EFFICACY OF DIFFERENT POST EMERGENCE HERBICIDES ON ONION (*Allium cepa* L.)

THESIS

Submitted to
Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola
in partial fulfilment of the requirements
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MASTER OF SCIENCE
IN
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By
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Enrolment Number – MM/1002 **2020**

DECLARATION OF STUDENT

I hereby declare that the experimental work and its interpretation of the thesis entitled **"EFFICACY OF DIFFERENT POST EMERGENCE HERBICIDES ON ONION (*Allium cepa* L.)"** 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 **(Panghate Pramod Devidas)**

Date : / / 2020 Enrolment No. MM/1002

CERTIFICATE

There is to certify that thesis entitled **"EFFICACY OF DIFFERENT POST EMERGENCE HERBICIDES ON ONION (*Allium cepa* L.)"** submitted in partial fulfillment of the requirement for the degree of **"Master of Science in Agriculture (Agronomy)"** of Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola is a record of bonafide research work carried out by **Panghate Pramod Devidas** under my guidance and supervision.

The subject of the thesis has been approved by the student's Advisory Committee.

Date : / / 2020

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Needless to say, errors and omissions are mine.

Place : Akola **(Panghate Pramod Devidas)**

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%	Per cent
^{o}c	Degree Celsius
/	Per
@	At the rate of
a.i.	Active ingredient
BSH	Bright sunshine hours
CD	Critical difference
Cm	Centimetre
cm^2	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^{-1}	Per hectare
HI	Harvest Index
Hrs	Hours
HW	Hand Weedding
i.e.	id est. (that is)
K	Potash
Kg	Kilogram
lit	Litre
M	Meter

m^2	Meter square
m^{-2}	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
PRE	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

(F) THESIS ABSTRACT

a)	**Title of the thesis**	**:**	**Efficacy Of Different Post Emergence Herbicides On Onion (*Allium cepa* L.)**
b)	**Full name of student**	**:**	**Panghate Pramod Devidas**
c)	**Name and address of Major Advisor**	**:**	**Dr. V.V. Goud** Associate professor, Agriculture Research Station, Washim, Dr, Panjabrao Deshmukh Krishi Vidyapeeth, Akola (M.S.) - 444104.
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j)	**Signature, name and address of forwarding authority**	**:**	

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ABSTRACT

The present investigation entitled “Efficacy of different post emergence herbicides on onion (*Allium cepa* L.)” variety *Akola safed* was conducted during the year 2018-2019 at All India Co-ordinated Research Project on Weed Management, Department of Agronomy, Dr. Panjabro Deshmukh Krishi Vidhyapeeth, Akola.

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

design with three replication and nine treatments. The treatments comprised of Clethodim 12 % EC 0.084 kg ha^{-1}, Clethodim 12 % EC 0.096 kg ha^{-1}, Clethodim 12 % EC 0.108 kg ha^{-1}, Clethodim 12 % EC 0.120 kg ha^{-1}, Clethodim 12 % EC 0.240 kg ha^{-1}, Propaquizafop 10 % EC 0.0625 kg ha^{-1}, Quizalofop ethyl 5 % EC 0.050 kg ha^{-1}, Weed free, Weedy check.

The soil of experimental field characterized as clay in texture, having slightly alkaline pH (7.4), moderate organic carbon status (5.28 %), low nitrogen content (219.23 kg ha^{-1}), medium available phosphorus content (15.20 kg ha^{-1}), high potassium status (340.57 kg ha^{-1}).

Onion (*Akola safed*) was transplanted on 11th January 2019 at 20 x 10 cm spacing with 100:50:50 kg ha^{-1} NPK. The crop was harvested on 6thMay 2019.

In the experiment field, predominant weed flora were *Cyperus rotundus* L.,*Cynodon dactylon, Parthenium hysterophorus, Alternanthera triandra* L., *Portulaca oleracea* L, *Euphorbia geniculate, Phyllanthus niruri* L., *Xanthium strumarium L., Convolvus arvensis etc.*

The weed density, weed dry matter accumulation and weed management efficiency varied significantly with the stages of the crop. Considering the weed management strategies significantly lower weed density, weed dry matter accumulation, weed index and relatively higher weed control efficiency were recorded in weed free plots followed by treatment with post emergence application of propaquizafop 10 % EC @ 0.0625 kg ha^{-1} which was at par with the post emergence application of clethodim 12 % EC @ 0.240 kg ha^{-1} applied at 20 DAT.

Among the herbicidal treatments post-emergence application of propaquizafop 10 % EC @ 0.0625 kg ha^{-1} at 20 DAT produced higher plant height, higher bulb weight, dry matter accumulation, polar and equatorial diameter, dry weight of bulb (g), bulb yield (q ha^{-1}). The nutrient uptake by weeds was observed to be more in weedy condition. However, total nutrient uptake by crop was observed maximum with application of propaquizafop 10 % EC @ 0.0625 kg ha^{-1}. And GMR, NMR and BCR over rest of the treatments, however, remained at par with clethodim PoE 12%

EC @ 0.108 kg ha^{-1}. The application of clethodim 12% EC @ 0.240 kg ha^{-1} (T_5) showed phytotoxicity symptoms on crop.

Keywords: onion, herbicides, weed management, growth, productivity, DAT

CHAPTER I

INTRODUCTION

1.1 Background Information

Onion (*Allium cepa L.)* belonging to family *Alliaceae*, is an important bulbous vegetable crop grown in India from the ancient times. The word “onion” is derived from *latin* which means “*large pearl*”. It is compared to a pearl not only for its shape but also for its highly valuable nutritional and medicinal value. Its pungent flavour makes “Quercetin” which is useful mainly as a spice, seasoning and flavoring for foodstuff involving both green tops and bulbs. The pungency in onion is due to a volatile oil known as allyl-propyl-disulphide.

Being most important commercial vegetable crops grown all over the world and it has various culinary, dietary, medicinal and nutritive uses. 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).

India ranks second in area and production of onion in the world after China. In India major onion growing states are Maharashtra, Karnataka, Madhya Pradesh, Bihar and Gujarat. It is cultivated in an area of 1.20 million hectares with a production of 19.40 MT and productivity 16.13 Tonnes/ha in India. In Maharashtra, it is grown over about 0.9 Million ha with a production of 2.06 MT and productivity of 16.51 Tonnes/ha (Anonymous, 2017).

Onion is a shallow rooted with narrow upright leaves and closely spaced cannot compete well with weeds. In addition to this, frequent application of irrigation and fertilizer allows successive flushes of weeds in onion. It has very poor competitive ability with weeds due to its inherent characteristics such as short stature, non-branching habit, sparse foliage and extremely slow growth in initial stages which cause rapid growth of weeds. The yield loss due to weed infestation has been recorded

to the tune of 40-80% (Channapagoudar and Biradar, 2007, Ramalingam *et al.* 2013).

Chemical weed control is a better supplement to conventional methods and forms an integral part of the modern crop production. Thus the use of herbicides is one of the options left with the farmers to eliminate crop weed competition at early growth stage of onion crop. The effectiveness of herbicide is decided by its behaviour under a soil type, its organic matter content, weather conditions and soil moisture, etc. Therefore, it is essential to screen several newly released herbicides and to fix optimum doses under particular agro climatic conditions for effective control of weeds in onion.

The traditional method of weed control i.e. hand weeding 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 scare and costlier. The mechanical cultivation in onion is difficult due to high plant density. Hence, these factors have induced interest in herbicidal weed control.

Herbicides available for use in this crop are limited, oxyfluorfen is registered for use in dry bulb onions only for control of many annual broadleaf weeds when applied as post-emergence. However, clethodim, propiquizafop and quizalofop-ethyl are selective post-emergence herbicides use in controlling annual and perennial grasses in a wide variety of broad leaf crops including soybeans, cotton, onion, garlic, sunflowers, potatoes, alfalfa and most vegetables.

1.2 Importance of study

Onion (*Allium cepa* L.) is popularly known as “Queen of Kitchen” because of its characteristics flavor. India is the second largest producer of onion in the world next to china. In India major onion growing states are Maharashtra, Karnataka, Madhya Pradesh, Bihar and Gujarat. It is cultivated in an area of 1.20 million hectare with a production of 19.40 MT and productivity 16.13 t ha^{-1} in India. In Maharashtra, it is grown over about 0.9 Million ha with a production of

2.06 MT and productivity of 16.51 t ha^{-1} and its poor competitive ability with its slow initial growth and lack of adequate foliage makes onion weak against weeds. In addition there cylindrical upright leaves do not shade the soil to smoother weed growth. The conventional method of weed control (hoeing or hand weeding) is laborious, expensive and sometimes causes damages to crop. On the other hand, use of herbicides alone does not prove effective for 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.

Weed problem in onion is very serious. High reduction in bulb yield of onion was observed due to weeds infection. Hand weeding is a common method of weed control adapted by farmers but comparatively this method is costly and time consuming. This problem assumed added significance due to non-availability of adequate labours during peak period of operations. Whereas, post emergence herbicides kill weeds and keep the hardy weeds under controlled by arresting their growth through various kinds of deformities in foliage and growing point.

Weed compete with onions for nutrient, soil moisture, space, light and considerably reduce the yield, quality and value of the crop through increased production and harvesting costs. Due to smaller leaf size and slow growth, onions cannot compete well with weeds. Weeds compete with crop plants at very early growth stages and harbor insect pest and disease causing organisms.

1.3 Objectives of Study

Keeping these facts in view, an experiment was undertaken to determine effective weed control for longer duration, by using different herbicides like clethodim, quizalofop-ethyl and propaquizafop comparison with weedy check in onion and farmers feedback associated with onion crop and the importance of weed management through chemical use, the present research problem entitled **“EFFICACY OF**

DIFFERENT POST EMERGENCE OF HERBICIDES ON ONION" is proposed with following objective:

1. To evaluate the efficacy of different post emergence herbicides for managing weed flora in onion.
2. To study the effect of different post emergence herbicides on growth and yield of onion.
3. To study the phyto-toxicity of different post emergence herbicides on onion.
4. To study the economics of treatments.

1.4 Hypothesis:

Improved weed control practices that include chemical weed control with newer formulations and herbicide mixtures 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 be maintained at a lower rate of input practice by bettering the weed management strategy. Also used newly released herbicide having new mode of action, which can control narrow as well as broad spectrum weed in onion. Use of the post emergence herbicides in such crop to control the weeds would therefore definitely give added advantage to onion grower of the region. It not only reduces the cost of cultivation of this crop but also improve the qualitative characteristics of onion.

1.5 Scope and limitation:

Due to intensive agriculture and development of newer technologies in the field of agriculture, there is a vast scope for controlling weeds by using herbicides in crop like onion. Further, there is lot of scope for use of herbicides, due to shortage and increase in wages of farm labours. Now a days, due to the adaptation of newer production techniques in various vegetable crops in general and bulbous crop like onion, garlic, turmeric and ginger in particular crop yield and quality is going to increase significantly. In this context, use of certain herbicides showed useful result in different crop combinations or cropping systems towards the weed control.

This crop did not received much attention in past and therefore technological information for this region is much scanty. Hence, it's cultivation in the region along with improved technological practices like use of post emergence herbicides towards reduction in the input cost on intercultural operations in general and labour cost in particular, has tremendous scope in future.

CHAPTER II

REVIEW OF LITERATURE

Weeds are often referred to as unwanted plants, prolific, persistent, competitive and harmful to the total environment. They are of great menace as they interfere with production of crop and add to the cost of cultivation. The reduction in crop yield has direct correlation with weed competition. Weed infestation is also one of the limiting factors in successful vegetable production.

The present study is directed to assess the losses caused by the weed flora in onion, phyto-toxicity, and effect herbicides growth and yield of onion, crop weed competition and economics of different non chemical and chemical method for the control of weeds in onion crop. A brief summary of research work carried out by various research workers in India and abroad on this aspect has been highlighted and reviewed under following heads.

2.1 Weed flora in onion:

Porwal and Singh (1993) recorded weeds in the onion field were *Chenopodium album* L*., Chenopodium morale., Spergula arvensis* L*., Anagalis arvensis* L*., Convolvulus arvensis* L*., Cyperus rotundus* L*., and Cynodon dactylon* L. under Vertisols.

Lopez and Alsina (1993) reported that propaquizafop at 1 to 1.5 lit/ha controlled the following weeds in onion and garlic : *Alopecurus myosuroides, Avena spp., Digitaria sp., Echinochloa spp., Lolium rigidum, Phalaris spp*. Some perennial grasses were also controlled when agil was applied at 1.5 - 2 lit.

Sharma and Mehta (1994) reported that, the predominant weed flora in onion field were *Cyperus rotundus* L., *Dactyloctenium aegyptium* L., *Cynodon dactylon* and *Phyllanthus niruri,* under Navasari (Gujarat) conditions.

Atre (2001) observed the weed flora *Echinocloa crusgalli, Parthenium hesterophores, Phyllanthus niruri* L*., Cyperus rotundus* L*.,*

Cynodon dactylon L., *Convalvulus arvensis, Hibiscus ponduriformis, Chenopodium album, Eclipta alba, Amaranthus viridis, Commelina benghalensis, Cynotis cristata*, in onion crop, under Dharwad (Karnataka) conditions.

