</sub>(pendimethalin 24% + oxyfluorfen 4% ZE @1083.60+185.12 g a.i./ha) treatment were comparable in respect of RGR. The lowest RGR values were recorded in T<sub>9</sub> (weedy check). This might be due to less dry matter accumulation in these treatments. The decline in RGR after reaching the maximum was due to leaf abscissions and crop age. The similar result in case of brinjal was also reported by Chnnapagouda *et al.* (2013).

#### **4.3 Effect of treatment on yield studies:**

##### **4.3.1 Influence of herbicides on diameter of onion bulb (mm)**

###### **4.3.1.1 Equatorial diameter of onion bulb (mm)**

The data regarding equatorial diameter of onion bulb as influenced by the different herbicidal along with newly formulated combination and different concentration treatments are presented in Table 23. and graphically showed in Fig 12 .

The data presented in Table 23 showed that, during the year of experimentation, the equatorial diameter of onion bulb did the marked and significant influence on bulb equatorial diameter at harvest by the different herbicidal treatments. The mean equatorial diameter was 61.04mm during experimentation.

**Table 23: Equitorial diameter of onion bulb as influenced by different weed control treatments (mm)**

| Treatment                                                                           | Equitorial Diameter (mm) |
|-------------------------------------------------------------------------------------|--------------------------|
| T <sub>1</sub> - Pendimethalin 24% + Oxyfluorfen 4% ZE @480+82 g a.i./ha PE         | 56.48                    |
| T <sub>2</sub> - Pendimethalin 24% + Oxyfluorfen 4% ZE @541.80+92.56 g a.i./ha PE   | 61.69                    |
| T <sub>3</sub> - Pendimethalin 24% + Oxyfluorfen 4% ZE @600+102.5 g a.i./ha PE      | 67.64                    |
| T <sub>4</sub> - Pendimethalin 24% + Oxyfluorfen 4% ZE @1083.60+185.12 g a.i./ha PE | 64.49                    |
| T <sub>5</sub> - Pendimethalin 38.7% CS@ 677.25 g a.i./ha PE                        | 59.88                    |
| T <sub>6</sub> - Oxyfluorfen 23.5% EC@ 200 g a.i./ha PE                             | 66.77                    |
| T <sub>7</sub> - Quizalofop ethyl 5% EC@ 50 g a.i./ha PoE                           | 54.18                    |
| T <sub>8</sub> - Two HW (25 & 45 DAT)                                               | 68.06                    |
| T <sub>9</sub> -WeedyCheck                                                          | 49.84                    |
| S.E(m)±                                                                             | 3.51                     |
| C.D. at 5%                                                                          | 10.52                    |
| G.M.                                                                                | 61.04                    |

Maximum bulb equatorial diameter was recorded in treatment with 2 handweeding (25 & 45 DAT)(T<sub>8</sub>) and minimum in T<sub>9</sub>.i.e. weedycheck. Thus it was observed that equatorial diameter increased with decreased in weed population level from weed free to weedy check, but the difference among the T<sub>3</sub>(pendimethalin 24% + oxyfluorfen 4% ZE @600+102.5 g a.i./ha), T<sub>6</sub> (oxyfluorfen 23.5% EC@ 200 g a.i./ha) and T<sub>4</sub> (pendimethalin 24% + oxyfluorfen 4% ZE @1083.60+185.12 g a.i./ha) was not much and found at par. During experimentation among all the herbicidal treatment, treatment T<sub>3</sub>(pendimethalin 24% + oxyfluorfen 4% ZE @600+102.5 g a.i./ha) was found significantly superior and other treatments (T<sub>4</sub>, T<sub>6</sub>, T<sub>2</sub> & T<sub>5</sub>) were closely at par with pendimethalin 24% + oxyfluorfen 4% ZE @600+102.5 g a.i./ha(T<sub>3</sub>). The bulb with significantly minimum diameter (49.84 mm) was harvested from the weedy check treatment which was lower than all other treatments. The results are in conformity with the findings of Saraf (2007), Saini and Walia (2012) and Shinde *et al.* (2012). They recorded maximum equatorial diameter in herbicidal treatment and minimum equatorial diameter in weedy condition. The positive response of herbicide in decreasing weed population which

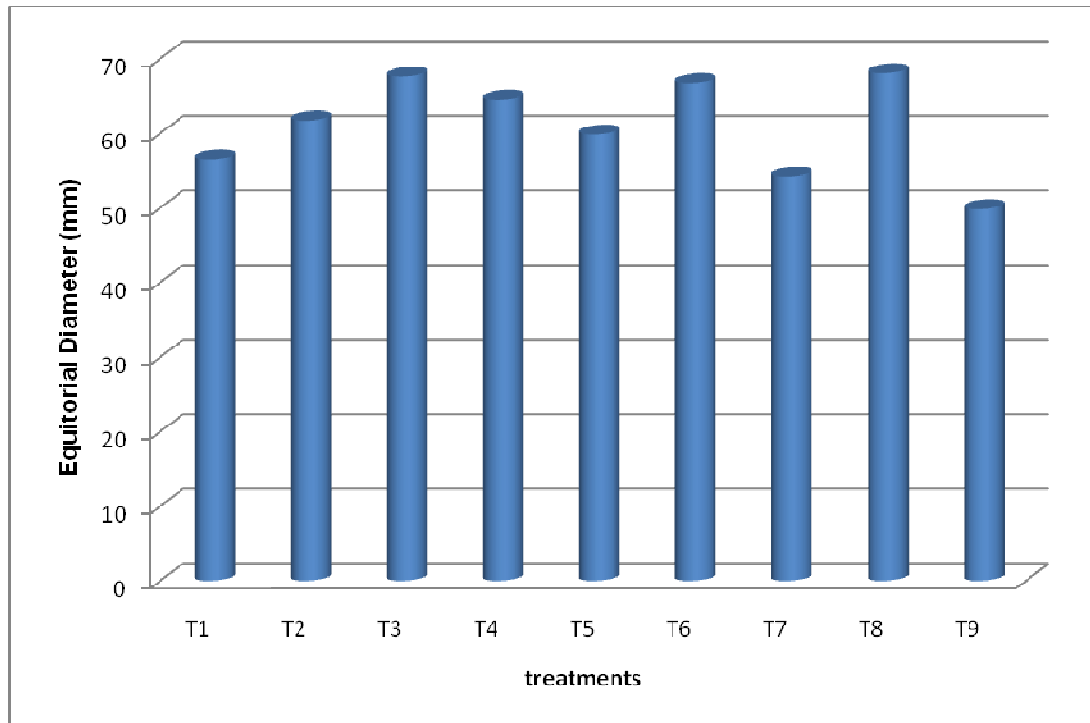


**Fig. 12 Equitorial diameter of onion bulb as influenced by different weed control treatments (mm)**

further result into restrict competition for nutrients and enhanced equatorial diameter of onion bulb. This might be due to enhanced the nutrient availability, mobility and uptake of applied nutrients due to minimum weed population which causes the positive effect on bulb size of onion bulb in herbicidal treatment resulting in more equatorial diameter of onion bulb as compared to weedy check where severe weed competition was observed.

#### 4.3.1.2 Polar diameter of onion bulb (mm)

The data regarding to polar diameter of onion bulbs are recorded after harvest as influenced by different herbicidal treatments are presented in Table 24 and graphically depicted in Fig.13. The mean polar diameter recorded during investigation was 48.95 mm.

**Table 24: Polar diameter of onion bulb as influenced by different weed control treatments(mm)**

| Treatment                                                                           | Polar Diameter (mm) |
|-------------------------------------------------------------------------------------|---------------------|
| T <sub>1</sub> - Pendimethalin 24% + Oxyfluorfen 4% ZE @480+82 g a.i./ha PE         | 45.92               |
| T <sub>2</sub> - Pendimethalin 24% + Oxyfluorfen 4% ZE @541.80+92.56 g a.i./ha PE   | 48.69               |
| T <sub>3</sub> - Pendimethalin 24% + Oxyfluorfen 4% ZE @600+102.5 g a.i./ha PE      | 54.01               |
| T <sub>4</sub> - Pendimethalin 24% + Oxyfluorfen 4% ZE @1083.60+185.12 g a.i./ha PE | 50.92               |
| T <sub>5</sub> - Pendimethalin 38.7% CS@ 677.25 g a.i./ha PE                        | 45.79               |
| T <sub>6</sub> - Oxyfluorfen 23.5% EC@ 200 g a.i./ha PE                             | 53.91               |
| T <sub>7</sub> - Quizalofop ethyl 5% EC@ 50 g a.i./ha PoE                           | 44.44               |
| T <sub>8</sub> - Two HW (25 & 45 DAT)                                               | 56.30               |
| T <sub>9</sub> - Weedy Check                                                        | 40.57               |
| S.E(m)±                                                                             | 2.71                |
| C.D. at 5%                                                                          | 8.12                |
| G.M.                                                                                | 48.95               |

From the table it is indicated that different herbicidal treatment and cultural method i.e. hand weeding did the marked and significant influence on bulb polar diameter at harvest. Application of herbicide with different concentration and newly formulated combination resulted significant increase in polar diameter over its lower concentration. During investigation, maximum polar diameter (56.30mm) was observed in two HW (25 & 45 DAT) (T<sub>8</sub>) closely followed by with treatment (T<sub>3</sub>) pendimethalin 24% + oxyfluorfen 4% ZE @600+102.5 g a.i./ha, (T<sub>6</sub>)