Kohle (2001) conducted field experiment during summer seasons of 1998 and 1999 at Raipur (MP) on sandy loam soil. They observed that *Physalis minima* (10.9%), *Chenopodium album* (4.2%), *Borreria uspida* (3.1 @), *Spilaranthes acmella* (6.8%), *Belipta alba* (5.6%), *Melilotus spp*. (2.3 %), grasses viz.., *Echinochloa colona* (17.1%), *Cynodon dactylon* (3.6%), *Brachiaria distachya* (9.1%) and *Cyperus rotundus* (14.3%) were present.

Priyadharshini and Anburani (2004) conducted a field experiment on efficacy of integrated weed management on weed control in onion cv. Gnanamedu Local at Annamalainagar (Tamil Nadu) during winter seasons of 2001-2002. They observed that the onion field was dominated by the weed flora *Cynodon dactylon, Cyperus rotundus, Dactyloctenium aegyptiacum, Echinochloa colona, Trianthema portulacastrum, Acalypha indica and Amaranthus viridis,*etc*.*

Rathod and Shekhawat (2004) conducted a field experiment in Rajasthan, india during the kharif seasons of 1995-1997. They reported that the major weeds flora in onion field were *Amaranthus viridis, Cynodon dactylon, Cyperus rotundus, Digera arvensis, Eclipta alba, Fumaria parviflora, Solanum nigrum, T. portulacastrum and Xanthium strumfarium.*

Ghadage *et al.* (2006) at Pune, Maharashtra, India, during *rabi* seasons of 2002. The predominant weed species infesting the experimental plots were *Panicum isachmi, Cynodon dactylon, Cyperus rotundus, Amaranthus polygamus, Convolvulus arvensis, Tridax procumbens, Parthenium hysterophorus, Euphorbia hirta and Acalypha indica.*

Channappagoudar and Biradar (2007) observed that the major weeds in the experimental plots include *Commelina benghalensis, Cyperus rotundus, Parthenium hysterophorus, Phyllanthu niruri, Euphorbia*

geniculate and Oxyfluorfen controlled the weeds effectively but resulted in lower yield because of its higher phyto-toxicity to direct sown onion.

Sable *et al.* (2013) observed that, the major monocot weeds like *Cyprus rotundus* L., *Cynedon dactylon* L., *Echinocloa crusgalli* L. *Brachiaria mutica* L. and dicot weeds like *Euphorbia hirta* L., *Enuphorbia geniculata* L., *Acharanthus aspera* L., *Phyllanthus niruri* L., *Tridex procumbensce* L., *Parthenium hesterophorus* L., *Commelina bengalensis* L., were recorded in onion experimental plot under Raichur, Karnataka conditions.

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

2.2 Critical crop weed competition:

Singh (1983) observed that as duration of competition increased, the degree of loss also increased. Competition for the first 15 days only caused 17 percent loss, while competition for the first 90 days caused 40 percent loss in the crop yield and when competition for the first 15 days was avoided, there was 25 percent increase in the yield and subsequent increased in the initial weed free period up to 60 days caused further increased in the yields.

Singh *et al*. (1985) found that uncontrolled weeds caused 74.9 percent reduction in onion bulb yield.

Rajendra Singh *et al.* (1986) asserted that, the stage of critical period of weed competition stand up to 40 days after transplanting in different cultivars of onion, under Sabour (Bihar) conditions.

Singh *et al.* (1986) reported the reduction of onion yield during 35-40 days after transplanting due to infestation of weeds, under Hyderabad (A.P) conditions.

Singh and Singh *et al.* (1994) reported loss in the bulb yield to the extent of 54 percent due to weeds.

Tei *et al.* (1996) reported that apart from planting method and period, onion shows slow growth, low ground cover and poor light interception ability and as a consequence low competitively against onion and weeds.

Sangeeta and Prasad (1999) reported that the most critical period of crop weed competition is between 30-40 days after planting of onion.

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) observed that significantly the highest onion bulb yield contributing characters were obtained in the plots remain weed free during the first 60 DAT and resulting in 15.4 tonne of onion bulb yield which indicated that the critical period of weed competition was up to 6- days after transplanting.

Williams *et al.* (2005) crop weed competition is always more in bulb production of onion when weed emergence precedes then crop emergence.

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.

Chopra and Kumar (2006) at Karnal (Haryana) reported that critical period of crop-weed competition in onion was found to be at 20-60 days after transplanting.

Chandrika *et al.* (2009) they reported that the hand weeding twice at 20 and 40 DAT significantly reduced the density and dry weight of weeds and resulted in the highest bulb yield as compared to other weed management practices.

2.3 Effect of herbicides on growth and yield of onion:

Mohmmad and Imran (2003) conducted an experiment using the pre emergence herbicides (pendimethalin and methabenzthiazuron) applied at 7 to 10 DAT and the post emergence herbicides (oxadiazon, methabenzthiazuron and propaquizafop) applied at 40 DAT in garlic. Pendimethalin as pre emergence and methabenthizuron as post emergence herbicides were found superior in the reduction of weed density and increasing the bulb yield. These treatments were at par with hand weeding. A cost benefit ratio of 1 to more than 10 was obtained for all weed control treatments.

Chinnusamy *et al.* (2006) found that, the bulb yield of onion with the application of proopaquizafop at 100 g ha^{-1} (5885 kg ha^{-1}) in experimental field.

Yumnam *et al.* (2009) observed that one hand weeding at 40 DAT along with application of quizalofop-ethyl (5% EC) at 2.5 ml/lit of water at 20 DAP significantly reduced weed density and weed dry weight in onion.

Ramani and Khanpara (2010) conducted a field experiment to study the effect of some herbicides like pre-emergence application of oxyfluorfen and post emergence application of oxadiargyl, quizalofop–ethyl and fenoxapn-p-ethyl at 60 DAS for weed control in garlic and their persistence. The result indicated that the treatment reduced the density and dry weight of weeds and increased yield.

Kalhapure and Shete *et al.* (2013) reported that weed free check recorded significantly the lowest weed density, dry weight of weeds and higher control efficiency and the higher plant height, neck thickness, bulb weight, bulb diameter, bulb yield and gross monetary return per hectare.

Sudhakara *et al.* (2014) resulted that the application of clethodim 24 % EC @ 60 g a i. /ha along with NIS + AMS significantly recorded higher number of pods per plant, the number of seeds per plant, pod weight per plant, 100-seed weight and seed yield of soybean this was

on par with application of clethodim 24% EC @ 48 g a i. /ha long with NIS + AMS.

Vishnu *et al.* (2014) conducted an experiment at Junagargh (Gujarat) and they found that the combined application of oxyfluorfen @ 0.240 kg/ha as PE and propaquizafop @ 0.090 kg/ha as POE at 45 DAT recorded the lowest weed index and highest bulb yield after weed free plot in onion.

Gagandeep Singh *et al*. (2014) reported that the application of alone propoquizafop 10% EC 750 ml/ha had not controlled grassy weed, least number of weeds was recorded in two hand weeding. Bulb yield was highest in two hand weeding which was at par with all weed control treatment except oxyfluorfen 23.5 % EC + propaquizafop 10% EC @ 625+625 ml/ha and alone application of propaquizafop 10% EC @ 750 ml/ha, however, highest B:C ratio was obtained by alone application of oxyfluorfen 23.5 % EC @ 950 ml/ha.

Vishnu *et al*. (2015) assessed that the weed free check treatment recorded significantly the lowest dry matter of weeds and the highest weed control efficiency, however, treatment combined spray of oxyfluorfen @ 0.240 kg/ha and propaquizafop @ 0.090 kg/ha as PE followed by second spray as POE at 45 DAT was equally effective with this treatment.

Ahmed *et al*. (2016) reported that among the chemical weed management practices clethodim 12.5% and bentazon 48% recorded lowest weed density than other treatment except hand weeding.

Harphool Meena *et al*. (2017) reported that the application of post emergence herbicides clethodim 24% EC @ 60 g a.i. /ha +NIS +AMS at 15-20 DAS was effective in controlling grassy weeds in cotton resulting into increased bolls plant^{-1} (30.63) and boll weight (4.38 gm).

Sahu *et al.* (2018) reported that the significantly maximum plant height was recorded 34.44 cm Weed free(T_2), 65.89 cm (T_2), 68.58 cm (T_2), and 67. 38 cm (T_2) and minimum plant height was recorded 26.33 cm Weedy check (T_1), 50.80 cm (T_1), 51.71 cm (T_1) and 50.70 cm (T_1) was

recorded 30,60,90 DAT and at harvest. The significantly maximum number of leaves was recorded 5.60, Oxyfluorfen 1 kg/ha + Quizalofop ethyl 1kg/ha (T_7), 8.30 Weed free (T_2), 10.00 (T_2),and 9.80 (T_2) and minimum number of leaves was recorded 4.67 Weedy check (T_1), 5.47 (T_1), 6.48 Weed free (T_2), and 6.13 (T_2) was recorded 30, 60,90 DAT and at harvest.

Reddy Venkateswara (2018) reported that application of pendimethalin and oxyflourfen supplemented with quizalofop ethyl @ 75 g a.i./ha as post emergence found to be at par with hand weeding thrice on yield contributing characters like bulb diameter, bulb length, average bulb weight, bulb yield.

Sahoo and Tripathy (2019) the result revealed that significantly highest marketable yield as well as total bulb yield was produced by the application of oxyfluorfen 23.5 % EC @ 2 ml/lit before planting and one hand weeding at 40-60 DAT than rest of the treatments. The weed control efficiency was significantly highest in T4 than rest of the treatments. thus applicaton of oxyflourfen 23.5 % EC @ 2 ml/lit before planting and one hand weeding at 40-60 DAT or combined spray of pendimethalin 30 % EC @ 2.5 ml/lit and quizalofop ethyl 5% EC @ 1.75 ml/lit. At the time of planting and at 30 DAT reduced the weed infestations with higher bulb yield in onion.

Soliman *et.al*. (2020) results showed that weed control efficiency for broad leaves species the maximum percent was recorded for oxyfluorfen. In controlling narrow leaves weed species, the maximum percent was recorded in clethodim (93.75 g a.i./fed). While controlling broad leaf and narrow leaves weeds, the maximum percent was recorded in oxyfluorfen + clethodim (270+93.75 g a.i./fed). Growth and yield parameters as plant height, bulb weight, and bulb diameters were recorded maximum in oxyfluorfen + clethodim (270+93.75 g a.i./fed) compared to rest for the treatment. We suggest that the best treatment was oxyfluorfen + clethodim (270+93.75 g a.i./fed) for controlling all species of weeds in the onion plant.

2.4 Effect of herbicide on soil micro flora:

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.

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.

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.

2.5 Economics of different treatments:

Prakash *et al*. (2000a) reported that control of weeds either through herbicide alone or in combination with hand weeding at 45 DAT registered higher net returns/rupee investment compared to weed free check.

Panse *et al.* (2014) revealed that the application of oxyfluorfen 23.5 % EC before planting + quizalofop-ethyl 5% EC at 30 days after transplanting recorded higher marketable bulb yield with cost benefit ratio.

Kumar (2014) estimated in different weed treatment practices over weedy check which indicated the maximum B:C ratio of 2.11 in oxyfluorfen 23.5 % EC @ 2 ml/ha before planting and quizalofop–ethyl 5 EC @ 3.5 ml/ha at 30 DAT.

Kumar (2014) the result indicated that significantly highest weed population was recorded in weedy check plot (T_8), while lowest in pendimethalin 30 EC @ 2.5 ml/lit + quizalofop ethyl 5 EC @ 1.75 ml/lit (T_6). The WCE varies from 41.01 Oxyfluorfen 23.5 EC @ 1 ml/lit + quizalofop ethyl 5 EC @ 1.75 ml/lit (T_3) to 68.23 (T_6). The B:C ratio estimate in

different weed treatment practices over weedy check indicated maximum B:C ratio of 2.30 in (T_7) closely followed by 1.75 in T_1 and 1.70 in T_6.

Vishnu *et al.*(2015) conducted the field experiment on Junagadh Agricultural University, Junagadh (Gujarat). Form economic point of view, the highest gross and net return was obtained under weed free check with benefit : cost ratio which was statistically at with a combined spray of oxyflourfen and propaquizafop. The lowest gross income of was received under pendimethalin as PE fb imazethapyr as POE followed by unweeded.

Thakare *et al*. (2018) conducted a field experiment was conducted with consisting of pre-emergence application of pendimethalin, post emergences application of oxyfluorfen, propaquizafop, quizalofop–ethyl, fluazifop-p-ethyl. The application of oxyfluorfen @ 0.200 kg a.i./ha proved to be most effective weed control treatments, which was recorded highest bulb yield (280 q/ha), gross monetary returns (Rs.279997/ha), net monetary returns (Rs.218327/ha) and B:C ratio (4.54) over all other chemical weed control treatments.

CHAPTER III

MATERIAL AND METHODS

This chapter deals with the details of material used during the course of investigation and methods adopted in conducting the present investigation entitled “Efficacy of different post emergence herbicides on onion *(Allium cepa* L.*)”.*

3.1 Experimental site

The field experiment was conducted during *Rabi* season of the year 2018-2019 in the field No**.**89 at the All India Co-ordinate Research Project on Weed Management, Department of Agronomy, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola.

Soil of the experimental field

Table 1: Physico- chemical properties of soil

Sr. No.	Particulars	Values (%)	Analytical method and reference
I	**Mechanical composition**		
1)	Sand (%)	32.74	Bouycous hydrometer method (Piper,1966)
2)	Silt (%)	21.78	
3)	Clay (%)	45.17	
4)	Textural class	Clayey	
II	**Chemical composition**		
1)	Available Nitrogen (kg/ha)	219.23	Alkaline permanganate method (Asija and Subhiah, 1956)
2)	Available Phosphorus (kg/ha)	15.20	Olsen’s method (Jackson, 1967)
3)	Available Potassium (kg/ha)	340.57	Walkely photometer (Jackson, 1967)
4)	Organic carbon (%)	5.28	Walkely and Blacks rapid titration method (Jackson, 1967)
5)	pH	7.4	pH meter (Jackson, 1967)
6)	EC (ds/m)	0.24	Electric conductivity bridge (Jackson, 1967)

The composite soil sample from 0-30 cm soil layers was taken with the help of screw auger before starting the field experiment. Soil thus collected was air dried and preserved properly in corrugated boxes. It was then analyzed for studying various physic-chemical properties. The techniques used for the determination of the properties are given in table 1. The soil of the experimental field was black and clayey in texture and slightly alkaline in reaction. The soil was low in nitrogen, medium in phosphorous and fairly rich in potash.

3.2 Cropping history

The cropping history of the experiment plot for the last three years is given in Table 2. The residual effect of previous cropping was practically uniform on the crop (Table 2) grown during the investigation.

Table 2: Cropping history of the experimental plot (field trial)

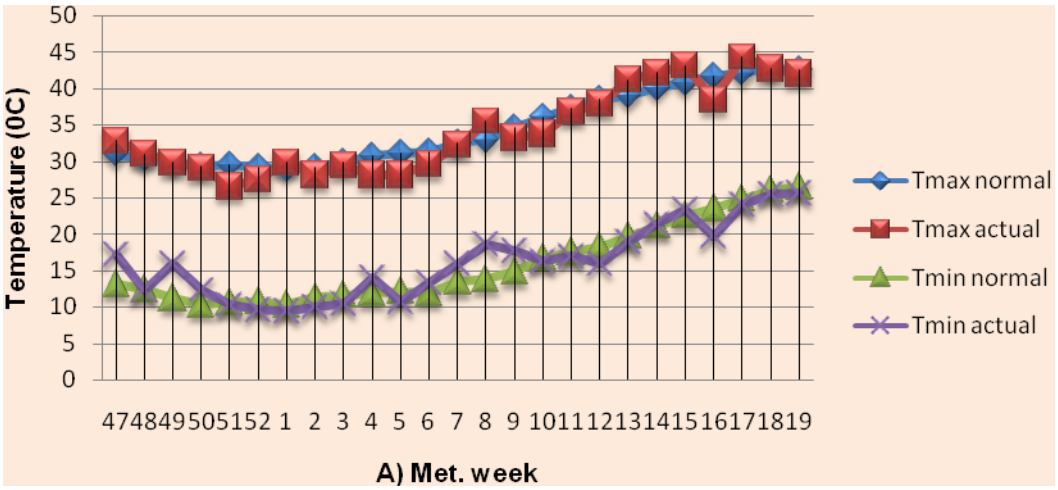
Sr. No.	Year	Sequence of crop grown		
		Kharif	Rabi	Summer
1.	2016-17	Maize	Wheat	Continued
2.	2017-18	Soybean	Onion	Continued
3.	2018-19	Soybean	Present investigation	-

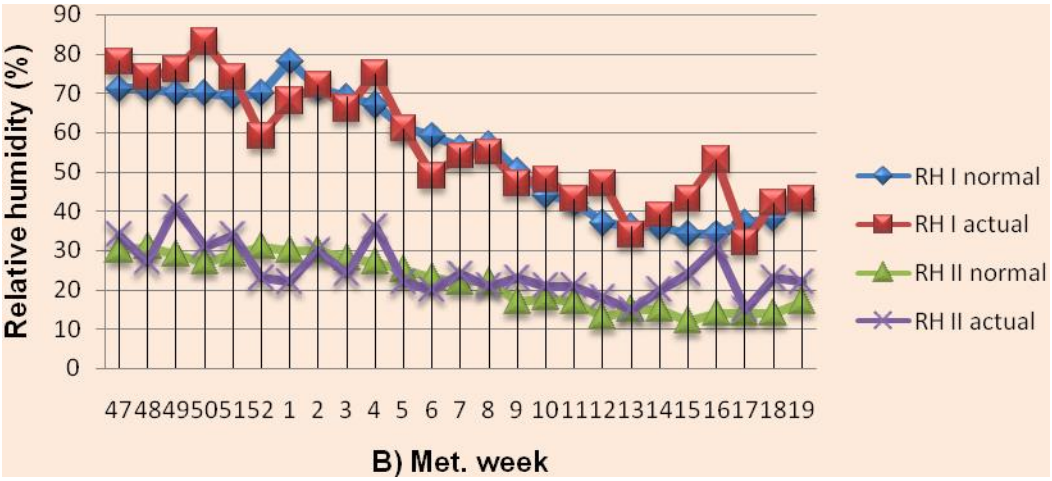
3.3 Climate and weather conditions

Akola comes under sub- tropical zone and is situated at latitude of $22^0$42'N and longitude of $77^0$02'E. The altitude of the place is 307.4 m from mean sea level. The mean annual precipitation on the basis of last fifteen years is 802 mm and which receives almost from South- West monsoon during June to October. The mean annual minimum and maximum temperatures are 9.4^{0}C and 44.3^{0}C, respectively. The humidity ranges from 30.75 percent and 61.62 percent in summer and rainy season, respectively. Akola, thus has hot dry summer and moderately cold winter. The details of meteorological data recorded monthly in respect of rainfall, maximum and minimum temperatures and relative humidity in the Agro-meteorological observatory of the Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola for the years 2018-2019 under study has been furnished in Table. 3 and graphically showed in Fig. 1 (a,b,c).

Table 3: Weekly Weather data for the year 2018-19 recorded at Meteorological Observatory Department of Agronomy Dr. PDKV., Akola

Weeks	Dates	2018-19																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





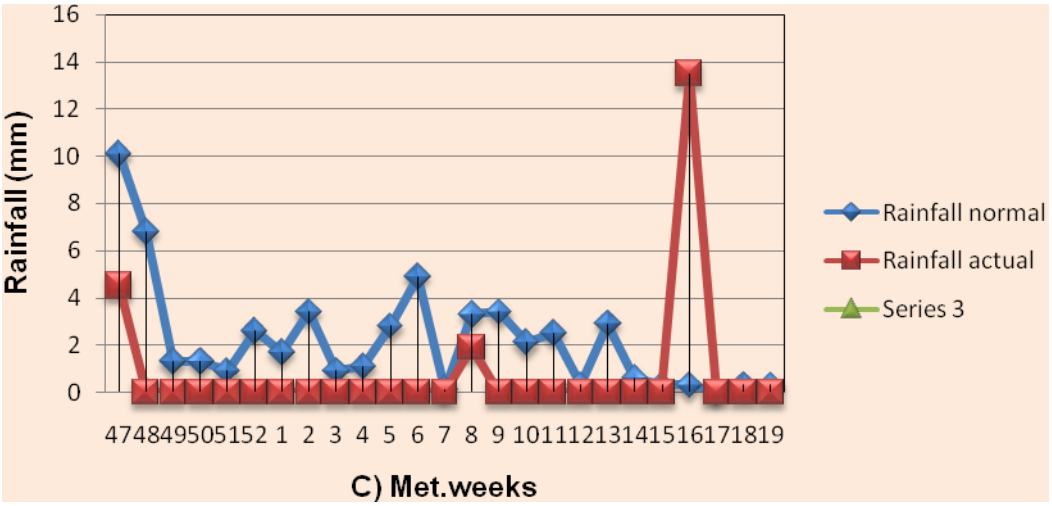


Fig. 1. Weekly weather data for crop growing period during the year 2018-2019

3.4 Experimental details

3.4.1 Design and treatments

The present experiment was laid out in Randomized Block Design (RBD) with nine treatments replicated three times. Allocation of treatments at each plot in each replication was done by randomization. The treatments was allotted to different plots are shown in Fig. 2. The details of different treatments with their symbols used are given in Table 4.

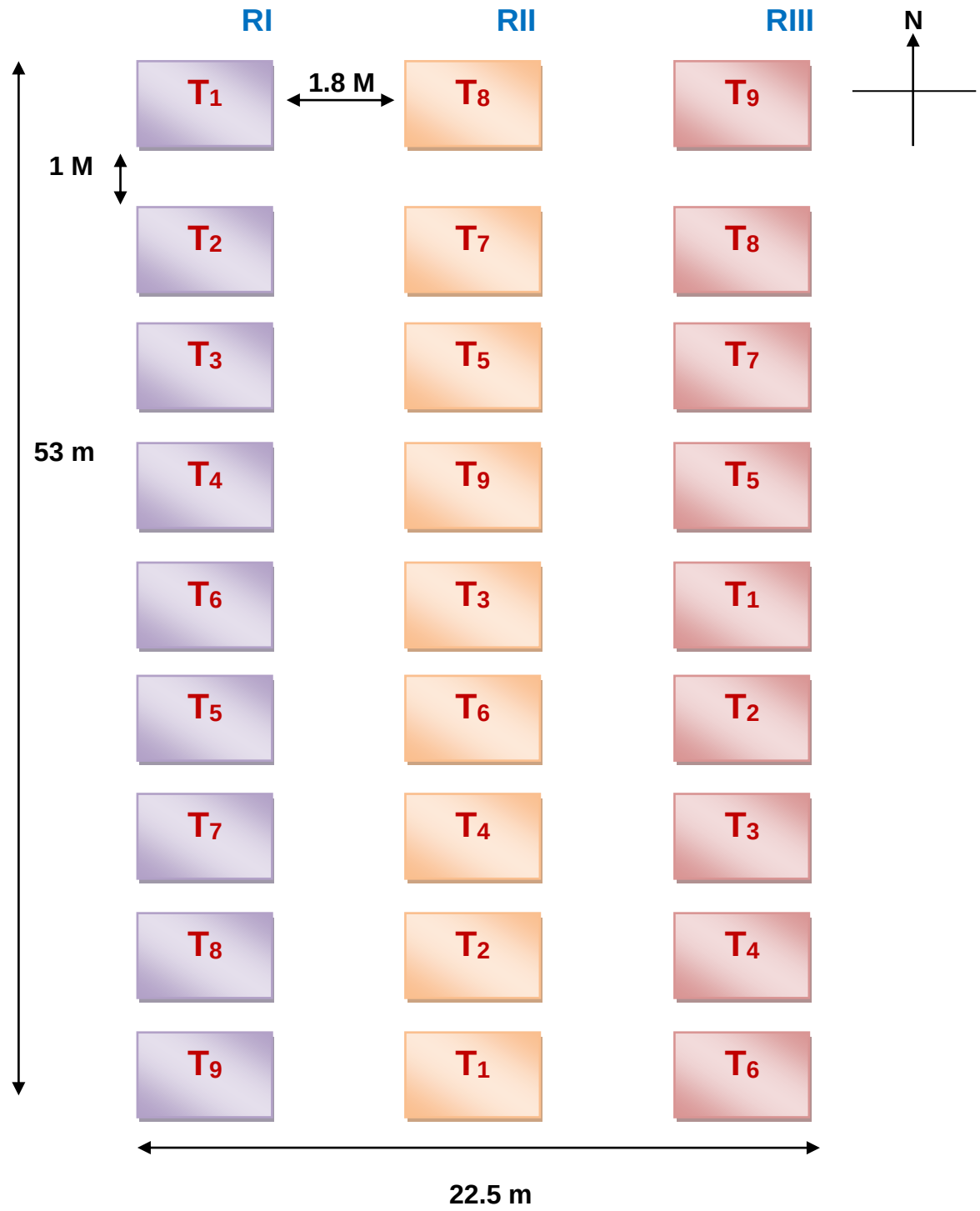
Table 4: The detail of different treatments

Abbreviation	Treatment	Dose (kg ha^{-1})	Time of Application
T_1	Clethodim 12% EC	0.084	POE 20 DAT
T_2	Clethodim 12% EC	0.096	POE 20 DAT
T_3	Clethodim 12% EC	0.108	POE 20 DAT
T_4	Clethodim 12% EC	0.120	POE 20 DAT
T_5	Clethodim 12% EC	0.240	POE 20 DAT
T_6	Propaquizafop 10 % EC	0.0625	POE 20 DAT
T_7	Quizalofop–ethyl 5% EC	0.050	POE 20 DAT
T_8	Weed Free	--	--
T_9	Weedy Check	--	--

POE : Post emergence DAT : Days after transplanting

3.4.2 Other experiment details.

1. Name of crop : Onion
2. Experimental design : Randomized Block Design
3. Number of replications : 3
4. Number of treatments : 9
5. Number of plots : 27
6. Plot size : Gross= 6.0 × 5.0 m
   Net = 5.6 x 4.8 m
7. Spacing : 20 cm x 10 cm