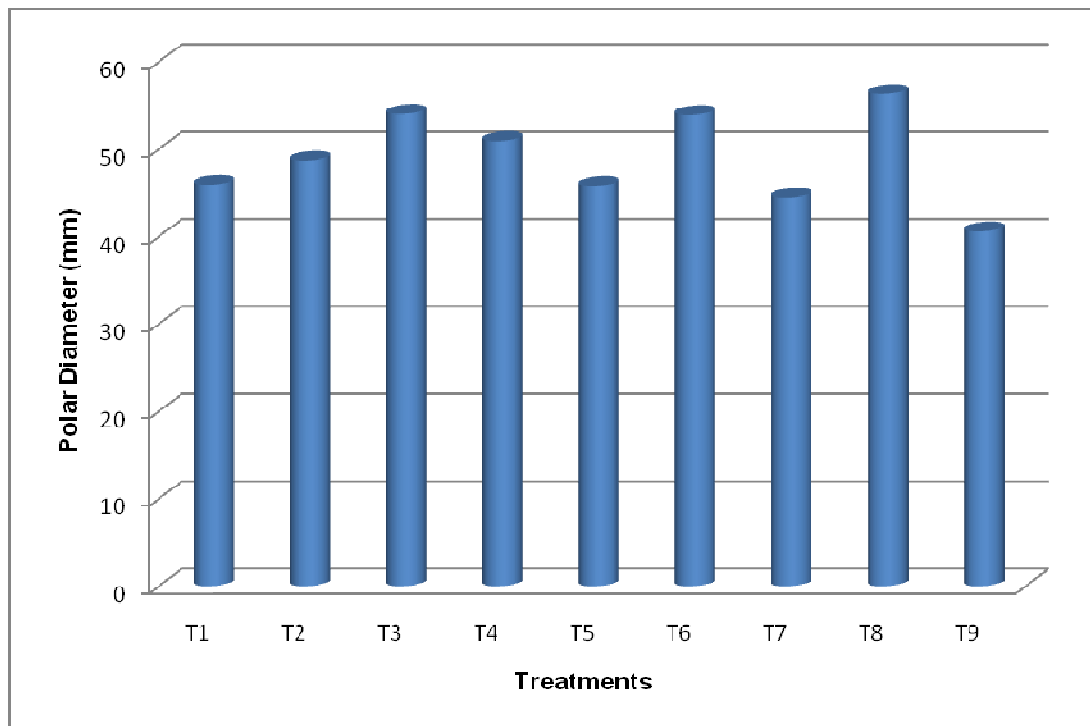


**Fig. 13 Polar diameter of onion bulb as influenced by different weed control treatments (mm)**

oxyfluorfen 23.5% EC@ 200 g a.i./ha, (T<sub>4</sub>) pendimethalin 24% + oxyfluorfen 4% ZE @1083.60+185.12 g a.i./ha, (T<sub>2</sub>) pendimethalin 24% + oxyfluorfen 4% ZE @541.80+92.56 g a.i./ha which were found at par with each other. The higher bulb diameter under treatment T<sub>3</sub> pendimethalin 24% + oxyfluorfen 4% ZE @600+102.5 g a.i./ha could be attributed due to the decreased competition of weed with crop for space, water, air, nutrients and sunlight because of their effective control as result of application of different pre or post emergence herbicides (Kalhapure *et al.* (2014). While lowest bulb polar diameter of 40.57 mm was recorded in treatment weedy check (T<sub>9</sub>) This could be attributed to severe crop weed competition, where in weed had utilized nutrients and ultimately resulted in lower polar diameter of onion bulb. Results were similar with findings reported by Warade *et al.* (2008), Vashi *et al.* (2011) and Shinde *et al.* (2012).

#### **4.3.2 Bulb yield (q ha<sup>-1</sup>)**

Bulb yield of onion is an important parameter which decide the efficiency and superiority of particular weed control treatment. The data presented in Table 25 and illustrated in Fig.14 revealed that herbicidal application produced significantly the highest marketable bulb yield of onion (196.74) during the year experimentation. The higher yield can be obtained through better plant physical condition through controlled weed population might have resulted in better root growth, nutrient absorption and better bulb development ultimately increased bulb yield.

Different herbicidal application treatment and weed management practice had a marked and significant influence on onion bulb yield over weedy check. Treatment (T<sub>8</sub>) i.e. weed free with two HW (25 & 45 DAT) recorded significantly higher onion bulb yield (196.74 q ha<sup>-1</sup>) as compared to rest of the treatments however it remained at par with treatments pendimethalin 24% + oxyfluorfen 4% ZE @600+102.5 g a.i./ha (T<sub>3</sub>) and oxyfluorfen 23.5% EC@ 200 g a.i./ha (T<sub>6</sub>) which recorded next higher onion bulb yield of 188.29 q ha<sup>-1</sup> and 172.63 q ha<sup>-1</sup> respectively. Treatments (T<sub>1</sub>, T<sub>2</sub> and T<sub>7</sub>) were found comparable in respect of bulb yield.

**Table 25: Per plot yield (kg) and per hectare yield (q/ha) as influenced by different weed control treatments**

| Treatment                                                                           | Per per plot (kg) | Per hectare yield (q/ha) |
|-------------------------------------------------------------------------------------|-------------------|--------------------------|
| T <sub>1</sub> - Pendimethalin 24% + Oxyfluorfen 4% ZE @480+82 g a.i./ha PE         | 41.28             | 146.95                   |
| T <sub>2</sub> - Pendimethalin 24% + Oxyfluorfen 4% ZE @541.80+92.56 g a.i./haPE    | 42.81             | 152.40                   |
| T <sub>3</sub> - Pendimethalin 24% + Oxyfluorfen 4% ZE @600+102.5 g a.i./ha PE      | 52.89             | 188.29                   |
| T <sub>4</sub> - Pendimethalin 24% + Oxyfluorfen 4% ZE @1083.60+185.12 g a.i./ha PE | 47.23             | 167.66                   |
| T <sub>5</sub> - Pendimethalin 38.7% CS@ 677.25 g a.i./ha PE                        | 36.83             | 131.11                   |
| T <sub>6</sub> - Oxyfluorfen 23.5% EC@ 200 g a.i./ha PE                             | 48.63             | 172.63                   |
| T <sub>7</sub> - Quizalofop ethyl 5% EC@ 50 g a.i./ha PoE                           | 39.83             | 141.79                   |
| T <sub>8</sub> - Two HW (25 & 45 DAT)                                               | 55.42             | 196.74                   |
| T <sub>9</sub> -Weedy Check                                                         | 25.21             | 89.84                    |
| S.E(m)±                                                                             | 2.84              | 9.42                     |
| C.D. at 5%                                                                          | 8.53              | 28.25                    |
| G.M.                                                                                | 43.35             | 154.16                   |

Data pertaining to per hectare yield ( $q\ ha^{-1}$ ) of onion bulb as influenced by different herbicidal treatments and weed management practice are presented in Table 25. The similar trend in respect of per plot yield of onion bulbs was noticed.

Different herbicidal treatment and weed management practices significantly improved the bulb yield over weedy check; this might be due to the better weed control associated with decrease in weed population and improvement in yield contributing characters in these treatments. The positive herbicidal effect in onion and cultural weed management practices leads to death of weeds, thus created favourable condition for better crop growth and onion bulb yield. The weedy check recorded minimum bulb yield owing to low chlorophyll content and photosynthetic rates due to unchecked weed growth thereby reducing the availability of moisture, light and nutrients to the crop and resulted in loss of yield in weedy check. Similar results were reported by Bhutia *et al.* (2005), Mondal *et al.* (2005), Vashi *et al.* (2011) and Saini andwalia (2012).

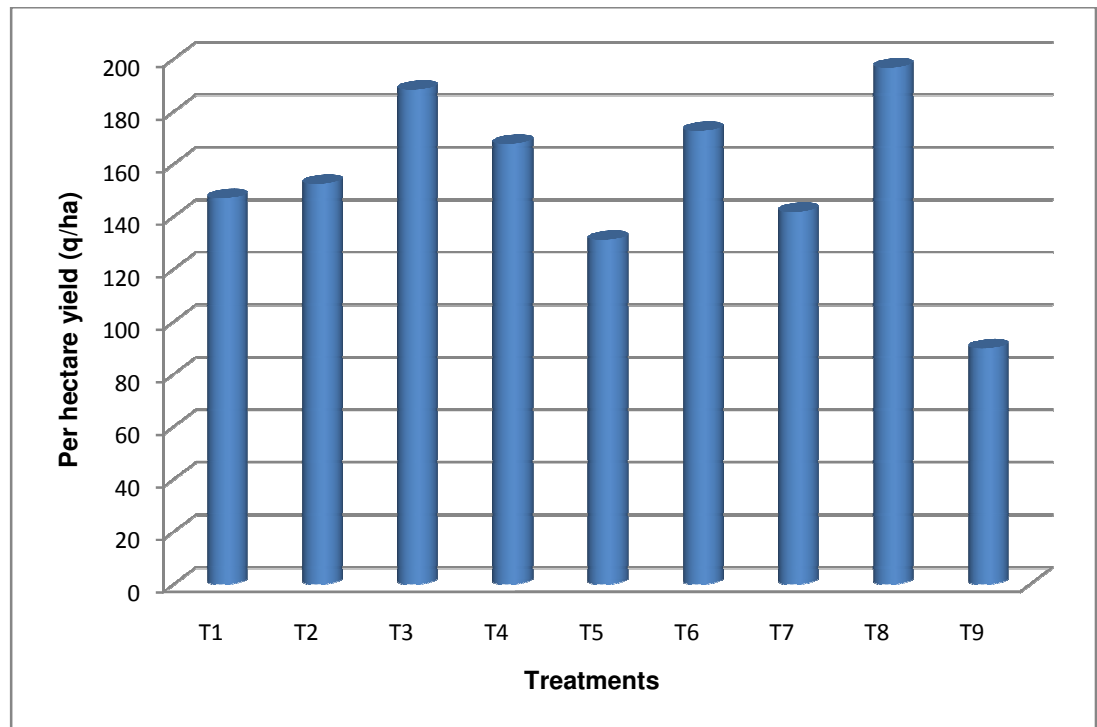


**Fig. 14 Per hectare yield (q/ha) as influenced by different weed control treatments**

#### 4.3.3 Dry weight of bulb plant<sup>-1</sup>(g)

The relevant data on the bulb dry weight after harvest are given in Table 26 and illustrated in Fig.15. The mean bulb dry weight recorded during experimentation was 13.30 g. The dry weight of bulb plant<sup>-1</sup> was significantly influenced due to different herbicidal treatments.

**Table 26: Dry weight of bulb plant<sup>-1</sup> (g) at harvest as influenced by different weed control treatments**

| Treatment                                                                           | Dry Weight of bulb (g) |
|-------------------------------------------------------------------------------------|------------------------|
| T <sub>1</sub> - Pendimethalin 24% + Oxyfluorfen 4% ZE @480+82 g a.i./ha PE         | 12.61                  |
| T <sub>2</sub> - Pendimethalin 24% + Oxyfluorfen 4% ZE @541.80+92.56 g a.i./ha PE   | 13.60                  |
| T <sub>3</sub> - Pendimethalin 24% + Oxyfluorfen 4% ZE @600+102.5 g a.i./ha PE      | 16.43                  |
| T <sub>4</sub> - Pendimethalin 24% + Oxyfluorfen 4% ZE @1083.60+185.12 g a.i./ha PE | 14.40                  |
| T <sub>5</sub> - Pendimethalin 38.7% CS@ 677.25 g a.i./ha PE                        | 11.17                  |
| T <sub>6</sub> - Oxyfluorfen 23.5% EC@ 200 g a.i./ha PE                             | 15.33                  |
| T <sub>7</sub> - Quizalofop ethyl 5% EC@ 50 g a.i./ha PE                            | 10.67                  |
| T <sub>8</sub> - Two HW (25 & 45 DAT)                                               | 17.40                  |
| T <sub>9</sub> -Weedy Check                                                         | 8.10                   |
| S.E(m)±                                                                             | 1.01                   |
| C.D. at 5%                                                                          | 3.04                   |
| G.M.                                                                                | 13.30                  |

Significant differences were found in bulb dry weight due to different concentration of herbicide application and hand weeding method. Highest bulb dry weight (17.40 g) during experimentation was recorded when two hand weeding at 25 & 45 DAT which was followed by pendimethalin 24% + oxyfluorfen 4% ZE @600+102.5 g a.i./ha (T<sub>3</sub>) i.e.16.43 g, treatment oxyfluorfen 23.5% EC@ 200 g a.i./ha (T<sub>6</sub>) 15.33 g, pendimethalin 24% + oxyfluorfen 4% ZE @1083.60+185.12 g a.i./ha (T<sub>4</sub>) 14.40 was found statistically at par with each other. The lowest bulb dry weight was recorded in the treatment weedy check (T<sub>9</sub>) which was 8.10 g. However, treatment (T<sub>1</sub>) pendimethalin 24% + oxyfluorfen 4% ZE @480+82 g a.i./ha and treatment (T<sub>2</sub>) pendimethalin 24% + oxyfluorfen 4% ZE @541.80+92.56 g a.i./ha were found equally effective in respect of bulb dry weight.

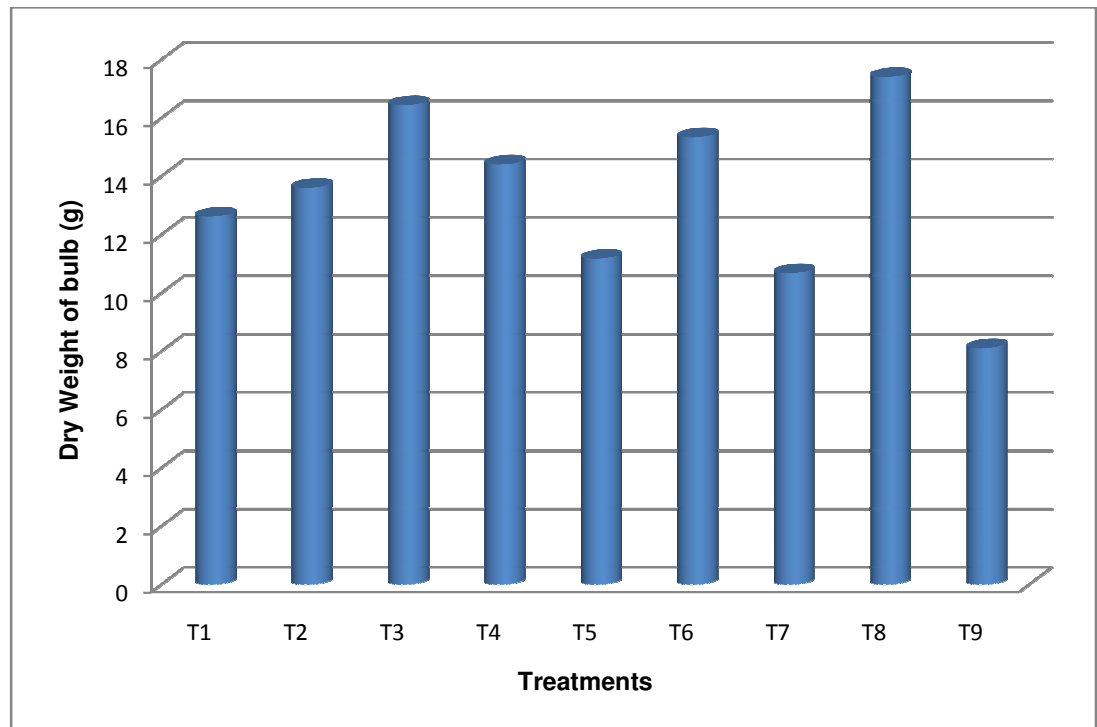


**Fig. 15 Dry weight of bulb plant<sup>-1</sup> (g) at harvest as influenced by different weed control treatments**

The variation in bulb dry weight per plant might be attributed due to variation in size of the bulb. Significantly higher bulb size and bulb dry weight with lower crop weed competition might be due to better vegetative growth with herbicidal application, which reduces competition for nutrients, sunlight among weed and onion crop and accelerated photosynthesis and create condition for luxurious crop growth and translocation of photosynthate (dry matter) into storage organs resulting in increased diameter and weight of bulb. These results are in conformation with the findings of Saraf (2007).

#### 4.4.1 Effect of treatments on microbial parameter

##### 4.4.1.1 Bacterial count

Data pertaining to effect of herbicide on soil bacterial count at different growth stages of the crop are presented in Table 27. and graphically showed in Fig.16.

**Table 27: Microbial count (Bacteria) at periodical growth stages as influenced by different weed control treatments (cfu g<sup>-1</sup> soil ×10<sup>7</sup>)**

| Treatment                                                                           | Bacterial count (cfu g <sup>-1</sup> soil ×10 <sup>7</sup> ) |             |            |
|-------------------------------------------------------------------------------------|--------------------------------------------------------------|-------------|------------|
|                                                                                     | Before Transplanting                                         | After spray | At Harvest |
| T <sub>1</sub> - Pendimethalin 24% + Oxyfluorfen 4% ZE @480+82 g a.i./ha PE         | 12.27                                                        | 11.20       | 27.42      |
| T <sub>2</sub> - Pendimethalin 24% + Oxyfluorfen 4% ZE @541.80+92.56 g a.i./ha PE   | 10.25                                                        | 9.10        | 25.05      |
| T <sub>3</sub> - Pendimethalin 24% + Oxyfluorfen 4% ZE @600+102.5 g a.i./ha PE      | 11.55                                                        | 7.60        | 24.79      |
| T <sub>4</sub> - Pendimethalin 24% + Oxyfluorfen 4% ZE @1083.60+185.12 g a.i./ha PE | 11.86                                                        | 6.83        | 20.88      |
| T <sub>5</sub> - Pendimethalin 38.7% CS@ 677.25 g a.i./ha PE                        | 12.68                                                        | 9.77        | 25.39      |
| T <sub>6</sub> - Oxyfluorfen 23.5% EC@ 200 g a.i./ha PE                             | 12.50                                                        | 7.63        | 22.29      |
| T <sub>7</sub> - Quizalofop ethyl 5% EC@ 50 g a.i./ha PoE                           | 10.43                                                        | 11.60       | 28.33      |
| T <sub>8</sub> - Two HW (25 & 45 DAT)                                               | 11.60                                                        | 9.70        | 21.77      |
| T <sub>9</sub> - Weedy Check                                                        | 13.10                                                        | 14.33       | 30.60      |
| S.E(m)±                                                                             | 0.79                                                         | 0.57        | 2.03       |
| C.D. at 5%                                                                          | NS                                                           | 1.72        | NS         |
| G.M.                                                                                | 11.81                                                        | 9.75        | 25.17      |

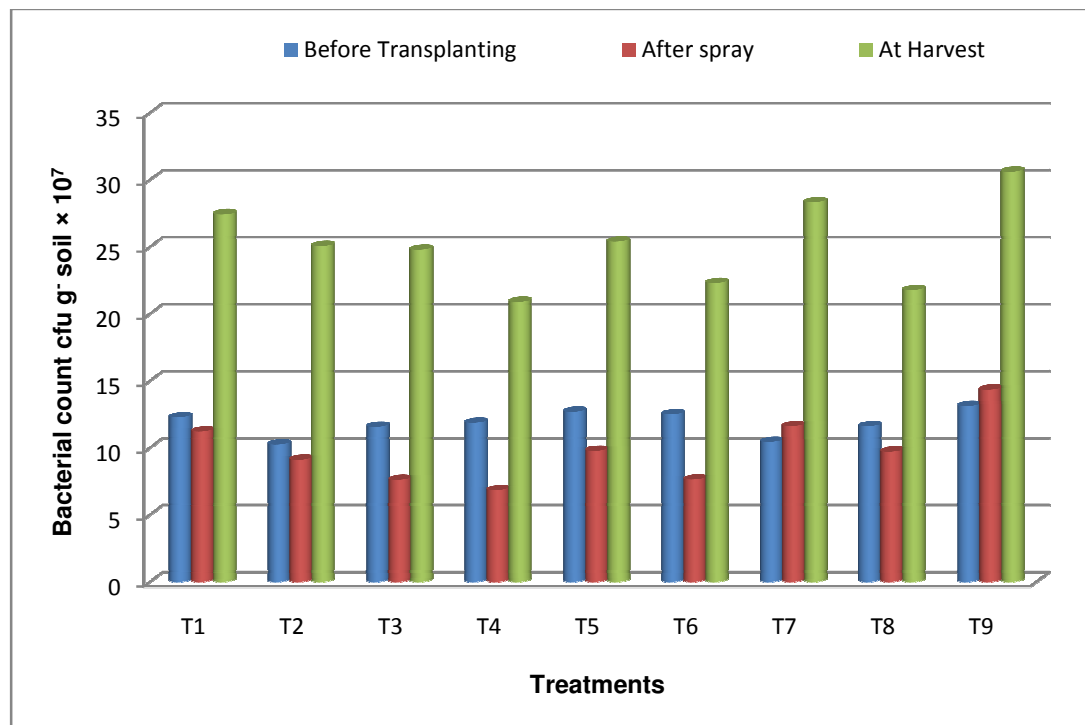


**Fig. 16 Microbial count (Bacteria) at periodical growth stages as influenced by different weed control treatments ( $\text{cfu g}^{-1} \text{ soil} \times 10^{-7}$ )**

Before sowing there were non-significant differences in microbial population. There was decrease in population of bacteria after spraying of herbicides. But it was recovered at harvest of the crop. Bacterial count after spray was significantly higher in treatment weedy check ( $T_9$ ) than rest of the treatments. Minimum bacterial count was observed in treatment pendimethalin 24% + oxyfluorfen 4% ZE @1083.60+185.12 g a.i./ha ( $T_4$ ). The results are in accordance with Adhikary *et al.* (2014) and Poddar *et al.* (2017).

Though bacterial count before transplanting and at harvest was not influenced by different treatments, however population of bacteria was increased at harvest of the crop. This is might be due to decomposition of herbicide, there is activation of function group attached to herbicide due to on decomposition of herbicide it release carbon molecules which are useful for enhancing microbial population in soil.

#### **4.4.1.2 Fungal count**

Data pertaining to effect of different herbicide on soil fungal at different growth stages of the crop are presented in Table 28. and graphically depicted in Fig.17.

Though fungal count was not-significantly affected before sowing, but after spraying of herbicide, fungal count was decreased by different treatments, but there was increase in population at harvest of the crop. Treatment weedy check ( $T_9$ ) recorded significantly higher fungal count after the application of herbicide than rest of the treatments. Pendimethalin 24% + oxyfluorfen 4% ZE @1083.60+185.12 g a.i./ha( $T_4$ ) recorded minimum fungal count. The results obtained during investigation were similar with Adhikary *et al.*(2014) and Poddar *et al.*(2017).

Though fungal count before transplanting and at harvest was not influenced by different treatments, but there was increased in population was observed at harvest of the crop.