Design	:	Randomize Block Design
Plot Size :	Gross	: 6 × 5 m
	Net	: 5.6 × 4.8 m

Fig. 2 PLAN OF LAYOUT

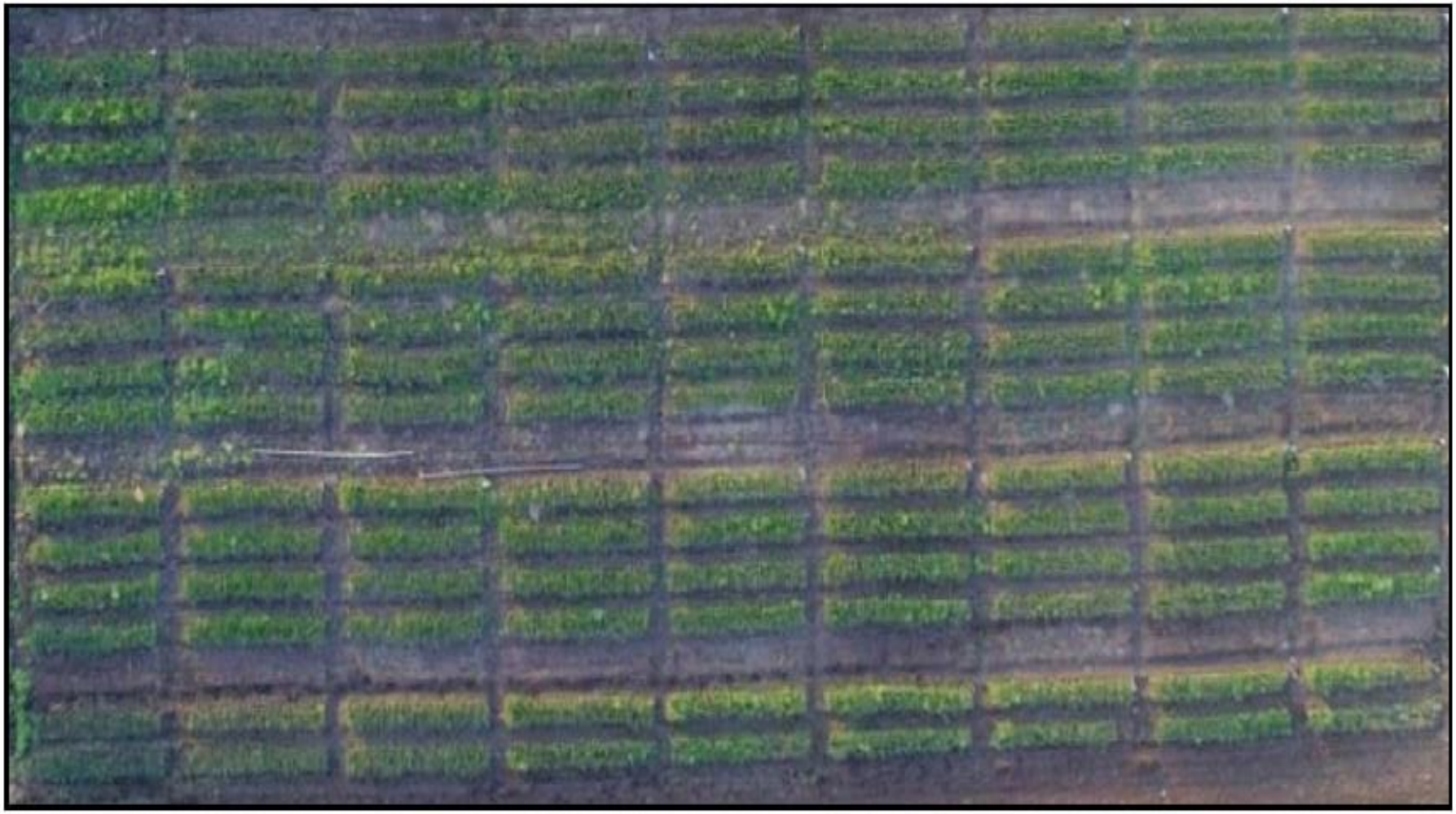


Plate 1 General experimental view

8. Seed rate : 8-10 kg/ha

9. Method of sowing : Transplanting

10 Variety : *Akola safed*

11. Fertilizer dose : 100:50:50 NPK kg/ha

12. Location : AICRP on Weed Management, Dr. PDKV Akola

13. Season : *Rabi*

14. Date of transplanting of Seedling : 11/1/2019

15. Date of harvesting : 6/5/2019

3.4.3 Seed material

The good quality seed of onion variety *Akola safed* (Selection White) was obtained from the Chilli and Vegetable Research unit, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola.

3.5 Application of herbicides

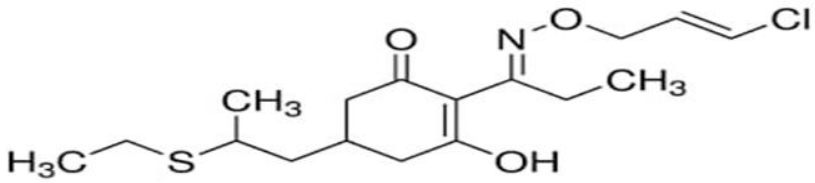
Chemical formulations of herbicides used in experiment are given below.

3.5.1 Clethodim

Trade Name	:	Arrow, Select
Chemical Name	:	(E)-(+)-2-[1-[[(3-Chloro-2-Propenyl)oxy]imino]propyl-5-[2-(ethylthio)propyl]-3-hydroxy-2-cyclohexen-1
Common Name	:	Clethodim
Herbicides Groups	:	Cyclohexenone
Active ingredient	:	12 % EC
Type of herbicides	:	Selective
Application	:	Post emergence
Emperical formula	:	$C_{17}H_{26}ClNO_3S$

Mode of action	:	It ia a selective, systematic post emergence herbicides which can be rapidly absorbed by plant leaves and conducted to roots and growing points to inhibits the biosynthesis of plant branched-chain fatty acids. The target weeds then grow slowly and lose competitiveness with seedling tissue early yellowing and followed by the remaining leaves wilting.

Structural formula :

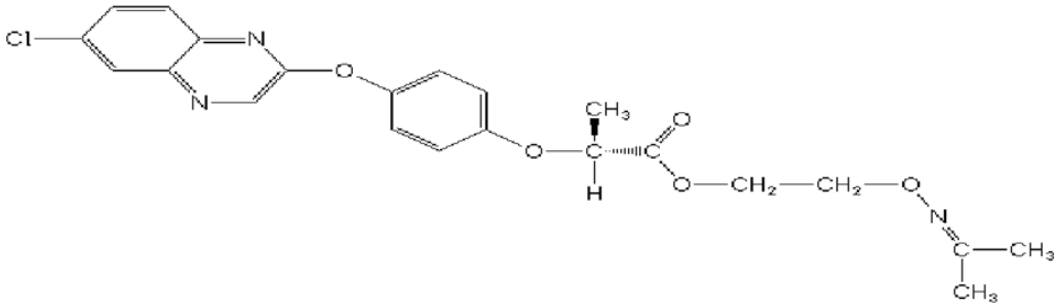


3.5.2 Propaquizafop

Trade Name	:	Agil, Shogun
Chemical Name	:	2-isopropylideneaminooxyethy (R) -2- [4-(6-chloroquinoxlin-2-yloxy)phenoxy] propionate
Common Name	:	Propaquizafop
Herbicides Groups	:	Aryloxyphenoxy propionate
Active ingredient	:	10 % EC
Type of herbicides	:	Selective
Application	:	Post emergence
General dosages	:	100 g a.i./ha
Emperical formula	:	$C_{22}H_{22}ClN_3O_5$

Mode of action	:	It is applied as a foliar spray and quickly absorbed through the leaves and translocated to the meristematic growing regions of the plants, where it inhibits cell growth and division through the inhibition of accase inhibition.

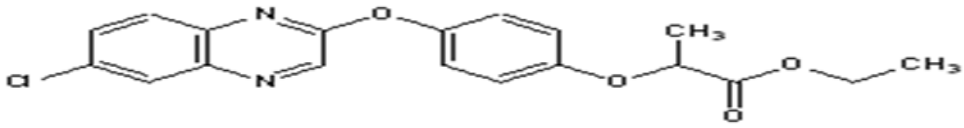
Structural formula :



3.5.3 Quizalofop–ethyl

Trade Name	:	Targa super
Chemical Name	:	(R)-2-{4-(6-choro-2-quinoxalinyl)oxy}phenoxyl} Propanoic acid
Common Name	:	Quizalofop-ethyl
Origin	:	Dhanuka Pesticides Ltd. In technical collaboration with M/S Nissan chemical Industries Ltd. Tokyo, japan
Herbicides Groups	:	Aryloxyphenoxy propionate
Active ingredient	:	5% EC
Type of herbicides	:	Selective
Application	:	Post emergence
General dosages	:	75-100 g a.i./ha
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.

Structural formula :



3.6 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 was mixed thoroughly and raised beds of 2m x 1m size with 15 cm height were prepared. The seeds were sown on raised beds in the rows spaced at 20 cm apart on 29th November, 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 there after at one week interval. The nursery beds were hand weeded thrice.

3.7 Preparatory tillage

An experimental land was ploughed and cross harrowings were given to bring the soil to the fine tilth. Clods were crushed by the clod crusher to make the soil loose and friable. The FYM was applied @ 25 cartloads per hectare and mixed thoroughly in the soil. The field was laid out with flat beds of desired dimensions during the experimentation.

3.8 Herbicidal application

The herbicides clethodim, quizalofop-ethyl, propaquizafop are post emergence and hence applied after transplanting of seedling in the moist soil. The quantity of herbicides per plots area (6 m x 5 m) was calculated and dissolved in 500 ml of water and spread over an areas of 30 m^{-2} according to different treatments by using Knapsack sprayer with flat pan nozzle.

3.9 Transplanting

The layout of the experiment was irrigated 2-3 days before the transplanting so as to facilitate easy transplanting. The sixes weeks old seedlings of uniform height from the nursery beds were transplanted at 2 cm depth in the soil at a spacing of 20 cm x 10 cm. The transplanted seedlings were pressed firmly and then plots were irrigated immediately.

3.10 Fertilizer application

The recommended dose of fertilizer is 100:50:50 NPK kg ha^{-1}. The per plot fertilizer requirement was worked out and then half dose of nitrogen i.e. 50 kg/ha in the form of Urea and full dose of phosphorus in the form of single super phosphate were applied at the time of transplanting and remaining half dose of nitrogen i.e. 50 kg ha^{-1} was applied at 30 DAT of seedlings as top dressing.

3.11 Irrigation

First irrigation was given one day prior of herbicides spraying. After transplanting of seedlings, immediately irrigation was given to the crop. The details regarding irrigation 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	Dates
I]	**Nursery management**	
1.	Ploughing	15/11/2019
2.	Harrowing	25/11/2019
3.	Seed bed preparation	28/11/2019
4.	Sowing of seeds	29/11/2019
5.	Irrigation (05)	29/11/2019 08/12/2019

6.	Weeding	16/12/2019 25/12/2019 01/01/2019 14/12/2019
II]	**Crop management**	
A.	**Preparatory tillage**	
1.	Ploughing (by tractor)	20/12/2018
2.	Harrow (blade harrow)	27/12/2018
3.	Stubble picking	28/12/2018
4.	Leveling	29/12/2018
5.	Layout of experimental plot	03/01/2019
B	**Transplanting of seedlings**	11/01/2019
C	**Fertilizer application**	
1.	Basal application	10/01/2019
2.	Top dressing	11/02/2019
D	**Weed control**	
1. 2.	Post emergence application of herbicides viz. and clethodim , propaquizafop, quizalofop-ethyl. Weeding	31/01/2019 16/01/2019 26/01/2019 04/02/2019 14/02/2019 24/02/2019 05/03/2019 18/03/2019
E	Irrigation	09/01/2019 15/01/2019 15/02/2019 26/02/2019 11/03/2019 26/03/2019 05/04/2019
F	Harvesting	06/05/2019

3.13 Harvesting and curing

The irrigation was stopped when the plants were fully matured i.e. when the leaves turned to yellow and started drying from tips. After 15 days with holding of water and when 50 % leaves were fallen down. The harvesting was done by pulling and digging of the bulbs along with the leaves. Then bulbs were cured under shade for 4 to 6 days following windrow method. Thereafter, foliage was cut by keeping of 2 cm neck.

3.14 Biometric observations

Randomly five plants were selected from each plot for recording the biometric observations. The selected plants were labeled and the observations were recorded on these plants periodically at 20 days interval from transplanting till 80 days and at the harvesting stage of the crop. The details of biometric observation recorded during the year of the experiment are given in Table 6.

Table 6. Details of biometric observations

Sr.	Particulars	Frequency	DAT
A. Weed studies			
1	Weed count (m^{-2})	5	20,40,60,80 and at harvest
2	Weed dry matter (g m^{-2})	5	20,40,60,80 and at harvest
3	Phyto-toxicity rating on crop	1	10 days after herbicides spray
B. Crop studies			
i. Growth studies			
1	Initial plant stand	1	20 DAT
2	Final plant stand	1	At harvest
3	Plant height (cm)	4	20,40,60 and at harvest
4	Fresh bulb weight $plant^{-1}$ (g)	5	20,40,60,80 and at harvest
5	Dry matter accumulation $plant^{-1}$ (g)	5	20,40,60,80 and at harvest

ii. Yield studies			
1	Polar Diameter of bulb (mm)	1	At harvest
2	Equatorial diameter of bulb (mm)	1	At harvest
3	Yield of onion (q ha^{-1})	1	After harvest
4	Dry weight of bulb $plant^{1}$ (g)	1	After harvest
C. Economics studies			
1.	Gross monetary returns (Rs ha^{-1})	1	After harvest
2.	Net monetary return (Rs ha^{-1})	1	After harvest
3.	B:C ratio	1	After harvest
D. Chemical properties			
1	NPK uptake by crop (kg ha^{-1})	1	At harvest
2	NPK uptake by weeds (kg ha^{-1})	1	At harvest
3	Soil analysis (p^{H}, EC, available NPK,OC)	1	Before Transplanting
E. Biological properties			
1	Microbial count	3	BT,30 DAT and after harvest

3.14.1 Weed study

3.14.1.1 Identification of weed flora

In treatment plots of each replication at every 15 days interval, with visual observation, 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^{-2} was selected in the middle of the plot and a quadrat was fixed. The species wise weeds from each quadrat were counted at an interval of 20 days till 80 days and at

the harvesting stage from transplanting. The weed count per square meter was worked out and recorded accordingly.