**Table 28: Microbial count (Fungal) at periodical growth stages as influenced by different weed control treatments (cfu g<sup>-1</sup> soil ×10<sup>4</sup>)**

| Treatment                                                                           | Fungal count(cfu g <sup>-1</sup> soil ×10 <sup>4</sup> ) |             |            |
|-------------------------------------------------------------------------------------|----------------------------------------------------------|-------------|------------|
|                                                                                     | Before Transplanting                                     | After spray | At Harvest |
| T <sub>1</sub> - Pendimethalin 24% + Oxyfluorfen 4% ZE @480+82 g a.i./ha PE         | 10.00                                                    | 8.19        | 23.43      |
| T <sub>2</sub> - Pendimethalin 24% + Oxyfluorfen 4% ZE @541.80+92.56 g a.i./ha PE   | 10.47                                                    | 7.13        | 22.14      |
| T <sub>3</sub> - Pendimethalin 24% + Oxyfluorfen 4% ZE @600+102.5 g a.i./ha PE      | 10.24                                                    | 6.24        | 23.19      |
| T <sub>4</sub> - Pendimethalin 24% + Oxyfluorfen 4% ZE @1083.60+185.12 g a.i./ha PE | 10.54                                                    | 5.26        | 19.48      |
| T <sub>5</sub> - Pendimethalin 38.7% CS@ 677.25 g a.i./ha PE                        | 10.47                                                    | 8.08        | 22.18      |
| T <sub>6</sub> - Oxyfluorfen 23.5% EC@ 200 g a.i./ha PE                             | 10.40                                                    | 7.78        | 22.53      |
| T <sub>7</sub> - Quizalofop ethyl 5% EC@ 50 g a.i./ha PoE                           | 10.13                                                    | 10.95       | 21.77      |
| T <sub>8</sub> - Two HW (25 & 45 DAT)                                               | 10.37                                                    | 8.80        | 18.57      |
| T <sub>9</sub> -Weedy Check                                                         | 10.43                                                    | 13.59       | 25.04      |
| S.E(m)±                                                                             | 0.76                                                     | 0.66        | 1.52       |
| C.D. at 5%                                                                          | NS                                                       | 1.99        | NS         |
| G.M.                                                                                | 10.34                                                    | 8.45        | 22.4       |

#### 4.4.1.3 Actinomycetes counts

Data shows that the effect of herbicide on soil actinomycetes at different growth stages of the crop are presented in Table 29 and depicted in fig. 18. The count of actinomycetes before sowing was unaffected however after spraying of herbicides there was decline in rate of population by different treatments, but there was increased in population at harvest of the crop. The treatment weedy check (T<sub>9</sub>) was recorded significantly higher actinomycetes count over rest of the treatments. The treatment pendimethalin 24% + oxyfluorfen 4% ZE @1083.60+185.12 g a.i./ha(T<sub>4</sub>) recorded minimum actinomycetes count. This might be due to application of herbicide in higher concentration. Similar observation was noted by Adhikary *et al.* (2014), Poddar *et al.* (2017).

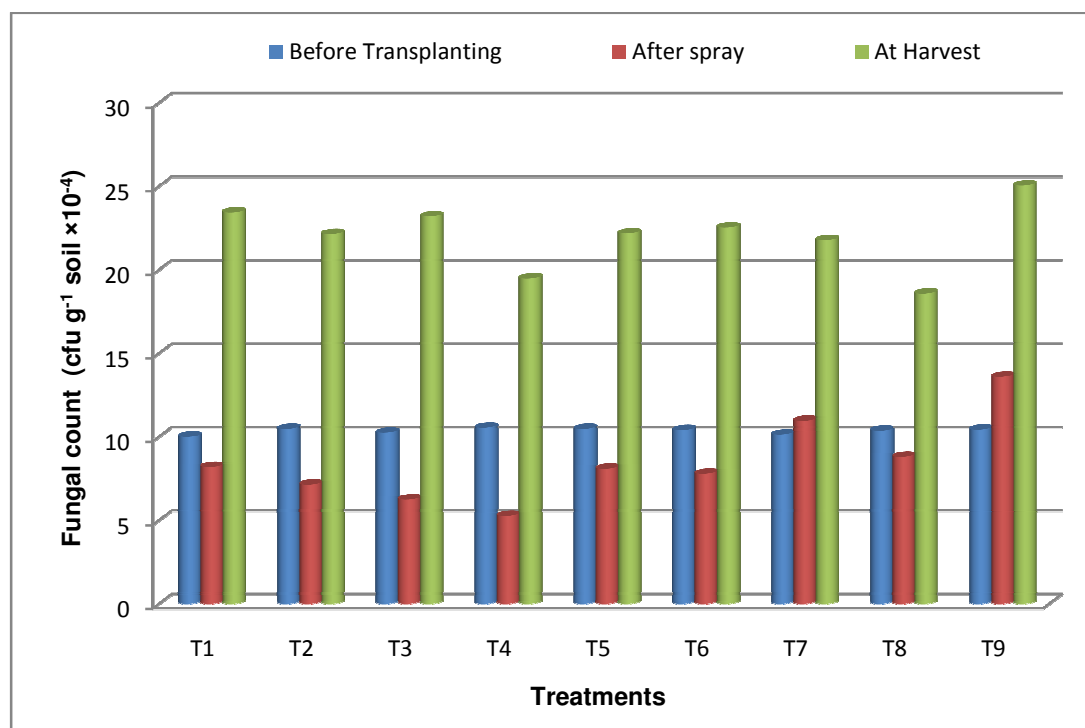


**Fig. 17 Microbial count (Fungal) at periodical growth stages as influenced by different weed control treatments (cfu g<sup>-1</sup> soil × 10<sup>-4</sup>)**

**Table 29: Microbial count (Actinomycetes) at periodical growth stages as influenced by different weed control treatments (cfu g<sup>-1</sup> soil ×10<sup>6</sup>)**

| Treatment                                                                           | Actinomycetes (cfu g <sup>-1</sup> soil ×10 <sup>6</sup> ) |             |            |
|-------------------------------------------------------------------------------------|------------------------------------------------------------|-------------|------------|
|                                                                                     | Before Transplanting                                       | After spray | At Harvest |
| T <sub>1</sub> - Pendimethalin 24% + Oxyfluorfen 4% ZE @480+82 g a.i./ha PE         | 8.30                                                       | 8.07        | 25.70      |
| T <sub>2</sub> - Pendimethalin 24% + Oxyfluorfen 4% ZE @541.80+92.56 g a.i./ha PE   | 8.50                                                       | 8.24        | 24.41      |
| T <sub>3</sub> - Pendimethalin 24% + Oxyfluorfen 4% ZE @600+102.5 g a.i./ha PE      | 8.77                                                       | 7.31        | 23.50      |
| T <sub>4</sub> - Pendimethalin 24% + Oxyfluorfen 4% ZE @1083.60+185.12 g a.i./ha PE | 8.53                                                       | 6.42        | 20.20      |
| T <sub>5</sub> - Pendimethalin 38.7% CS@ 677.25 g a.i./ha PE                        | 8.27                                                       | 8.10        | 24.45      |
| T <sub>6</sub> - Oxyfluorfen 23.5% EC@ 200 g a.i./ha PE                             | 8.53                                                       | 8.30        | 28.31      |
| T <sub>7</sub> - Quizalofop ethyl 5% EC@ 50 g a.i./ha PoE                           | 8.03                                                       | 7.63        | 22.26      |
| T <sub>8</sub> - Two HW (25 & 45 DAT)                                               | 8.70                                                       | 8.30        | 21.03      |
| T <sub>9</sub> -Weedy Check                                                         | 8.73                                                       | 18.60       | 29.97      |
| S.E(m)±                                                                             | 0.64                                                       | 0.55        | 2.02       |
| C.D. at 5%                                                                          | NS                                                         | 1.67        | 6.07       |
| G.M.                                                                                | 8.49                                                       | 9.00        | 24.43      |

Though actinomycetes count before transplanting and at harvest was not influenced by different treatments, but there was increased in population was observed at harvest of the crop.

Effect of herbicide after spray, significantly influenced the population of soil micro-organisms, bacteria, fungi, actinomycetes as compared to their population before herbicide application. But at the time of harvest of the crop the microbial population with all the treatment attained the higher level. It was clear that the persistence of herbicide on soil microbes was for a temporary period. The increase in microbial population might be due to after decomposition of herbicide, there is activation of different function group attached to herbicide. After decomposition of herbicide it release carbon molecules which are useful for enhancing microbial population in soil. These were in conformity with the result of Pal *et al.* (2009) and Ghosh *et al.* (2012) and Poddar *et al.* (2017).

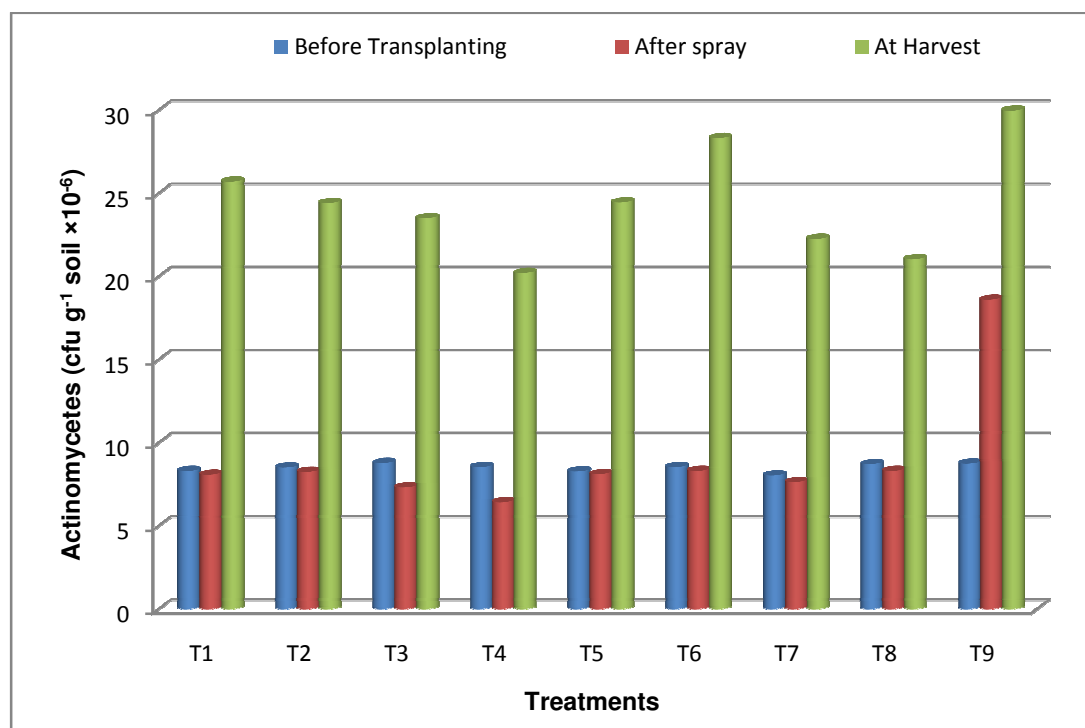


**Fig. 18** Microbial count (Actinomycetes) at periodical growth stages as influenced by different weed control treatments (cfu g<sup>-1</sup> soil × 10<sup>-6</sup>)

#### 4.5 Nitrogen, phosphorus and potassium uptake by onion bulb ( $\text{kg ha}^{-1}$ )

Data regarding nitrogen, phosphorus and potassium uptake ( $\text{kg ha}^{-1}$ ) by onion bulb as influenced by different herbicidal treatments are furnished in Table 30. and graphically showed in Fig.17.

##### 4.5.1 Nitrogen uptake by onion bulb

##### 4.5.1.1 Nitrogen content in bulb

The data presented in Table 30. revealed that mean nitrogen content of bulb was 0.27%.

**Table 30: Nutrients content (%) and uptake (N, P and K) by onion bulb ( $\text{kg ha}^{-1}$ ) as influenced by various weed control treatments**

| Treatment                                                                           | N content (%) | N uptake $\text{kg/ha}$ | P content (%) | P uptake $\text{kg/ha}$ | K content (%) | K uptake $\text{kg/ha}$ |
|-------------------------------------------------------------------------------------|---------------|-------------------------|---------------|-------------------------|---------------|-------------------------|
| T <sub>1</sub> - Pendimethalin 24% + Oxyfluorfen 4% ZE @480+82 g a.i./ha PE         | 0.26          | 38.30                   | 0.06          | 8.81                    | 0.12          | 17.63                   |
| T <sub>2</sub> - Pendimethalin 24% + Oxyfluorfen 4% ZE @541.80+92.56 g a.i./ha PE   | 0.27          | 41.14                   | 0.07          | 10.66                   | 0.13          | 18.28                   |
| T <sub>3</sub> - Pendimethalin 24% + Oxyfluorfen 4% ZE @600+102.5 g a.i./ha PE      | 0.29          | 54.60                   | 0.08          | 16.94                   | 0.14          | 26.36                   |
| T <sub>4</sub> - Pendimethalin 24% + Oxyfluorfen 4% ZE @1083.60+185.12 g a.i./ha PE | 0.28          | 44.98                   | 0.07          | 11.24                   | 0.12          | 20.88                   |
| T <sub>5</sub> - Pendimethalin 38.7% CS@ 677.25 g a.i./ha PE                        | 0.26          | 34.08                   | 0.06          | 7.86                    | 0.12          | 15.73                   |
| T <sub>6</sub> - Oxyfluorfen 23.5% EC@ 200 g a.i./ha PE                             | 0.29          | 49.12                   | 0.08          | 13.55                   | 0.13          | 22.01                   |
| T <sub>7</sub> - Quizalofop ethyl 5% EC@ 50 g a.i./ha PoE                           | 0.27          | 38.61                   | 0.07          | 9.92                    | 0.12          | 17.01                   |
| T <sub>8</sub> - Two HW (25 & 45 DAT)                                               | 0.30          | 59.02                   | 0.09          | 17.70                   | 0.15          | 29.51                   |
| T <sub>9</sub> - Weedy Check                                                        | 0.23          | 20.66                   | 0.06          | 5.76                    | 0.11          | 9.88                    |
| S.E(m)±                                                                             | 0.01          | 2.78                    | 0.008         | 0.75                    | 0.01          | 1.48                    |
| C.D. at 5%                                                                          | NS            | 8.33                    | NS            | 2.27                    | NS            | 4.45                    |
| G.M.                                                                                | 0.27          | 42.28                   | 0.07          | 11.38                   | 0.13          | 19.70                   |

Treatment weed free with two HW (25 & 45 DAT) (T<sub>8</sub>) and Pendimethalin 24% + Oxyfluorfen 4% ZE @600+102.5 g a.i./ha (T<sub>3</sub>) recorded numerically higher nitrogen content in bulb 0.30 and 0.29 respectively. The lowest N content was recorded in treatment weedy check (T<sub>9</sub>). However, nitrogen content in bulb was not affected much due to different herbicidal treatment.

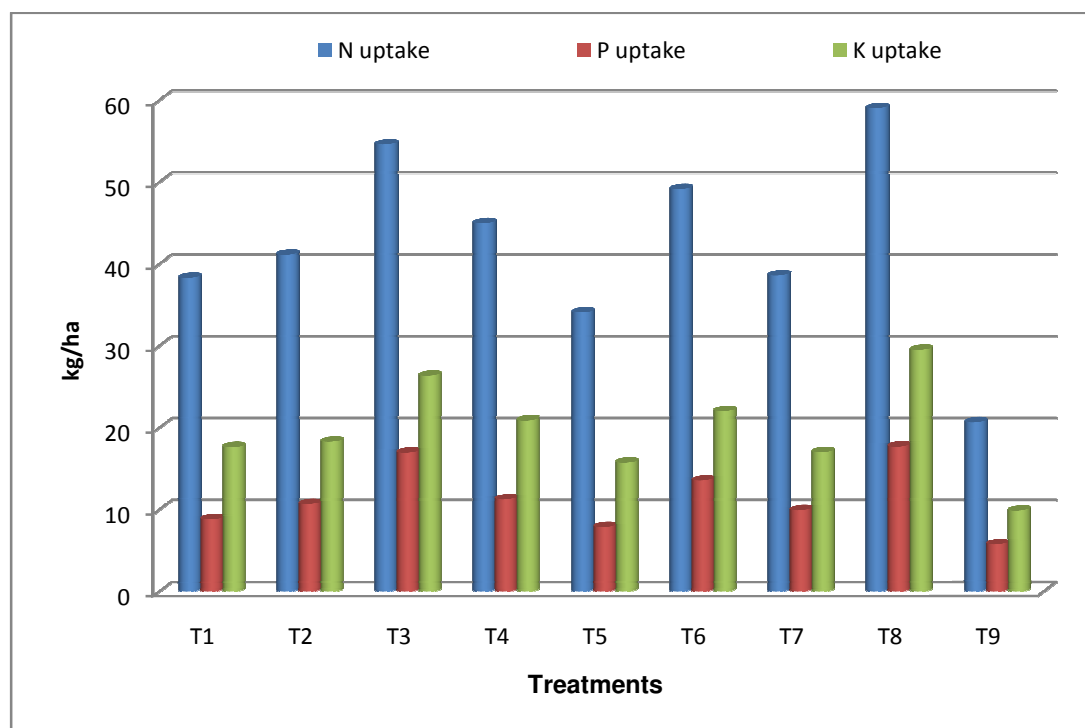


**Fig. 19 Nutrients content (%) and uptake (N, P and K) by onion bulb ( $\text{kg ha}^{-1}$ ) as influenced by various weed control treatments**

#### 4.5.1.2 Nitrogen uptake ( $\text{kg ha}^{-1}$ )

The data presented in Table 30 and graphically showed in Fig.19. revealed that the mean uptake of nitrogen by bulb was  $42.28 \text{ Kg ha}^{-1}$ .

Higher uptake of nitrogen was recorded in the treatment Two HW (25 & 45 DAT) ( $T_8$ ) which was found to be followed by the treatments Pendimethalin 24% + Oxyfluorfen 4% ZE @600+102.5 g a.i./ha ( $T_3$ ) and Oxyfluorfen 23.5% EC@ 200 g a.i./ha ( $T_6$ ) and Pendimethalin 24% + Oxyfluorfen 4% ZE @1083.60+185.12 g a.i./ha ( $T_4$ ) Significantly lowest uptake of nitrogen was noted in the treatment Weedy check ( $T_9$ ) and the remaining treatments recorded medium values for an uptake of nitrogen due to onion bulb yield. The higher nitrogen uptake in weed free treatment was observed due to less weed infestation, competition of weed was low and more production dry matter and higher onion bulb yield due to optimized utilization of available resources as compared to other treatments. Similar results were also reported by Sable *et al.* (2013).

#### 4.5.2 Phosphorus uptake by onion bulb.

##### 4.5.2.1 Phosphorus content in onion bulb

The data regarding to phosphorus content in onion bulb are presented in Table 30. It revealed that, the mean of phosphorus content was 0.07 % in bulb.

Higher phosphorus content (0.09%) in onion bulb was recorded in treatment Two HW (25 & 45 DAT) ( $T_8$ ) which was superior among all treatments, whereas among herbicidal treatment, Pendimethalin 24% + Oxyfluorfen 4% ZE @600+102.5 g a.i./ha ( $T_3$ ) and Oxyfluorfen 23.5% EC@ 200 g a.i./ha ( $T_6$ ) was found superior with phosphorus content (0.08%). The lowest phosphorus content was recorded with the treatment Weedy check ( $T_9$ ).

##### 4.5.2.2 Phosphorus uptake ( $\text{kg ha}^{-1}$ )

Data in respect of phosphorus uptake by bulb is presented in Table 30 and graphically illustrated in Fig. 19. The mean uptake of phosphorus by bulb was  $11.38 \text{ Kg ha}^{-1}$ .

Higher phosphorus uptake by bulb was found with treatment of Two HW (25 and 45 DAT) ( $T_8$ ), but was statistically at par with treatment Pendimethalin 24% + Oxyfluorfen 4% ZE @600+102.5 g a.i./ha ( $T_3$ ) found significantly superior over the rest of treatments. It was because of production of higher bulb yield in these treatments due to minimum weed population density, excessive dry matter accumulation and greater availability of phosphorus which ultimately resulted in increase in P uptake. Similar findings were also reported by Sable *et al.* (2013).

#### **4.5.3 Potassium uptake by onion bulb.**

##### **4.5.3.1 Potassium content in onion bulb.**

The data in respect of potassium content in onion bulb are presented in Table 30. which revealed that, the mean of potassium content was 0.13 % in bulb.

Numerically higher potassium content (0.15%) and (0.14%) were recorded in bulb by treatment Two HW (25 & 45 DAT) ( $T_8$ ), Pendimethalin 24% + Oxyfluorfen 4% ZE @600+102.5 g a.i./ha ( $T_3$ ). The lowest potassium content was recorded with the treatment Weedy check ( $T_9$ ) which was 0.11%.

##### **4.5.3.2 Potassium uptake ( $\text{kg ha}^{-1}$ )**

Data in respect of potassium uptake by bulb are presented in Table 30 and graphically illustrated in Fig.19. The mean uptake of potassium by bulb was  $28.63 \text{ Kg ha}^{-1}$ .

Maximum potassium uptake by bulb was found in treatment with Two HW (25 & 45 DAT) ( $T_8$ ) which was closely at par with treatments Pendimethalin 24% + Oxyfluorfen 4% ZE @600+102.5 g a.i./ha ( $T_3$ ) followed by Oxyfluorfen 23.5% EC@ 200 g a.i./ha ( $T_6$ ) however, these treatments were comparable with each other and found significantly superior over the rest of treatments. The lowest potassium uptake was recorded with the treatment Weedy check ( $T_9$ ).

#### 4.5.4 Nitrogen, phosphorus and potassium uptake by weed.

Data regarding nitrogen, phosphorus and potassium uptake ( $\text{kg ha}^{-1}$ ) by weed as influenced by different treatment are presented in Table 31 and graphically showed in Fig.20.