3.14.1.3 Dry weight of weed (g m^{-2})

Inside the each experimental plot, a quadrate 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 60^0 C for 8-10 days. After 6 days of oven drying, daily the sample were weight till they recorded the constant weight. Then, the value of dry weight of weed was recorded treatment wise accordingly in gram.

3.14.1.4 Weed Control Efficiency (WCE)

Weed control efficiency expresses the percentage reduction in weed dry weight due to weed management practices over control. It is worked out by using weed dry weight present in control and treated plots (Mishra and Tosh., 1979).

$$\text{WCE (\%)} = \frac{\text{DMPc} - \text{DMPt}}{\text{DMPc}} \times 100$$

Where,

DMPc = Weed dry matter produced m^{-2} in control plot.

DMPt = Weed dry matter produced m^{-2} in treated plot.

3.14.1.5 Weed Index (WI

It is defined as the reduction in yield due to the presence of weeds in comparison with no weed plot. It is calculated as follows (Gill and Vijay Kumar, 1966).

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

Where,

X = Yield from minimum weed competition plot.

Y = Yield from treatment for which WI is to be worked out.

3.14.1.6 Phytoxicity of herbicides

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

Effect	Rate	Description of crop
None	0	No injury, normal growth
Slight	1	Slight stunting, injury discoloration
	2	Some stand loss, stunting or discoloration
	3	Injury more pronounce but not persistent
Moderate	4	Moderate injury, recovery possible
	5	Injury more persistent, recovery doubtful
	6	Near severe injury, no recovery possible
Severe	7	Severe injury, stand loss surviving
	8	Almost destroyed, a few plants surviving
	9	Very few plants alive
Complete	10	Complete destruction

3.14.2 Crop growth studies

3.14.2.1 Plant population

Twenty days later of transplanting, the plant population in each treatment plot was counted and compared with per plot plant population required. The surviving plant population was recorded as an initial plant population 20 after transplanting and existing plants at the time of harvesting were counted and noted in each treatments as a final plant population.

3.14.2.2 Plant height (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 plant was recorded at 20 days interval till 60 days at the harvesting stage of the crop.

3.14.2.3 Fresh bulb weight plant^{-1} (g)

Five onion plant were selected randomly from each experimental plot and measured fresh bulb weight by using the weighing

balance immediately. The observation was recorded at 20 days interval till 80 days and at the harvesting stage of crop and an average as recorded in grams (g).

3.14.2.4 Dry matter accumulation of plant^{-1} (g)

For the dry matter study, five random plants were selected and uprooted from each plot. The plant were dried under sun and then dried in the oven at 60^0 C till they attained constant weight and it was recorded in gram (g). The dry matter of plant was recorded at 20 days interval till 80 days and at the harvesting stage crop.

3.14.3 Post harvest study

3.14.3.1 Equatorial and polar diameter of onion bulb (mm)

Polar and equatorial diameter of onion bulb of all the observational plants from each experimental plot were measured with the help of Vernier caliper and an average was recorded in centimeter (mm).

3.14.4 Yield studies

3.14.4.1 Dry weight of bulbs plant^{-1} (g)

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 60^0C 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.

3.14.4.2 Bulb yield (q ha^{-1})

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

3.14.5 Economic studies

3.14.5.1 Gross Monetary Returns (GMR)

From the total yield of each treatment plot, the gross monetary returns were worked out on the basis of average selling price of the produce and recorded accordingly in Rs ha^{-1}.

3.14.5.2 Net monetary returns (NMR)

From the gross monetary returns of each treatment plot, the expenditure incurred on the same treatment was deducted and treatment wise net monetary returns were worked out and recorded accordingly in Rs ha^{-1}.

3.14.5.3 Benefit cost ratio

The benefit cost ratio is the ratio of gross returns to the cost of cultivation. It can also be expressed as returns per rupee invested.

3.14.6 Chemical study

3.14.6.1 Plant analysis

a) Nutrient uptake (NPK) by plant (kg ha^{-1})

For estimation of nitrogen, phosphorous and potassium per cent content in onion bulbs, a sample of 0.5 gm 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 Nitrogen analyser, Phosphorous by Vanado-molybdo phosphoric acid yellow colour method (di-acid extract) by using spectronic 710 spectrophotometer and potassium content was estimated (di-acid extract) by using flame photometer (Jackson, 1967). Total nitrogen, phosphorous 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 kg ha^{-1}.

b) Nutrient uptake (NPK) by weed (kg ha^{-1})

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, phosphorous in weeds were estimated by Kjeldahl's method and Vanado-molybdate yellow colour method (from di-acid extract) respectively (Piper, 1966). The total nutrient uptake in kg/ha was calculated by using the formula,

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

3.14.6.2 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, phosphorous 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 and pH was estimation by pH meter, and organic carbon was estimation by Walkely and Blacks rapid titration method, Similarly EC was estimation by Electric conductivity bridge method respectively.

3.14.6.3 Microbial count

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

3.14.7 Statistical analysis

Data collected during the course of investigation were statistical analyzed by adopting standard procedure of analysis of variance by Panse and Sukhatme (1971). Wherever, the result were significant critical differences (CD) were worked out at 5% level of probability for comparison of treatment means. The treatment effects are presented in appropriate tables.

CHAPTER IV

RESULTS AND DISCUSSION

The present investigation entitled “Efficacy of different post emergence herbicides on onion (*Allium cepa* L.)” was conducted during *Rabi* season of 2018-2019. The observations taken during the course of investigation and the results obtained have been discussed in this chapter and the inferences have been supported with logical reasoning and appropriate evidences.

4.1 Soil

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.

4.2 Weed studies

4.2.1 Weed flora

Weed flora of the experimental field were collected, identified and classified under grassy, broadleaved weeds and sedges category. Scientific name, common name and family of these weeds have been presented in Table 7. The correct identification helps to group them into different classes. The weed of a specific group normally responded to a particular treatment because of their morphological characteristics, genetic make-up and growth similarities.

Table 7: Weed flora observed in experimental field

Sr.No.	Common name	Scientific name	Family
A) Sedges			
1.	Nagar Motha	*Cyperus rotundus* L.	Cyperaceae
B) Grassy weeds			
1.	Haryali	*Cynodon dactylon*	Poaceae
C) Broad leaves weeds			
1.	Gajar gawat	*Parthenium hysterophorus* L.	Compositae
2.	Reshimkata	*Alternanthera triandra* L.	Amaranthaceae
3.	Ghol	*Portulaca oleracea* L.	Portulacaceae
4.	Mothi dudhi	*Euphorbia geniculata* Orteg.	Euphorbiaceae
5.	Hajardani	*Phyllanthus niruri* L.	Euphorbiaceae
6.	Gokharu	*Xanthium strumarium* L.	Compositae
7.	Chandvel	*Convolvus arvensis*	Amaranthaceae

4.2.2 Weed population

The weeds were classified into two groups i.e. monocot and dicot, to study the effect of different treatments on each groups.

4.2.2.1 Monocot weeds (m^{-2})

The data regarding the mean number of monocot weeds are presented in Table 8.

Table 8: Monocot weed count as influenced by different treatments

Treatment	Dose (kg ha^{-1})	Monocot weed count				
		20 DAT	40 DAT	60 DAT	80 DAT	At harvest
T1- Clethodim 12% EC	0.084	4.13 (16.60)	4.31 (18.10)	5.22 (26.80)	5.84 (33.60)	6.05 (36.10)
T2- Clethodim 12% EC	0.096	4.16 (16.80)	4.27 (17.70)	5.16 (26.10)	5.89 (32.80)	5.97 (35.20)
T3- Clethodim 12% EC	0.108	3.92 (15.10)	4.18 (17.00)	4.91 (23.62)	5.30 (27.60)	5.48 (29.60)
T4- Clethodim 12% EC	0.120	4.17 (17.20)	4.15 (16.70)	4.92 (23.70)	5.37 (28.40)	5.60 (30.90)
T5- Clethodim 12% EC	0.240	4.04 (16.20)	4.10 (16.30)	4.74 (22.00)	5.06 (25.20)	5.36 (28.30)
T6- Propaquizafop 10% EC	0.0625	4.02 (16.00)	4.09 (16.20)	4.68 (21.45)	5.10 (25.60)	5.24 (27.00)
T7- Quizalofop-ethyl 5% EC	0.050	4.00 (17.30)	4.45 (19.30)	4.34 (18.40)	5.30 (27.70)	5.57 (30.60)
T8- Weed free	--	1.53 (1.84)	1.63 (2.15)	1.69 (2.35)	1.76 (2.60)	1.79 (2.70)
T9- Weedy check	--	4.12 (16.50)	7.79 (60.20)	9.54 (90.50)	10.04 (100.40)	10.20 (103.50)
S.E(m)±	--	0.70	0.12	0.19	0.15	0.16
C.D. at 5%	--	NS	0.38	0.57	0.47	0.49
G.M.	--	4.06	4.32	5.02	5.51	5.69

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

Figures in parentheses are original values.

A perusal data presented in Table 8 showed that number of monocot weeds were affected significantly at all the periodical intervals due to different treatments. Weed count was progressively increased from 20 DAT. Weedy check (T_9) recorded significantly highest number of monocot weeds which increased progressively towards harvest stage of the crop and lowest monocot weeds m^{-2} was noticed in weed free throughout the growth period of crop.

The data revealed that among the herbicidal treatment monocot weed m^{-2} were significantly lower with propaquizafop 10% EC @ 0.0625 kg ha^{-1} (T_6) as PoE which was statistically at par with clethodim 12% EC @ 0.108 kg ha^{-1} (T_3) throughout the growth stages, however, clethodim at higher (0.120 and 0.240 kg ha^{-1}) and lower levels (0.084 and 0.096 kg ha^{-1}) and quizalofop-ethyl 5% EC was not found effective in reducing the monocot weeds. This might be due to the propaquizafop 10% EC have better effect on managing dominant monocot weed population of *Cynodon dactylon* and sedges *Cyperus rotundus*. Similar results was also reported by Chinnusamy *et al*. (2006).

4.2.2.2 Dicot weeds (m^{-2})

Data pertaining to mean number of dicot weeds are presented in Table 9.

A perusal of the data presented in Table 9 showed that the number of dicot weeds was affected significantly at all the periodical intervals due to the different herbicidal treatments. Less number of dicot weeds m^{-2} were observed as compared to monocot weeds at initial stage of crop. Lowest dicot weeds m^{-2} was noticed in T_8 (Weed free) throughout the growth period of crop whereas highest in weedy check (T_9).

Among the different herbicide treatments, propaquizafop 10% EC @ 0.0625 kg ha^{-1}, clethodim 12% EC and quizalofop-ethyl 10% EC did not showed superiority in recording least dicot weed count at different growth stages. This might be due to herbicide are convenient in controlling emerges annual and perennial grasses and sedges. Dicot weed population was not reduced conspicuously due to herbicidal treatments at all growth

stages. So no much effect of Quizalofop ethyl was noted on dicot weeds. The results confirm the finding of Vishnu *et al*. (2015).

Table 9: Dicot weed count as influenced by different treatments

Treatment	Dose (kg ha^{-1})	Dicot weed count				
		20 DAT	40 DAT	60 DAT	80 DAT	At harvest
T1- Clethodim 12% EC	0.084	3.29 (10.30)	4.15 (16.73)	4.91 (23.63)	5.42 (28.93)	5.47 (29.39)
T2- Clethodim 12% EC	0.096	3.19 (9.70)	4.03 (15.73)	4.78 (22.37)	5.33 (27.90)	5.40 (28.63)
T3- Clethodim 12% EC	0.108	3.13 (9.30)	3.95 (15.13)	4.71 (21.71)	5.15 (26.03)	5.34 (28.07)
T4- Clethodim 12% EC	0.120	3.08 (9.00)	3.95 (15.13)	4.63 (21.00)	5.10 (25.53)	5.22 (26.73)
T5- Clethodim 12% EC	0.240	3.01 (8.60)	3.93 (14.97)	4.57 (20.47)	4.99 (24.53)	5.10 (25.57)
T6- Propaquizafop 10% EC	0.0625	3.04 (8.80)	3.92 (14.90)	4.50 (19.83)	4.91 (23.73)	4.94 (24.00)
T7- Quizalofop-ethyl 5% EC	0.050	3.22 (9.90)	4.11 (16.40)	4.78 (22.40)	5.40 (28.73)	5.49 (29.70)
T8- Weed free	--	1.34 (1.30)	1.37 (1.39)	1.41 (1.49)	1.46 (1.65)	1.47 (1.68)
T9- Weedy check	--	3.38 (10.93)	4.26 (17.67)	5.38 (28.40)	6.71 (44.50)	6.88 (46.87)
S.E(m)±	--	0.51	0.11	0.12	0.14	0.14
C.D. at 5%	--	NS	0.34	0.38	0.42	0.43
G.M.	--	2.96	3.74	4.40	4.94	5.03

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

Figures in parentheses are original values.