**Table 31: Nutrients uptake (N, P and k) by weeds ( $\text{kg ha}^{-1}$ ) as influenced by various weed control treatments**

| Treatment                                                                           | N<br>( $\text{Kg ha}^{-1}$ ) | P<br>( $\text{Kg ha}^{-1}$ ) | K<br>( $\text{Kg ha}^{-1}$ ) |
|-------------------------------------------------------------------------------------|------------------------------|------------------------------|------------------------------|
| T <sub>1</sub> - Pendimethalin 24% + Oxyfluorfen 4% ZE @480+82 g a.i./ha PE         | 15.90                        | 4.45                         | 7.96                         |
| T <sub>2</sub> - Pendimethalin 24% + Oxyfluorfen 4% ZE @541.80+92.56 g a.i./ha PE   | 13.49                        | 3.93                         | 6.74                         |
| T <sub>3</sub> - Pendimethalin 24% + Oxyfluorfen 4% ZE @600+102.5 g a.i./ha PE      | 10.45                        | 2.84                         | 5.69                         |
| T <sub>4</sub> - Pendimethalin 24% + Oxyfluorfen 4% ZE @1083.60+185.12 g a.i./ha PE | 12.23                        | 3.05                         | 6.10                         |
| T <sub>5</sub> - Pendimethalin 38.7% CS@ 677.25 g a.i./ha PE                        | 14.32                        | 4.09                         | 8.19                         |
| T <sub>6</sub> - Oxyfluorfen 23.5% EC@ 200 g a.i./ha PE                             | 11.20                        | 2.93                         | 5.87                         |
| T <sub>7</sub> - Quizalofop ethyl 5% EC@ 50 g a.i./haPoE                            | 16.77                        | 7.46                         | 11.19                        |
| T <sub>8</sub> - Two HW (25 & 45 DAT)                                               | -                            | -                            | -                            |
| T <sub>9</sub> - Weedy Check                                                        | 62.93                        | 19.70                        | 36.12                        |
| S.E(m)±                                                                             | 1.16                         | 0.34                         | 0.73                         |
| C.D. at 5%                                                                          | 3.48                         | 1.04                         | 2.19                         |
| G.M.                                                                                | 17.48                        | 5.38                         | 9.76                         |

##### 4.5.4.1 Nitrogen uptake by weed ( $\text{kg ha}^{-1}$ )

The data presented in Table 31 and graphically depicted in Fig 20. revealed that the mean uptake of nitrogen by different weed was  $17.48 \text{ kg ha}^{-1}$ . The removal of nitrogen by weeds was significantly less in treatment Pendimethalin 24% + Oxyfluorfen 4% ZE @600+102.5 g a.i./ha (T<sub>3</sub>) as compared to rest of the treatments. Other treatment Oxyfluorfen 23.5% EC@ 200 g a.i./ha (T<sub>6</sub>) it was statistically followed by treatments Pendimethalin 24% + Oxyfluorfen 4% ZE @1083.60+185.12 g a.i./ha (T<sub>4</sub>), Pendimethalin 24% + Oxyfluorfen 4% ZE @541.80+92.56 g a.i./ha (T<sub>2</sub>), Pendimethalin 38.7% CS@ 677.25 g a.i./ha (T<sub>5</sub>), Pendimethalin 24% + Oxyfluorfen 4% ZE @480+82 g a.i./ha (T<sub>1</sub>) Quizalofop ethyl 5% EC@ 50 g

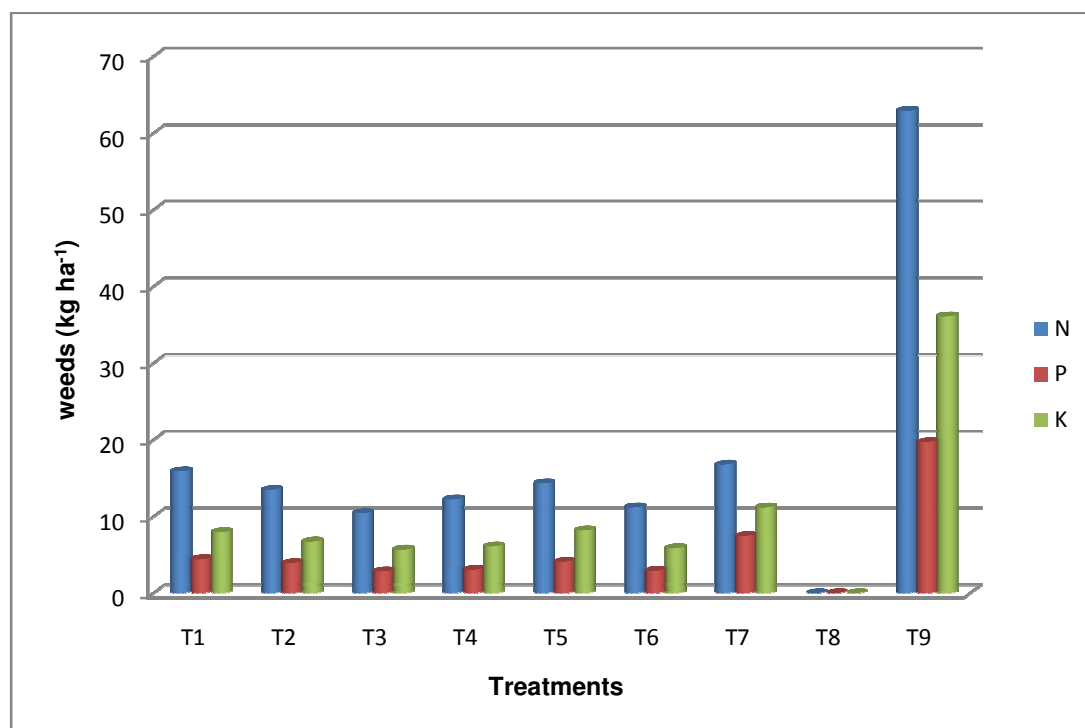


**Fig. 20 Nutrients uptake (N, P and k) by weeds (kg ha<sup>-1</sup>) as influenced by various weed control treatments**

a.i./ha (T<sub>7</sub>). Treatment T<sub>9</sub> (Weedy check) removed significantly more nitrogen than rest of the treatments. The higher nitrogen uptake in weedy check treatment resulted due to more weed population owing to more dry matter accumulation by weeds.

#### 4.5.4.2 Phosphorus uptake by weed (kg ha<sup>-1</sup>)

The data represented in Table 31 and graphically showed in Fig.20 revealed that the mean uptake of phosphorous by different weed was 5.38 kg ha<sup>-1</sup>. The uptake of phosphorous by weeds was significantly less in treatment Pendimethalin 24% + Oxyfluorfen 4% ZE @600+102.5 g a.i./ha (T<sub>3</sub>) as compared to rest of the treatments. Treatment oxyfluorfen 23.5% EC@ 200 g a.i./ha (T<sub>6</sub>) it was statistically at par with (T<sub>3</sub>). Treatments followed by (T<sub>6</sub>) and (T<sub>3</sub>) were pendimethalin 24% + Oxyfluorfen 4% ZE @1083.60+185.12 g a.i./ha (T<sub>4</sub>), pendimethalin 24% + oxyfluorfen 4% ZE @541.80+92.56 g a.i./ha (T<sub>2</sub>), pendimethalin 38.7% CS@ 677.25 g a.i./ha (T<sub>5</sub>), pendimethalin 24% + oxyfluorfen 4% ZE @480+82 g a.i./ha (T<sub>1</sub>) quizalofop ethyl 5% EC@ 50 g a.i./ha (T<sub>7</sub>). Treatment T<sub>9</sub> (Weedy check) removed significantly more phosphorous than rest of the treatments.

#### 4.5.4.3 Potassium uptake by weed (kg ha<sup>-1</sup>)

The data represented in Table 31 and graphically showed in Fig.20 revealed that the mean uptake of potassium by different weed was 9.76 kg ha<sup>-1</sup>. Treatment T<sub>3</sub> (pendimethalin 24% + oxyfluorfen 4% ZE @600+102.5 g a.i./ha) recorded significantly less uptake of potassium than other weed control treatments, but at par with treatment oxyfluorfen 23.5% EC@ 200 g a.i./ha (T<sub>6</sub>) and pendimethalin 24% + oxyfluorfen 4% ZE @1083.60+185.12 g a.i./ha (T<sub>4</sub>) followed by treatments pendimethalin 24% + oxyfluorfen 4% ZE @541.80+92.56 g a.i./ha (T<sub>2</sub>), pendimethalin 24% + oxyfluorfen 4% ZE @480+82 g a.i./ha (T<sub>1</sub>) and pendimethalin 38.7% CS@ 677.25 g a.i./ha (T<sub>5</sub>), quizalofop ethyl 5% EC@ 50 g a.i./ha (T<sub>7</sub>). Treatment T<sub>9</sub> (weedy check) recorded significantly more potassium uptake by the weed.

Among the different weed control measures, weedy check (T<sub>9</sub>) recorded significantly higher N (62.98 kg ha<sup>-1</sup>), P (19.70 kg ha<sup>-1</sup>) and K (36.12 kg ha<sup>-1</sup>) uptake by weed. The treatment (T<sub>3</sub>) (pendimethalin 24% + oxyfluorfen 4% ZE @600+102.5 g a.i./ha) recorded lower value of nutrient uptake by weed than those of other treatments followed by treatment (T<sub>6</sub>) and (T<sub>4</sub>). This was mainly due to heavy infestation of weeds which took up enormous amount of NPK from soil in weedy check as nutrient uptake and which was directly governed by dry matter production of weeds. The same kind of result was also reported by Sable *et al.* (2013).

#### 4.6 Economic of different weed control treatments

The regional adaptability of any agronomic practices in the yield of any crop is completely based on the economic value of treatment. Therefore, it is necessary to work out economics of different treatments for valid comparison of agronomic practices and sound recommendation. Sometimes the most effective treatment may become poorer in economics.

**Table 32: Economics of different weed control treatments in onion**

| Treatment                                                                           | Gross monetary returns (Rs ha <sup>-1</sup> ) | Total cost of cultivation (Rs ha <sup>-1</sup> ) | NMR (Rs ha <sup>-1</sup> ) | B:C ratio |
|-------------------------------------------------------------------------------------|-----------------------------------------------|--------------------------------------------------|----------------------------|-----------|
| T <sub>1</sub> - Pendimethalin 24% + Oxyfluorfen 4% ZE @480+82 g a.i./ha PE         | 146950                                        | 61470                                            | 85480                      | 2.39      |
| T <sub>2</sub> - Pendimethalin 24% + Oxyfluorfen 4% ZE @541.80+92.56 g a.i./ha PE   | 152400                                        | 61624                                            | 90776                      | 2.47      |
| T <sub>3</sub> - Pendimethalin 24% + Oxyfluorfen 4% ZE @600+102.5 g a.i./ha PE      | 188290                                        | 61770                                            | 126520                     | 3.04      |
| T <sub>4</sub> - Pendimethalin 24% + Oxyfluorfen 4% ZE @1083.60+185.12 g a.i./ha PE | 167660                                        | 64518                                            | 103142                     | 2.59      |
| T <sub>5</sub> - Pendimethalin 38.7% CS@ 677.25 g a.i./ha PE                        | 131110                                        | 61792                                            | 69318                      | 2.12      |
| T <sub>6</sub> - Oxyfluorfen 23.5% EC@ 200 g a.i./ha PE                             | 169381                                        | 61332                                            | 107986                     | 2.76      |
| T <sub>7</sub> - Quizalofop ethyl 5% EC@ 50 g a.i./ha PoE                           | 141791                                        | 61420                                            | 80371                      | 2.30      |
| T <sub>8</sub> - Two HW (25 & 45 DAT)                                               | 196740                                        | 69870                                            | 126870                     | 2.81      |
| T <sub>9</sub> - Weedy Check                                                        | 89740                                         | 59790                                            | 29950                      | 1.50      |
| <b>S.E(m)±</b>                                                                      | 6869                                          | -                                                | 6869                       | -         |
| <b>C.D. at 5%</b>                                                                   | 20595                                         | -                                                | 20595                      | -         |
| <b>G.M.</b>                                                                         | 153784                                        | 62620                                            | 91157                      | 2.44      |