4.2.2.3 Total weeds count (m^{-2})

The data pertaining to total weed population as influenced by various herbicidal weed management practices are presented in Table 10. Total weed population had affected significantly by herbicidal weed control methods at all the stages of observation. In general grasses especially, *Cynodon dactylon* and sedges especially, *Cyperus rotundus* appeared during the initial growth stages, whereas broad-leaved weeds emerged

later. These weeds (grasses and sedges) which were dominant emerged during 15 to 20 DAT and thereafter continuously throughout the growth stages.

Table 10 : Total weed count as influenced by different treatments

Treatment	Dose (kg ha^{-1})	Total weed count				
		20 DAT	40 DAT	60 DAT	80 DAT	At harvest
T1- Clethodim 12% EC	0.084	5.23 (26.9)	5.94 (34.83)	7.14 (50.43)	7.94 (62.53)	8.12 (65.49)
T2- Clethodim 12% EC	0.096	5.19 (26.5)	5.83 (33.43)	7.00 (48.47)	7.82 (60.7)	8.02 (63.83)
T3- Clethodim 12% EC	0.108	4.97 (24.4)	5.71 (32.13)	6.77 (45.33)	7.35 (53.63)	7.62 (57.67)
T4- Clethodim 12% EC	0.120	5.14 (26.2)	5.68 (31.83)	6.72 (44.7)	7.37 (53.93)	7.62 (57.63)
T5- Clethodim 12% EC	0.240	4.99 (24.8)	5.63 (31.27)	6.54 (42.47)	7.08 (49.73)	7.36 (53.87)
T6- Propaquizafop 10% EC	0.0625	4.99 (24.8)	5.62 (31.1)	6.45 (41.28)	7.05 (49.33)	7.16 (51.00)
T7- Quizalofop-ethyl 5% EC	0.050	5.14 (27.2)	6.02 (35.7)	6.42 (40.8)	7.54 (56.43)	7.79 (60.3)
T8- Weed free	--	1.91 (3.14)	2.01 (3.54)	2.08 (3.84)	2.18 (4.25)	2.21 (4.38)
T9- Weedy check	--	5.28 (27.43)	8.85 (77.87)	10.93 (118.9)	12.06 (144.9)	12.28 (150.37)
S.E(m)±	--	0.92	0.22	0.19	0.21	0.21
C.D. at 5%	--	NS	0.67	0.57	0.63	0.64
G.M.	--	4.76	5.69	6.67	7.37	7.57

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

Figures in parentheses are original values.

Amongst herbicides, post-emergence (PoE) application of propaquizafop 10% EC @ 0.0625 kg ha^{-1} found in effectively controlling total population of weed but remained at par with clethodim PoE 12% EC @ 0.108 kg ha^{-1}. Application of propaquizafop 10% EC, clethodim PoE 12% EC and quizalofop-ethyl 5% EC remained least effective in decreasing broadleaf weed density. Overall weed population was reduced significantly

due to various weed management treatments at all stages of crop growth over weedy check. This might be due to herbicides viz., propaquizafop 10% EC and clethodim PoE 12% EC that have found effectively controlling dominant monocot weed population especially *Cynodon dactylon* and sedges *Cyperus rotundus*. Similar results were reported by Vishnu et al. (2015).

4.2.3 Dry matter production by weeds (g m^{-2})

The total dry weight of weed as influenced by different weed management treatments in onion at different growth stages differed significantly are presented in Table 11. Irrespective of growth stages the weed dry weight was lower in weed free check (T_8) compared to all other treatments throughout the growth period of crop.

Table 11: Dry matter production of weeds as influenced by different treatments

Treatment	Dose (kg ha^{-1})	Dry matter production of weeds				
		20 DAT	40 DAT	60 DAT	80 DAT	At harvest
T1- Clethodim 12% EC	0.084	3.07 (8.90)	3.89 (14.60)	5.17 (26.20)	5.77 (32.80)	6.17 (37.5)
T2- Clethodim 12% EC	0.096	3.02 (8.60)	3.58 (12.30)	5.03 (24.87)	5.57 (30.60)	5.97 (35.2)
T3- Clethodim 12% EC	0.108	2.76 (7.10)	3.42 (11.21)	4.07 (16.10)	4.37 (18.60)	4.46 (19.4)
T4- Clethodim 12% EC	0.120	2.95 (8.20)	3.34 (10.65)	4.03 (15.80)	4.29 (17.90)	4.35 (18.42)
T5- Clethodim 12% EC	0.240	2.79 (7.32)	3.30 (10.40)	3.75 (13.60)	4.21 (17.20)	4.29 (17.88)
T6- Propaquizafop 10% EC	0.0625	2.79 (7.30)	3.27 (10.20)	3.65 (12.90)	4.07 (16.10)	4.15 (16.76)
T7- Quizalofop-ethyl 5% EC	0.050	3.27 (10.20)	4.11 (16.40)	3.60 (12.50)	5.15 (26.10)	5.42 (28.9)
T8- Weed free	--	1.40 (1.46)	1.50 (1.76)	1.60 (2.08)	1.65 (2.22)	1.70 (2.40)
T9- Weedy check	--	4.28 (17.80)	5.40 (28.70)	6.87 (46.70)	8.64 (74.20)	8.89 (78.5)
S.E(m)±	--	0.60	0.10	0.16	0. 14	0.17
C.D. at 5%	--	NS	0.30	0.48	0.42	0.52
G.M.	--	2.92	3.53	4.19	5.07	5.04

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

Figures in parentheses are original values.

Weed dry weight was recorded prior to implementations of weed management measures. In general the dry matter of weed was minimum at 20 DAT and was increased and reached to maximum at 80 DAT and slightly increased at harvest.

The weed free treatment was superior over rest of the treatments and weedy check recorded significantly higher weed biomass accumulation.

Among herbicides application of propaquizafop 10% EC @ 0.0625 kg ha^{-1} as PoE showed significantly less weed dry weight over rest of the treatments and it was statistically at par with clethodim 12% EC @ 0.108 kg ha^{-1} at different growth stages. The highest reduction of weed dry matter was recorded with propaquizafop 10% EC @ 0.0625 kg ha^{-1} this might be due to effective management of dominant annual and perennial grasses population and brought significant reduction in weed dry matter as compared to weedy check.

4.2.4 Weed control efficiency (%)

Weed control efficiency influenced by different weed management treatments are presented in Table 12. Weed control efficiency denotes the control of weeds in respective treatment.

Among herbicides propaquizafop 10 % EC recorded highest weed control efficiency which was comparable with higher level of clethodim 12% EC @ 0.240, 0.120 and 0.108 kg ha^{-}1, however, these higher level (0.240 kg ha^{-1}) were found phytotoxic to onion. The propaquiafop 10% EC and clethodim 12% EC @ 0.108 kg ha^{-1} are safe and effective management of dominant monocot weed thereby increasing weed control efficiency. Similar result reported by Vishnu *et al*. (2015).

4.2.5 Weed Index (%)

Data pertaining to weed index are presented in Table 12. Weed index was computed as the yield reduction comparative to highest yielding treatment i.e. weed free (T_8).

Table 12: Weed control efficiency and Weed index as influenced by different treatments

Treatment	Dose (kg ha^{-1})	Weed control efficiency (%)	Weed index (%)
T1- Clethodim 12% EC	0.084	52.14	13.90
T2- Clethodim 12% EC	0.096	55.14	17.57
T3- Clethodim 12% EC	0.108	75.26	2.70
T4- Clethodim 12% EC	0.120	76.53	23.94
T5- Clethodim 12% EC	0.240	77.19	27.80
T6- Propaquizafop 10% EC	0.0625	78.62	1.35
T7- Quizalofop-ethyl 5% EC	0.050	63.15	11.78
T8- Weed free	--	96.94	00
T9- Weedy check	--	0.00	43.63

However, weed check treatment recorded maximum weed index i.e. 43.63% indicating the reduction in onion yield due to presence of weeds throughout crop growth period. Lower weed index was recorded in propiquizafop 10% EC and clethodim 12% EC @ 0.108 kg ha^{-1} might be due to better weed management, which provided favourable conditions for crop growth, which ultimately increased the bulb yield of onion as compared to weedy check. Tei *et al.* (1996) reported that onion shows slow growth, low ground cover and poor light interception ability as a consequence low productivity in weedy check plot.

4.2.6 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 monitored at 10 days after application of herbicide in respective treatment.

Table 13: Crop phytotoxicity visual score rate scale (0 to 10) at 10 days herbicide application

Treatment	Dose (kg ha^{-1})	Crop phytotoxicity score scale		
		Effect	Rating	Description
T1- Clethodim 12% EC	0.084	None	0	No injury, normal growth
T2- Clethodim 12% EC	0.096	None	0	No injury, normal growth
T3- Clethodim 12% EC	0.108	None	0	No injury, normal growth
T4- Clethodim 12% EC	0.120	None	0	No injury, normal growth
T5- Clethodim 12% EC	0.240	Slight	1	Slight stunting injury or discoloration
T6- Propaquizafop 10% EC	0.0625	None	0	No injury, normal growth
T7- Quizalofop-ethyl 5% EC	0.050	None	0	No injury, normal growth
T8- Weed free	--	--	--	--
T9- Weedy check	**--**	**--**	**--**	**--**

Amongst post-emergence herbicides clethodim 12% EC up to 0.120 kg ha^{-1}, propaquizafop 10 EC @ 0.0625 kg ha^{-1} and quizalofop-ethyl 5% EC @ 0.050 kg ha^{-1}proved better, however, it has been observed that, clethodim 12% EC @ 0.240 kg ha^{-1} was injurious to the onion crop. Nevertheless due to lowest dry matter of weeds in higher dose applied to the plot i.e. 0.240 kg ha^{-1} significant reduction in ancillary parameters was noticed due to crop phytotoxicity (having 1 visual score rating), however due to application of clethodim 12% EC @ 0.240 kg ha^{-1} at 20 DAS injury was less pronounced but not persistent. The results pertaining to phytotoxicity scoring was slight stunting injury or discoloration, but no plants died from the treatment. It was observed that the effects of clethodim 12% EC @ 0.240 kg ha^{-1} occurred severely in young tissue even though the age of the plant was relatively young i.e. seedling stage.

4.3 Crop studies

4.3.1 Emergence count and final plant stand of onion

The data regarding initial and final population as influenced by the different herbicidal treatments are presented in Table 14.

Table 14: Plant population of onion as influenced by different treatments

Treatment	Dose (kg ha^{-1})	Plant stand ha^{-1}	
		Initial at 20 DAT	Final at harvest
T1- Clethodim 12% EC	0.084	1422.67	1343.33
T2- Clethodim 12% EC	0.096	1415.00	1334.67
T3- Clethodim 12% EC	0.108	1439.33	1362.67
T4- Clethodim 12% EC	0.120	1404.67	1326.67
T5- Clethodim 12% EC	0.240	1448.00	1321.67
T6- Propaquizafop 10% EC	0.0625	1444.00	1368.67
T7- Quizalofop-ethyl 5% EC	0.050	1425.00	1348.67
T8- Weed free	--	1432.00	1354.67
T9- Weedy check	--	1436.00	1388.00
S.E(m)±	--	48.58	44.17
C.D. at 5%	--	NS	NS
G.M.	--	1429.63	1349.88

Data revealed that different weed management treatments had no significant influence on initial and final plant stand, there by indicating uniform plant stand and its persistence throughout the crop growth period. The treatment difference therefore on different parameters under study were treatment effect and plant population was not a variable factor. Similar results were reported by Warade *et al*. (2008) and Kolse *et al*. (2010).

4.3.2 Plant height (cm)

The various weed control treatments significantly influenced plant height at all growth stages except at 20 DAT where the treatment differences were statistically not significant. However, from 40 DAT up to

harvest weed free treatment recorded significantly higher plant height over rest of the treatments and lowest plant height was noticed in weedy check (T_9). Among herbicides treatments propaquizafop 10% EC @ 0.0625 kg ha^{-1} were found highly superior over rest of the treatments, which was found at par with the clethodim 12 % EC @ 0.108 kg ha^{-1}.

Table 15: Plant height (cm) at as influenced by different treatments

Treatment	Dose (kg ha^{-1})	Plant height			
		20 DAT	40 DAT	60 DAT	At harvest
T1- Clethodim 12% EC	0.084	25.83	44.00	50.37	63.30
T2- Clethodim 12% EC	0.096	24.57	42.70	48.83	61.90
T3- Clethodim 12% EC	0.108	28.47	52.90	63.27	74.55
T4- Clethodim 12% EC	0.120	21.67	39.13	48.17	61.33
T5- Clethodim 12% EC	0.240	21.00	38.07	47.50	60.37
T6- Propaquizafop 10% EC	0.0625	29.33	54.40	64.43	75.77
T7- Quizalofop-ethyl 5% EC	0.050	28.07	46.13	52.03	64.67
T8- Weed free	--	29.83	58.00	65.87	76.47
T9- Weedy check	--	20.23	34.66	45.90	58.07
S.E(m)±	--	2.63	2.06	2.80	3.40
C.D. at 5%	--	NS	6.20	8.40	10.21
G.M.	--	25.44	45.55	54.04	66.26

The increase in plant height of onion under treatment weed free and propaquizafop 10% EC @ 0.0625 kg ha^{-1} might be due to the least crop-weed competition. Significant reduction in plant height was noticed in weedy check might be due to 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 results reported by Saraf (2007).

4.3.3 Fresh bulb weight $plant^{-1}$ (g)

The data presented in Table 16 revealed that, the fresh weight of onion bulb was significant influenced at different stages.