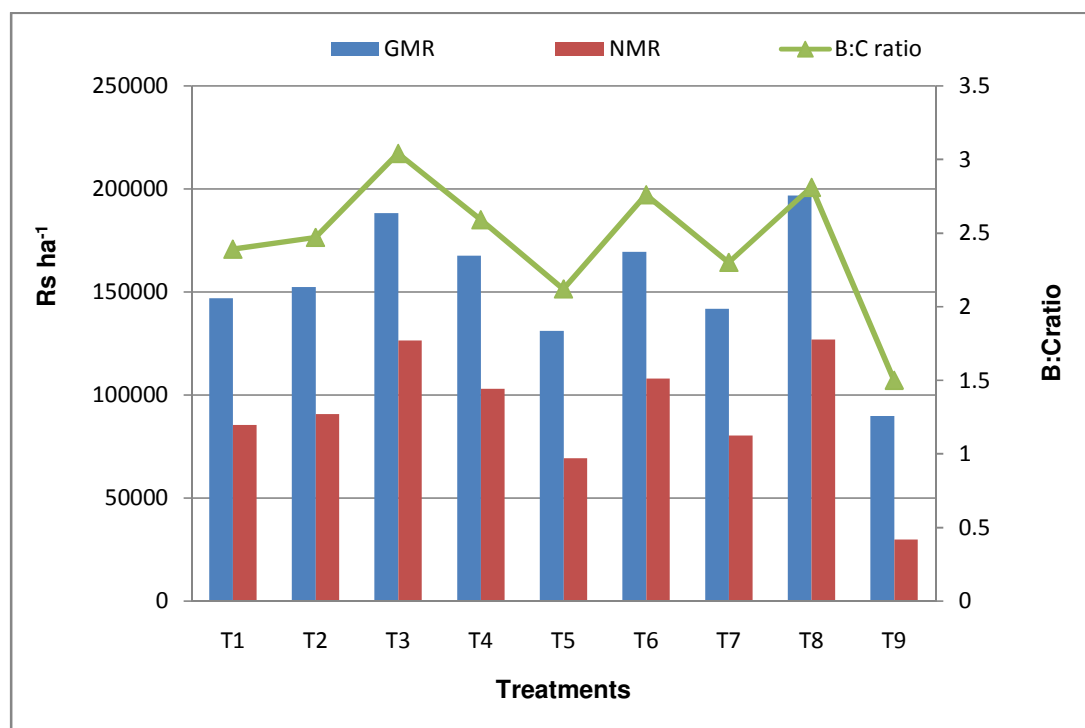


**Fig. 21 Economics of different weed control treatments in onion**

Economics of different treatments as influenced by various herbicides applied in combination and as a sole in onion on experimentation is presented in Table 32 and depicted in graph 21.

Result summarised in Table 32 regarding economics as influenced by herbicidal application indicated that higher net realization (188290 Rs ha<sup>-1</sup>) was noticed under the treatment of pendimethalin 24% + oxyfluorfen 4% ZE @600+102.5 g a.i./ha (T<sub>3</sub>) with highest benefit : cost ratio, (3.04) found in treatment (T<sub>3</sub>) as compared to no application of herbicide or any control measure i.e. weedy check (T<sub>9</sub>) because the application of herbicide increased the cost of cultivation but it can enhance the profitability by decreasing crop weed competition.

#### **4.6.1 Gross monetary return**

The data presented in Table 32, revealed that gross monetary returns Rs ha<sup>-1</sup> influenced by different herbicidal treatments and average gross monetary returns was 153784 Rs ha<sup>-1</sup>. Treatment with 2 HW at 25 and 45 DATP (T<sub>8</sub>) i.e. weed free recorded maximum gross monetary returns of (196740 Rs ha<sup>-1</sup>).

GMR of different weed management practices indicated that higher additional income over control. Among the herbicidal treatment highest gross monetary return was observed under the, application of pendimethalin 24% + oxyfluorfen 4% ZE @600+102.5 g a.i./ha as pre-emergence (T<sub>3</sub>) recorded second higher gross realization (188290 ha<sup>-1</sup>) after weed free followed by (T<sub>6</sub>) (oxyfluorfen 23.5% EC@ 200 g a.i./ha), (T<sub>4</sub>) (pendimethalin 24% + oxyfluorfen 4% ZE @1083.60+185.12 g a.i./ha). These four treatments were statistically at par with each other. The lowest gross monetary return was recorded in treatment of weedy check (T<sub>9</sub>). These results are in accordance with findings of Nandal and Singh (2002), Kathepuriet *al.* (2011b), Kalhapure and Shete (2012), Govindarajan *et al.* (2012) and Jangreet *al.* (2019).

#### **4.6.2 Net monetary returns**

Net monetary return (Rs. ha<sup>-1</sup>) was influenced due to various herbicidal treatments and hand weeding treatment. Average net monetary

returns  $\text{ha}^{-1}$  was Rs 91157. The weed free plot ( $T_8$ ) resulted in higher cost of cultivation and net monetary return (Rs.126870  $\text{ha}^{-1}$ ). Among the herbicidal treatments, application with pendimethalin 24% + oxyfluorfen 4% ZE @600+102.5 g a.i./ha( $T_3$ ) (Rs.126520  $\text{ha}^{-1}$ ) found superior over rest of the herbicidal treatment and application of oxyfluorfen 23.5% EC@ 200 g a.i./ha ( $T_6$ ) (Rs. 107986  $\text{ha}^{-1}$ ) stood second in NMR. These treatments were at par with weed free While minimum net monetary return was observed in treatment weedy check ( $T_9$ ) (Rs.29950  $\text{ha}^{-1}$ ).

This type of variation in treatments for net monetary returns is due to different herbicide cost. Similar results were obtained by Nandal and Singh (2002) and Saraf (2007).

#### **4.6.3 Benefit to cost ratio.**

The B: C ratio was worked out for each herbicidal treatment and hand weeding presented in Table 32.

The data presented in Table 32. showed that though higher GMR and NMR were registered under treatment with 2 HW 25 & 45 DAT ( $T_8$ ), maximum B:C ratio was recorded in the treatment with herbicidal application pendimethalin 24% + oxyfluorfen 4% ZE @600+102.5 g a.i./ha( $T_3$ ) recorded highest benefit cost ratio, i.e.3.04 followed by treatments weed free 2HW 25 & 45 DAT ( $T_8$ ) i.e. 2.81 and Oxyfluorfen 23.5% EC@ 200 g a.i./ha ( $T_6$ ) (2.76).

The higher values of B:C ratio in these treatment might be due to yield advantage with lower cost of cultivation in these treatments than rest of the treatments. Pendimethalin and oxyfluorfen was applied in combination @ 600+102.5 g a.i./ha. It leads towards lower cost of herbicide treatment compared to weed free treatment. In weed free plot the cost of cultivation increased remarkably due to regular weeding operations followed for clean cultivation. It increased the cost of manual weeding and this increased the cost of cultivation. Moreover weedy check recorded lesser B:C ratio (1.50) due to lower onion bulb yield owing to more weed competition. Lowest benefit cost ratio (1.50) was recorded in treatment weedy check ( $T_9$ ) as a result of higher crop weed competition which



**T<sub>1</sub> Pendimethalin 24% + Oxyfluorfen  
4% ZE @480+82 g a.i./ha**



**T<sub>2</sub> Pendimethalin 24% + Oxyfluorfen  
4% ZE @541.80+92.56 g a.i./ha**



**T<sub>3</sub> Pendimethalin 24% + Oxyfluorfen  
4% ZE @600+102.5 g a.i./ha**



**T<sub>4</sub> Pendimethalin 24% + Oxyfluorfen  
4% ZE @1083.60+185.12 g a.i./ha**



**T<sub>5</sub> Pendimethalin 38.7% CS@ 677.25 g a.i./ha**

**Plate 3a Effect of different herbicidal treatments on weed**



**T<sub>6</sub> Oxyfluorfen 23.5% EC@ 200 g a.i./ha**



**T<sub>7</sub> Quizalofop ethyl 5% EC@ 50 g a.i./ha**



**T<sub>8</sub> Two HW (25 & 45 DAT)**



**T<sub>9</sub> Weedy Check**

**Plate 3b Effect of different herbicidal treatments on weed**

reduced the onion yield. The differences in B:C ratio is due to the cost of herbicides and productivity of the crop. Economic feasibility of adopting herbicidal application have been reported by Singh *et al.* (1996) Mandeep Kaur Saini and Walia (2012) and Jangreet *et al.* (2019).

## CHAPTER V

### SUMMARY AND CONCLUSIONS

#### 5.1 Summary

The present investigation was carried out during *Rabi* season of the year 2018-2019 on clayey soil at the farm of AICRP-Weed Management, Department of Agronomy Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, to study “ Efficacy of pre and post emergence herbicides against weedflora in onion (*Allium cepa* L.)”.

In the present experimentation, chemical weed management practices i.e. herbicides viz; Pendimethalin 24% + Oxyfluorfen 4% ZE @480+82 g a.i./ha(T<sub>1</sub>), Pendimethalin 24% + Oxyfluorfen 4% ZE @541.80+92.56 g a.i./ha(T<sub>2</sub>), Pendimethalin 24% + Oxyfluorfen 4% ZE @600+102.5 g a.i./ha(T<sub>3</sub>), Pendimethalin 24% + Oxyfluorfen 4% ZE @1083.60+185.12 g a.i./ha(T<sub>4</sub>) are the herbicide with combine (pre-mix) formulation with different concentration of active ingredient, Pendimethalin 38.7% CS@ 677.25 g a.i./ha(T<sub>5</sub>), Oxyfluorfen 23.5% EC@ 200 g a.i./ha(T<sub>6</sub>), Quizalofop ethyl 5% EC@ 50 g a.i./ha(T<sub>7</sub>) were used for different treatments. Pre and post-emergence herbicides sprayed with knapsack sprayer fitted with flat fan nozzle by using 500 litre of water ha<sup>-1</sup>. These were compared with cultural method of hand weeding at 25DAT & 45 DAT(T<sub>8</sub>) along with un-weeded control(T<sub>9</sub>). The experiment was laid out in randomized block design with three replications. The objectives were to evaluate the bio- efficacy of different pre-emergence and post-emergence herbicides against weedflora, growth and yield of onion. Another aspect was to evaluate the phytotoxicity of different pre-emergence and post-emergence herbicides in onion and to study economics of different method of weed control. The onion crop was transplanted on 14<sup>th</sup> December, 2018 and harvested on 9<sup>th</sup> April, 2019.