All the weed control treatments significantly influenced the fresh bulb weight of onion plant^{-1} at all the growth stages of crop except at 20 DAT.

At 40 DAT, weed free treatment recorded maximum fresh bulb weight of onion plant^{-1} than that of weedy check, which in turn was statistically at par with propaquizafop 10% EC @ 0.0625 kg ha^{-1}, and clethodim 12% EC @ 0.108 kg ha^{-1}. Similar result was recorded throughout the growth stages of crop.

Maximum fresh bulb weight of onion plant^{-1} was recorded with weed free over rest of the treatments and it was statistically at par with propaquizafop 10% EC @ 0.0625 kg ha^{-1}, and clethodim 12 % EC @ 0.108 kg ha^{-1}. Similar trend was noticed throughout the growth period of crop.

Table 16: Fresh bulb weight (g) as influenced by different treatments

Treatment	Dose (kg ha^{-1})	Fresh bulb weight plant^{-1}				
		20 DAT	40 DAT	60 DAT	80 DAT	At harvest
T1- Clethodim 12% EC	0.084	1.1	8.6	37.2	74.0	86.4
T2- Clethodim 12% EC	0.096	1.0	6.9	36.5	72.0	81.1
T3- Clethodim 12% EC	0.108	1.3	13.6	43.0	81.4	99.2
T4- Clethodim 12% EC	0.120	0.9	5.9	34.3	69.3	77.0
T5- Clethodim 12% EC	0.240	0.8	4.8	31.2	66.7	71.6
T6- Propaquizafop 10% EC	0.0625	1.3	13.9	43.2	82.9	100.4
T7- Quizalofop-ethyl 5% EC	0.050	1.2	9.2	41.3	77.8	88.4
T8- Weed free	--	1.4	14.7	47.9	89.6	106.4
T9- Weedy check	--	0.6	3.4	27.0	58.9	65.2
S.E(m)±	--	0.16	0.53	1.83	3.66	3.67
C.D. at 5%	--	NS	1.61	5.49	10.98	11.00
G.M.	--	1.06	9	37.96	74.74	86.18

Minimum number of fresh bulb weight plant^{-1} was recorded with weedy check (T_9) because 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).

4.3.4 Dry matter accumulation of plant^{-1} (g)

Data in respect of dry matter accumulation plant^{-1} as influenced by different treatments are presented in Table 17.

All the weed control treatments significantly influenced the dry matter accumulation plant^{-1} at all the growth stages of crop except at 20 DAT. Significantly higher dry matter accumulation was recorded with weed free over rest of the treatments except propaquizafop 10% EC @ 0.0625 kg ha^{-1} and clethodim 12 % EC @ 0.108 kg ha^{-1} at 60 DAT. The higher dry matter accumulation in weed free treatment may be due to favourable environment due to clean cultivation resulting in more absorption of solar radiation and absorption of more nutrients. These results are in confirmation with the findings of Vishnu *et al*. (2015).

Table 17: Total dry matter accumulation plant^{-1} as influenced by different treatments

Treatment	Dose (kg ha^{-1})	Total dry matter accumulation plant^{-1}				
		20 DAT	40 DAT	60 DAT	80 DAT	At harvest
T1- Clethodim 12% EC	0.084	0.87	1.47	6.13	11.78	12.67
T2- Clethodim 12% EC	0.096	0.86	1.40	6.00	10.70	11.80
T3- Clethodim 12% EC	0.108	0.91	1.87	7.97	14.80	16.13
T4- Clethodim 12% EC	0.120	0.82	1.37	5.86	9.80	10.73
T5- Clethodim 12% EC	0.240	0.79	1.27	4.93	8.93	9.83
T6- Propaquizafop 10% EC	0.0625	0.93	1.89	8.43	15.81	17.01
T7- Quizalofop-ethyl 5% EC	0.050	0.89	1.53	6.47	12.79	14.27
T8- Weed free	--	0.96	1.93	8.50	16.20	17.60
T9- Weedy check	--	0.76	1.10	3.97	6.17	7.63
S.E(m)±	--	0.04	0.08	0.30	0.54	0.59
C.D. at 5%	--	NS	0.26	0.90	1.61	1.77
G.M.	--	0.87	1.53	6.47	11.88	13.07

4.4 Post-harvest studies

4.4.1. Equatorial diameter of onion bulb (mm)

The data regarding equatorial diameter of onion bulb as influenced by the different herbicidal treatments are presented in Table 18.

Table 18: Equatorial and polar diameter of onion bulb as influenced by different treatments

Treatment	Dose (kg ha^{-1})	Equatorial diameter of onion bulb (mm)	Polar diameter of onion bulb (mm)
T1- Clethodim 12% EC	0.084	55.7	43.2
T2- Clethodim 12% EC	0.096	52.8	41.0
T3- Clethodim 12% EC	0.108	63.9	50.9
T4- Clethodim 12% EC	0.120	50.4	38.9
T5- Clethodim 12% EC	0.240	48.8	36.7
T6- Propaquizafop 10% EC	0.0625	65.4	52.8
T7- Quizalofop-ethyl 5% EC	0.050	59.3	45.1
T8- Weed free	--	67.9	54.4
T9- Weedy check	--	45.0	33.9
S.E(m)±	--	2.60	2.30
C.D. at 5%	--	7.80	7.10
G.M.	--	56.5	44.10

The treatment weed free produced significantly the maximum equatorial diameter of onion bulb (67.9 mm) over rest of the treatments and which in turn was found at par with propaquizafop 10% EC @ 0.0625 kg ha^{-1} and clethodim 12 % EC @ 0.108 kg ha^{-1}. The bulb with significantly minimum diameter (45.0 mm) was harvested from the weedy check treatment. Similar results were also reported by Saraf (2007) and Shinde *et al.* (2012) recorded maximum equatorial diameter in herbicidal treatment and minimum equatorial diameter in weedy condition. The higher equatorial diameter in all the herbicidal treatment was due to better uptake of nutrients by onion bulb as compared to weedy check where severe weed competition was observed.

4.4.2 Polar diameter of onion bulb (mm)

The data regarding polar diameter of onion bulbs as influenced due to different herbicidal treatment are presented in Table 18.

The maximum polar diameter of onion bulb was recorded with weed free (54.4 mm) treatment and which was found to be at par with the propaquizafop 10% EC @ 0.0625 kg ha^{-1} and clethodim 12 % EC @ 0.108 kg ha^{-1}. At higher level of clethodim showed reduction in polar diameter due to its phytotoxic effect on onion. The bulb with significantly minimum diameter (33.9 mm) was harvested from the weedy check. Similar results were also reported by Saraf (2007) and Shinde *et al.* (2012) recorded maximum polar diameter in herbicidal treatment and minimum polar diameter in weedy condition. The higher polar diameter in all the herbicidal treatment was due to better uptake of nutrients by onion bulb as compared to weedy check where severe weed competition was observed.

4.5 Yield studies

4.5.1 Dry weight of bulb $plant^{1}$ (g)

The data presented in Table 19 revealed that, the dry weight of bulb $plant^{1}$ was significantly influenced due to various herbicidal treatments.

The weed free treatment accumulated significantly higher dry weight of bulb (17.55 g) over weedy check (5.21 g) at harvest and was statistically comparable with propaquizafop 10% EC @ 0.0625 kg ha^{-1} (17.20 g), and clethodim 12 % EC @ 0.108 kg ha^{-1} (15.60 g) and all these treatment showed superiority over remaining treatments.

The higher dry weight of bulb $plant^{1}$ was recorded in weed free (T_8), propaquizafop 10% EC 0.0625 kg ha^{-1} might be due to less weed competition, there by facilitating luxurious crop growth resulting in to more dry matter production $plant^{1}$ as compared to unweeded control treatment. These results are in conformation with the findings of Saraf (2007).

Table 19: Dry weight of bulb (g) as influenced by different treatments

Treatment	Dose (kg ha^{-1})	Dry weight of bulb plant^{-1} (g)
T1- Clethodim 12% EC	0.084	11.43
T2- Clethodim 12% EC	0.096	9.98
T3- Clethodim 12% EC	0.108	15.60
T4- Clethodim 12% EC	0.120	7.78
T5- Clethodim 12% EC	0.240	6.45
T6- Propaquizafop 10% EC	0.0625	17.20
T7- Quizalofop-ethyl 5% EC	0.050	13.34
T8- Weed free	--	17.55
T9- Weedy check	--	5.21
S.E(m)±	--	0.68
C.D. at 5%	--	2.05
G.M.	--	11.61

4.5.2 Bulb yield (q ha^{-1})

The data regarding per hectare of onion bulbs as influenced due to the different herbicidal treatment are presented in Table 20 and graphically depicted in Fig. 3.

The maximum yield of onion bulbs were harvested from the treatment weed free (172.67 q ha^{-1}) as compared to remaining treatments but found at par with propaquizafop 10% EC @ 0.0625 kg ha^{-1} (170.33 q ha^{-1}) and clethodim 12 % EC @ 0.108 kg ha^{-1} (168.00 q/ha). All these treatment showed superiority over weedy check (97.33 q ha^{-1}). Different 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 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 there by 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).

Table 20 : Bulb yield as influenced by different treatments

Treatment	Dose (kg ha^{-1})	Bulb yield (q ha^{-1})
T1- Clethodim 12% EC	0.084	148.67
T2- Clethodim 12% EC	0.096	142.33
T3- Clethodim 12% EC	0.108	168.00
T4- Clethodim 12% EC	0.120	131.33
T5- Clethodim 12% EC	0.240	124.67
T6- Propaquizafop 10% EC	0.0625	170.33
T7- Quizalofop-ethyl 5% EC	0.050	152.33
T8- Weed free	--	172.67
T9- Weedy check	--	97.33
S.E(m)±	--	4.63
C.D. at 5%	--	13.89
G.M.	--	145.29

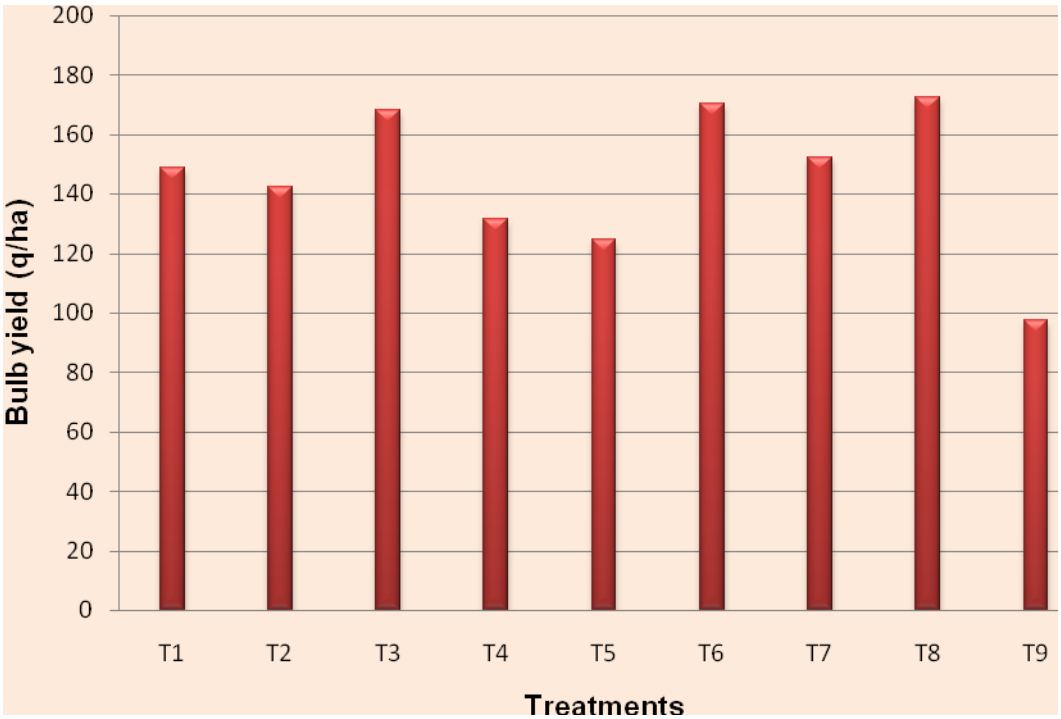


Fig 3. Bulb yield (q/ha) as influenced by different weed management treatments

4.6 Economic studies

Considering the prevailing cost of labour and input's required for weed control treatments, economics was worked out for different treatments and data in respect of gross monetary return (GMR), net monetary returns (NMR) and benefit cost ratio (BCR) are presented in Table 21.

Table 21 : Economics of weed management treatments

Treatment	Dose (kg ha^{-1})	GMR (Rs. ha^{-1})	Cost of cultivation (Rs. ha^{-1})	NMR (Rs. ha^{-1})	B:C Ratio
T1- Clethodim 12% EC	0.084	74333	42390	31943	1.75
T2- Clethodim 12% EC	0.096	71166	42510	28656	1.67
T3- Clethodim 12% EC	0.108	84000	42630	41370	1.97
T4- Clethodim 12% EC	0.120	65666	42750	22916	1.53
T5- Clethodim 12% EC	0.240	62333	53950	18383	1.41
T6- Propaquizafop 10% EC	0.0625	85166	42612	42554	1.99
T7- Quizalofop-ethyl 5% EC	0.050	76166	43025	33141	1.77
T8- Weed free	--	86333	49410	36923	1.74
T9- Weedy check	--	48666	41550	7116	1.17
S.E(m)±	--	3321	-	3321	-
C.D. at 5%	--	9956	-	9956	-
G.M.	--	72648	-	29222	-

The data revealed that gross monetary returns affected significantly due to different treatments. Significantly higher GMR (Rs.86333 ha^{-1}) and NMR (Rs. 36923 ha^{-1}) were recorded by weed free over remaining treatments. Among herbicides treatments application of propaquizafop 10% EC @ 0.0625 kg ha^{-1} and clethodim 12% EC @ 0.108 kg ha^{-1} registered maximum GMR and NMR over rest of the treatments. These was due to better control of weeds in these treatments. The lowest gross monetary returns of Rs.48666 ha^{-1} was resulted in weedy check. Effective weed management with better bulb yield resulted in higher returns in above treatments. Similar results were obtained by Mondal *et al*. (2005), Chopra and Chopra *et al*. (2006) and Vishnu *et al*. (2015).

Post-emergence application of propaquizafop 10% EC @ 0.0625 kg ha^{-1} recorded highest benefit cost ratio, i.e. 1.99 followed by treatments clethodim 12% EC @ 0.108 kg ha^{-1} (1.97) and weed free (1.74). The higher B:C ratio with propaquizafop 10% EC was due to less 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 (1.17) due to lower onion bulb yield owing to more weed competition. Lowest benefit cost ratio (1.17) was recorded in treatment weedy check (T_7) as a result of higher crop weed competition which reduced the onion yield. The differences in B:C ratio is due to the cost of herbicides and productivity of the crop. Similar results were obtained by Vishnu *et al*. (2015).

4.7 Chemical studies

4.7.1 Nutrient uptake (NPK) by onion bulb (kg ha^{-1})

Data regarding nitrogen, phosphorus and potassium uptake (kg ha^{-1}) by onion bulb as influenced by different treatments are presented in Table 22.

Higher uptake of nutrient (NPK) were recorded with weed free treatment which was found at par with propaquizafop 10% EC @ 0.0625 kg ha^{-1} and clethodim 12% EC @ 0.108 kg ha^{-1}, however, lowest uptake of nutrients were noted in weedy check (T_9). The higher nutrients uptake resulted due to less weed competition and more dry matter production and higher onion bulb yield due to the better use of resources as compared to other treatments. Similar results were also reported by Vishnu *et al*. (2015).

Table 22: Nutrient uptake (NPK) by onion bulb (kg ha^{-1}) as influenced by different treatments

Treatment	Dose (kg ha^{-1})	Nutrient uptake (kg ha^{-1})		
		N Uptake	P uptake	K uptake
T1- Clethodim 12% EC	0.084	38.65 (0.26)	10.41 (0.07)	17.84 (0.12)
T2- Clethodim 12% EC	0.096	37.01 (0.26)	9.96 (0.07)	17.08 (0.12)
T3- Clethodim 12% EC	0.108	47.04 (0.28)	15.12 (0.09)	21.84 (0.13)
T4- Clethodim 12% EC	0.120	34.15 (0.26)	9.19 (0.07)	17.07 (0.13)
T5- Clethodim 12% EC	0.240	29.92 (0.24)	7.48 (0.07)	16.21 (0.13)
T6- Propaquizafop 10% EC	0.0625	49.40 (0.29)	15.33 (0.09)	22.14 (0.13)
T7- Quizalofop-ethyl 5% EC	0.050	41.13 (0.27)	10.66 (0.07)	18.28 (0.12)
T8- Weed free	--	51.80 (0.30)	15.54 (0.08)	24.17 (0.13)
T9- Weedy check	--	22.39 (0.23)	5.84 (0.06)	9.73 (0.10)
S.E(m)±	--	1.74	0.48	0.80
C.D. at 5%	--	5.23	1.44	2.42
G.M.	--	39.05	11.05	18.26

4.7.2 Nitrogen, phosphorus and potassium uptake by weeds

Data regarding nitrogen, phosphorus and potassium uptake (kg ha^{-1}) by weed as influenced by different treatment are presented in Table 23.

Among the different weed control measures weedy check (T_9) recorded significantly higher N (70.09 kg/ha), P (17.52 kg/ha), and K (29.20 kg/ha) uptake by weed. The weed free treatment recorded lower value of nutrient uptake by weeds than other treatments closely followed by treatment propaquizafop 10 % EC @ 0.0625 kg ha^{-1}, and clethodim 12% EC @ 0.108 kg ha^{-1} (T_3). 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 similar results were also observed by Vishnu *et al*. (2015)

Table 23: Nutrient uptake (N, P and k) by weeds (kg ha^{-1}) as influenced by different treatments

Treatment	Dose (kg ha^{-1})	Nutrient uptake by weeds		
		N kg/ha	P kg/ha	K kg/ha
T1- Clethodim 12% EC	0.084	36.30	9.77	19.55
T2- Clethodim 12% EC	0.096	34.05	9.17	17.02
T3- Clethodim 12% EC	0.108	18.76	5.05	9.38
T4- Clethodim 12% EC	0.120	17.82	4.80	8.91
T5- Clethodim 12% EC	0.240	15.96	4.66	8.65
T6- Propaquizafop 10% EC	0.0625	14.96	4.36	8.11
T7- Quizalofop-ethyl 5% EC	0.050	29.03	8.60	15.05
T8- Weed free	--	2.23	0.63	1.1
T9- Weedy check	--	70.09	17.52	29.20
S.E(m)±	--	0.95	0.26	0.48
C.D. at 5%	--	2.86	0.80	1.44
G.M.	--	26.57	7.17	13.00

4.7.3 Microbial study

4.7.3.1 Microbial count

Data pertaining to effect of herbicide on soil microbial (bacterial, fungal and actinomycetes) count at different growth stages of the crop are presented in Table 24.

Though microbial count before transplanting (BTP) and at harvest was not influenced by different treatments, however population of bacteria was increased at harvest of the crop.

Table 24 : Microbial count at influenced by different treatments.

Treatment	Dose (kg ha^{-1})	Bacterial count (cfu g^{-1} soil $\times 10^7$)		Fungal count (cfu g-1 soil $\times 10^4$)		Actinomycetes count (cfu g-1 soil $\times 10^6$)	
		30 DAT	At Harvest	30 DAT	At Harvest	30 DAT	At Harvest
T1- Clethodim 12% EC	0.084	6.50	23.37	7.1	22.36	8.3	23.70
T2- Clethodim 12% EC	0.096	6.12	23.10	6.6	22.27	7.7	23.17
T3- Clethodim 12% EC	0.108	8.95	27.50	7.9	23.59	9.1	26.57
T4- Clethodim 12% EC	0.120	5.80	21.41	5.7	22.07	6.6	22.85
T5- Clethodim 12% EC	0.240	5.37	19.42	5.2	21.97	6.0	21.70
T6- Propaquizafop 10% EC	0.0625	9.45	28.24	8.2	23.86	9.8	27.32
T7- Quizalofop-ethyl 5% EC	0.050	7.30	24.78	7.6	23.50	8.8	24.71
T8- Weed free	--	10.32	18.10	8.5	18.20	10.3	20.97
T9- Weedy check	--	13.23	29.63	14.3	26.60	12.2	30.85
S.E(m)±	--	0.46	2.63	0.28	1.40	0.40	2.00
C.D. at 5%	--	1.38	NS	0.86	NS	1.21	NS
G.M.	--	8.11	23.95	7.88	22.71	8.75	24.64
Initial value		11.80		10.41		8.76	

Treatment weedy check (T_9) recorded significantly higher number of bacteria, fungi, actinomycetes. Effect of herbicide 30 DAT significantly influenced the population of soil microorganisms (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 equal level. It was clear that the effect of herbicide on soil microbes was for a temporary period. The result confirm the findings of Pal *et al*. (2009) and Ghosh *et al.* (2012).

CHAPTER V

SUMMARY AND CONCLUSION

The present investigation entitled **"Efficacy of Different Post Emergence Herbicides on Onion (*Allium cepa* L.)"** was conducted during the year 2018-2019 at All India Co-ordinated Research Project on Weed Management, Department of Agronomy, Dr. Panjabrao Deshmukh Krishi Vidhyapeeth, Akola. The experiment was laid out in Randomized Block Design with three replications and nine treatments in *onion* variety *Akola safed* (Selection white). The study was conducted to know the efficacy of different post emergence herbicides for managing weed flora in onion and effect of different post emergence herbicides on growth and yield of onion. Nine treatments viz. post emergence herbicides i.e. clethodim 12% EC @ 0.084 kg ha^{-1}, clethodim 12% EC @ 0.096 kg ha^{-1}, clethodim 12% EC @ 0.108 kg ha^{-1}, clethodim 12% EC @ 0.120 kg ha^{-1}, clethodim 12% EC @ 0.240 kg ha^{-1}, propaquizafop 10% EC @ 0.0625 kg ha^{-1}, quizalofop-ethy 5% EC @ 0.050 kg ha^{-1}, weed free and weedy check. Observations were recorded on different aspects of weeds, morphological, growth and yield parameters related to crop in which yield per hectare and B:C ratio was also worked out.

The prominent weed species observed in experiment site were *Cyperus rotundus, Cynadon dactylon, Parthenium hysterophorus, Alternanthera triandra, Portulaca oleracea, Euphorbia geniculate, Phyllanthus niruri, Xanthium strumarium, Convolvus arvensis* etc.

Hand weeding was the most effective method for controlling *Cyperus rotundus, Cynadon dactylon, Parthenium hysterophorus, Alternanthera triandra, Portulaca oleracea, Euphorbia geniculate, Phyllanthus niruri, Xanthium strumarium, Convolvus arvensis,* but the hand weeding is not possible to large scale. For large scale cultivation application of herbicides is most prevalent method to control the weeds. Among various treatments of herbicides, application of propaquizafop 10 % EC @ 0.0625 kg ha^{-1} was found the most effective for controlling the weeds

on the basis of weed density. It could be possible due to better weed control index.

Maximum weed control efficiency was recorded propaquizafop 10 % EC @ 0.0625 kg ha^{-1} for all type of weeds observed in the field and followed by clethodim 12 % EC @ 0.240 kg ha^{-1} control narrow leaves weeds.

Among all the studied treatments, weed free treatment recorded significantly highest plant height, average bulb weight, polar and equatorial diameter, per hectare yield (q ha^{-1}) was superior over all other treatments. Weedy check registered the lowest values for most of the parameter viz. plant height, average bulb weight, polar and equatorial diameter, per hectare yield (q ha^{-1}). On the other hand, weedy check also recorded maximum values for dry matter accumulation of weeds, weed density and weed index.

Among the different herbicidal treatments post emergence application of propaquizafop 10 % EC @ 0.0625 kg ha^{-1} applied at 20 days after transplanting was found better in controlling weeds as compared to other herbicides, thus resulted in higher weed control efficiency at both early and late stages of the crop. Bulb yield was also significantly higher in this treatment as compared to other treatments.

As there were only one phytotoxic symptoms recorded in treatment T_5 (Clethodim 12 % EC @ 0.240 kg ha^{-1}) like leaf yellowing, leaf curling were visual after 10 days after herbicidal spray.

Maximum gross returns (Rs.86333 ha^{-1}), net income (Rs.36923 ha^{-1}) and B:C ratio (1.74) was recorded in weed free treatment. Among herbicidal treatments maximum gross returns (Rs.85166 ha^{-1}) and net income (Rs.42554 ha^{-1}) and B:C ratio (1.99) was observed with the application of propaquizafop 10 % EC @ 0.0625 kg ha^{-1} applied at 20 days after transplanting.

Minimum gross returns, net income and benefit: cost ratio was recorded in weedy check.

CONCLUSION:

It is evident from this experiment that onion is an important nutritious crop and weeds are menace during the crop growth period and affect the bulb yield considerably. The weeds in crop field have high competitive ability, as they compete with crop plant (onion) for space, moisture, nutrient, sunlight etc.

On the basis of present investigation, it is concluded that onion variety *Akola safed* responded well in terms of weed control, growth, yield and net profit to application of herbicides.

On the basis of present investigation, it is concluded propaquizafop 10 % EC @ 0.0625 kg ha^{-1} at all the crop growth stages were the most effective herbicide for control of weeds in onion. The use of post-emergence herbicides was found highly profitable for getting higher yield and economic returns due to effective weed control.

Application of post emergence herbicide propaquizafop 10 % EC @ 0.0625 kg ha^{-1} applied at 20 days after transplanting was found superior among herbicidal treatments for growth and yield characters of onion. Application of post emergence herbicide clethodim 12 % EC @ 0.108 kg ha^{-1} applied at 20 days after transplanting was found to be second best option.

Application of propaquizafop 10 % EC @ 0.0625 kg ha^{-1} which gave the B:C ratio of 1.99 and yield 170.33 q ha^{-1} with net return Rs.42554 $ha^{-1}$and weedy check gave the lowest net return of Rs.7116 ha^{-1} with B : C ratio of 1.17 in comparison to the control.

CHAPTER VI

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APPENDIX

Fertilizer cost		
	SSP	Rs 4.8 /kg
Herbicide cost		
	Clethodim	Rs 1200 /lit.
	Propaquizafop	Rs 1700 /lit.
	Quizalofop ethyl	Rs 1450 /lit.
Seed cost	-	Rs 500 /kg
Labour charges		
	Male	Rs 240 /days
	Female	Rs 240 /days
	Machinery	Rs 500 /H
Selling price of onion	-	Rs 500 q^{-1}