The important research findings are summarized here

### 5.1.1 Effect on weed studies

1. Weed flora observed in the experimental field, mainly comprised of *Datura stramonium*, *Parthenium hysteriphorus* followed by *Euphorbia hirta* L., *Commelinabenghalensis*, *Alternanatheratriandra*, *Digera arvensis* Forst., *Tridaxprocumbens* L., *Euphorbia geniculata* Orteg., *Argemone mexicana* L., *Xanthium strumarium* L., *Chenopodium album* L., *Phyllanthus niruri* L., *Portulaca oleracea* L., *Lagascamollis* and *Acalypha indic* these were dicot weeds and among monocot *Cyprus rotundus*, *Cynodondactylon*, *Eleusinindica* L. and *Dactyloctenium aegyptium* L.
2. Treatment (T<sub>4</sub>) Pendimethalin 24% + Oxyfluorfen 4% ZE @1083.60+185.12 g a.i./ha, recorded lowest monocot and dicot weeds, total weed count and weed dry weight at early stages of crop growth. Subsequently at 40 DAT to at harvest, the total weed count and weed dry weight were lower in (T<sub>3</sub>) Pendimethalin 24% + Oxyfluorfen 4% ZE @600+102.5 g a.i./ha. The treatment T<sub>9</sub> (Weed check) showed highest monocot and dicot weeds infestation and weed dry weight.
3. Maximum weed control efficiency at 20 DAT was obtained with (T<sub>4</sub>) Pendimethalin 24% + Oxyfluorfen 4% ZE @1083.60+185.12 g a.i./ha however at 40 DAT up to at harvest higher weed control efficiency was observed in treatment (T<sub>3</sub>) i.e. Pendimethalin 24% + Oxyfluorfen 4% ZE @600+102.5 g a.i./ha.
4. Lowest weed index was recorded in treatment (T<sub>3</sub>) i.e. Pendimethalin 24% + Oxyfluorfen 4% ZE @600+102.5 g a.i./ha and highest weed index was obtained with treatment weedy check (T<sub>9</sub>).
5. Initially, phytotoxicity effect was observed on (T<sub>4</sub>) Pendimethalin 24% + Oxyfluorfen 4% ZE @1083.60+185.12 g a.i./ha due to its higher concentration of active ingredient which was upto the easily recoverable extent.

### 5.1.2 Effect on crop studies:

1. Initial and final plant stand were not influenced due to different weed control treatments.
2. Plant height of onion crop was significantly improved in treatment T<sub>3</sub> (Pendimethalin 24% + Oxyfluorfen 4% ZE @600+102.5 g a.i./ha), while treatment T<sub>9</sub> (Weedy check) recorded minimum plant height.
3. Maximum fresh leaves and bulb weight of onion per plant was recorded in the treatment T<sub>3</sub> (Pendimethalin 24% + Oxyfluorfen 4% ZE @600+102.5 g a.i./ha). Whereas, maximum number of leaves plant<sup>-1</sup> was also recorded in treatment T<sub>3</sub> (Pendimethalin 24% + Oxyfluorfen 4% ZE @600+102.5 g a.i./ha) over treatment of weedy check.
4. Plant dry matter initially (20 DAS) was higher in Pendimethalin 24% + Oxyfluorfen 4% ZE @1083.60+185.12 g a.i./ha (T<sub>4</sub>), later growth stages treatment (T<sub>3</sub>) with Pendimethalin 24% + Oxyfluorfen 4% ZE @600+102.5 g a.i./ha recorded highest dry matter. Lowest plant dry matter was recorded in weedy check.

### 5.1.3 Effect on yield studies:

1. Treatment with application of pendimethalin 24% + oxyfluorfen 4% ZE @600+102.5 g a.i./ha produced significantly the maximum equatorial diameter of onion bulb (67.64 mm) as well as polar diameter (54.01 mm). The bulb with significantly minimum equatorial diameter (49.84 mm) and polar diameter (40.57 mm) was harvested from the treatment T<sub>9</sub> (Weedy check).
2. Different weed management practices significantly improved the bulb yield. Treatment T<sub>3</sub> (Pendimethalin 24% + Oxyfluorfen 4% ZE @600+102.5 g a.i./ha) registered highest bulb yield (188.29 q ha<sup>-1</sup>) which showed superiority over Weedy check (89.84 q ha<sup>-1</sup>) and was comparable with treatment T<sub>6</sub> i.e. Oxyfluorfen 23.5% EC @ 200 g a.i./ha.

#### 5.1.4 Effect on microbial studies:

Microbial count of bacteria, fungi, actinomycetes was observed higher in weedy check over other treatments. Minimum bacterial count was observed in treatment T<sub>4</sub> (Pendimethalin 24% + Oxyfluorfen 4% ZE @1083.60+185.12 g a.i./ha).

#### 5.1.5 Effect on chemical studies:

Uptake of NPK (kg ha<sup>-1</sup>) by onion bulb was significantly more with treatment weed free treatment followed by T<sub>3</sub> (Pendimethalin 24% + Oxyfluorfen 4% ZE @600+102.5 g a.i./ha). The lowest value of NPK uptake was recorded in treatment T<sub>9</sub> (Weedy check).

Nitrogen, phosphorous and potassium uptake (kg ha<sup>-1</sup>) by weed was significantly less in weed free followed by treatment T<sub>3</sub> (Pendimethalin 24% + Oxyfluorfen 4% ZE @600+102.5 g a.i./ha). The highest value of NPK uptake by weed was recorded in T<sub>9</sub> (Weedy check).

#### 5.1.6 Effect on economic studies:

Cultural method of weed management i.e. 2 HW recorded maximum GMR (Rs 196740 ha<sup>-1</sup>) however among the herbicidal treatment, treatment with application of pendimethalin 24% + oxyfluorfen 4% ZE @600+102.5 g a.i./ha (T<sub>3</sub>) recorded maximum GMR (Rs 188290 ha<sup>-1</sup>), NMR (Rs.126520 ha<sup>-1</sup>) and B:C ratio (3.04). While minimum GMR (Rs 89740 ha<sup>-1</sup>), NMR (Rs.29950 ha<sup>-1</sup>) and B:C (1.50) ratio was observed in treatment T<sub>9</sub> (Weedy check).

#### 5.2 Conclusion:

On the basis of the outcomes obtained from present investigation following conclusions are emerged.

1. Cultural weed management i.e. twice hand weeding proved most effective in management of weeds with good performance on crop growth at all the stages, yield attributes and bulb yield of onion. However, among the herbicides, application of pendimethalin 24% + oxyfluorfen 4% ZE @600+102.5 g a.i./ha had effectively managed the weeds throughout the growth period of onion there by improving growth

and yield contributing characters and consequently recorded highest bulb yield and GMR per hectare.

2. The highest reduction in total weed population, weed dry matter, increase in the weed control efficiency, lowest weed index and highest growth and yield attributes was found with application of pendimethalin 24% + oxyfluorfen 4% ZE @600+102.5 g a.i./ha among different herbicide.
3. Phytotoxicity effect in the initial crop stage was observed in treatment where Pendimethalin 24% + Oxyfluorfen 4% ZE @1083.60+185.12 g a.i./ha was sprayed due to its higher concentration of active ingredient but it was recovered thereafter.
4. The treatment of Pendimethalin 24% + Oxyfluorfen 4% ZE @600+102.5 g a.i./ha proved economically feasible with maximum GMR (Rs. 188290 ha<sup>-1</sup>), NMR (Rs. 126520 ha<sup>-1</sup>) and B:C ratio (3.04).

It is concluded from the experiment that, though cultural weed management of hand weeding twice proved more effective in controlling weeds and higher onion bulb yield, but chemical weed management with pre-mix herbicides is suitable method for broad spectrum weed management and for more economic returns to the farmer.

Conclusions are drawn on the basis of one year experimentation and it needs confirmation through further experimentation.



Plate 4 Visit of dignitaries team

## CHAPTER VI

### LITERATURE CITED

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**Appendix**  
**Economics of Weed Management in Onion**

| SN       | Operation Details                                                                                                                                                                | Inputs/<br>Services                                                                    | Cost of<br>Input/Services<br>(Rs unit <sup>-1</sup> )                              | Total<br>Cost<br>(Rs ha <sup>-1</sup> )    |
|----------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------|------------------------------------------------------------------------------------|--------------------------------------------|
| <b>1</b> | <b>Nursery</b><br>Nursery preparation<br>Nursery Management                                                                                                                      | 02 ML<br>14 FL                                                                         | 240 Rs/ day<br>240 Rs/ day                                                         | 480<br>3360                                |
| <b>2</b> | <b>Land Preparation:</b><br>a) Cultivator<br>b) Harrowing<br>c) leveling<br>d) Stubble picking<br>e) Preparation of BBF<br>f) Basal application SSP                              | Tractor, 3 hrs<br>Tractor, 4 hrs<br>Tractor, 2 hrs<br>06 FL<br>Tractor, 3 hrs<br>03 FL | 400 Rs/ hr<br>350 Rs/ hr<br>250 Rs/ hr<br>240 Rs/ day<br>400 Rs/ hr<br>240 Rs/ day | 1200<br>1400<br>500<br>1440<br>1200<br>720 |
| <b>3</b> | <b>Seed and Transplanting</b><br>a) Cost of seed<br>b) Transplanting of seedling                                                                                                 | 9 kg<br>40 FL                                                                          | 500 Rs/ kg<br>240 Rs/ day                                                          | 4500<br>9600                               |
| <b>4</b> | <b>Interculture operation</b><br>a) Hand Weeding (02)                                                                                                                            | 42 FL                                                                                  | 240 Rs/ day                                                                        | 10800                                      |
| <b>5</b> | <b>Plant Protections</b><br>Treatment of seedling in<br>Bavistin solution<br>Spraying of Quinolphos<br>Spraying of COC<br>Cost of spraying application<br>Petrol for power spray | 0.25 kg<br>0.5 L<br>0.5 kg<br>03 ML<br>02 FL<br>6 L                                    | 600 Rs/ kg<br>280 Rs/ L<br>440 Rs/ L<br>240 Rs/ day<br>480<br>80 Rs/ L             | 150<br>140<br>220<br>720<br>480<br>480     |
| <b>6</b> | <b>Irrigation charges</b>                                                                                                                                                        | 10                                                                                     | 560 Rs/ irrigation                                                                 | 5600                                       |
| <b>7</b> | <b>Harvesting</b><br>Uprooting of Bulbs<br>Cutting the leaves from<br>bulbs                                                                                                      | 25 FL<br>45 FL                                                                         | 240 Rs/day<br>240 Rs/ day                                                          | 6000<br>10800                              |
|          | <b>Total Cost</b>                                                                                                                                                                |                                                                                        |                                                                                    | 59790                                      |
|          | <b>Herbicide cost</b>                                                                                                                                                            | Pendimethalin +<br>Oxyfluorfen<br>Pendimethalin<br>Oxyfluorfen<br>Quizalofop ethyl     | 600 Rs/ L<br>870 Rs/ L<br>1300 Rs/ L<br>1250 Rs/ L                                 |                                            |
|          | <b>Fertilizer</b>                                                                                                                                                                | Urea<br>SSP<br>MOP                                                                     | 7 Rs/ kg<br>21.6 Rs/ kg<br>11.6 Rs/ kg                                             |                                            |