STUDIES ON TANK MIX APPLICATION OF POST - EMERGENCE HERBICIDES FOR EFFICIENT WEED CONTROL IN GROUNDNUT (*Arachis hypogaea* L.)

THESIS

Submitted to the
Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola
in partial fulfilment of the requirements
for the Degree of

MASTER OF SCIENCE
IN
AGRICULTURE
(AGRONOMY)

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Enrolment No. JJ/78 **2017**

DECLARATION OF STUDENT

I hereby declare that the experimental work and its interpretation of the thesis entitled "**STUDIES ON TANK MIX APPLICATION OF POST-EMERGENCE HERBICIDES FOR EFFICIENT WEED CONTROL IN GROUNDNUT (*Arachis hypogaea L.*)"** or part thereof has neither been submitted for any other degree or diploma of any University, nor the data have been derived from any thesis or publication of any University or scientific organization. The source of material used and all assistance received during the course of investigation have been duly acknowledged.

Place : Akola **(PAWAR SUNIL BHIMRAO)**

Date : / / 2016 Enrolment No. JJ/78

CERTIFICATE

There is to certify that thesis entitled "**STUDIES ON TANK MIX APPLICATION OF POST-EMERGENCE HERBICIDES FOR EFFICIENT WEED CONTROL IN GROUNDNUT (*Arachis hypogaea 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 **Pawar Sunil Bhimrao** under my guidance and supervision.

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

Dr. P. V. Mahatale
Chairman
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Place : Akola
Date : / / 2017

Countersigned

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Date : / / 2017 Enrolment No. JJ/78

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(D) Abbreviations

%	-	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
DAA	-	Day after application
DAE	-	Days after emergence
DAS	-	Days after sowing
DAT	-	Days after Treatment
dm^2	-	Square decimetre
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 Weeding
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	**: "STUDIES ON TANK MIX APPLICATION OF POST-EMERGENCE HERBICIDES FOR EFFICIENT WEED CONTROL IN GROUNDNUT (*Arachis hypogaea* L.)"**
b) Full name of student	**: Pawar Sunil Bhimrao**
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ABSTRACT

A field investigation entitled **"Studies on tank mix application of post-emergence herbicides for efficient weed control in groundnut (*Arachis hypogaea* L.)"** was carried out at the farm of Oilseed Research Unit, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola during the *Kharif* season of 2016.

The investigation was carried out to study the relative efficacy of herbicides on weed control in groundnut as well as to study its effect on growth and yield of groundnut. The experiment was laid out in randomized block design with ten treatments replicated thrice. The treatments comprised of Pendimethalin @ 1.5 kg ai/ha (PE) + Imazethapyr @ 75 g ai/ha at 20-30 DAS (T_1), Pendimethalin @ 1.5 kg ai/ha (PE) + Quizalofop ethyl @ 50 g ai/ha at 20-30 DAS (T_2), Pendimethalin @ 1.5 kg ai/ha (PE) Imazethapyr (50%) + Quizalofop ethyl (50%) at 20-30 DAS (T_3), Pendimethalin @ 1.5 kg ai/ha (PE) + Imazethapyr (60%) + Quizalofop ethyl (40%) at 20-30 DAS, Pendimethalin @ 1.5 kg ai/ha (PE) + Imazethapyr (40%) + Quizalofop ethyl (60%) at 20-30 DAS (T_5), Imazethapyr (50%) + Quizalofop ethyl (50%) at 20-30 DAS (T_6), Imazethapyr (60%) + Quizalofop ethyl (40%) at 20-30 DAS (T_7), Imazethapyr (40%) + Quizalofop ethyl (60%) at 20-30 DAS (T_8) ,Weedy check (T_9) ,Weed free (T_{10}).

The soil of experimental field characterized as clay loam in texture, having slightly alkaline pH (7.9), moderate organic carbon status (0.40%), low nitrogen content (225.29 kg ha^{-1}), medium available phosphorus content (17.92 kg ha^{-1}), high potassium status (384.62 kg ha^{-1}). Groundnut (TAG-24) was sown on 29th June 2016 at 30 x 10 cm spacing with 25:50:00 NPK kg ha^{-1}. The crop was harvested on 29th October 2016.

In the experimental field, predominant weed flora were *Euphorbia geniculata, Achyranthus aspera, Parthenium hysterophorus, Digera arvensis, Argemone Mexicana, Phyllanthus niruri, Celosia argentia* among the dicot weeds, and *Cynadon dactylon, Ischaemum pilosum, Digitaria sanguinalis, Panicum spp, Commelina benghalensis,* among the monocot. Weedy condition throughout the crop growth period caused 56.97 % reduction in pod yield of groundnut. Among the herbicidal treatments, Pendimethalin @1.5kg ai/ha (PE) + Imazethapyr @ 75g ai/ha at 20-30DAS was found to be effective in controlling weeds across the crop growth period.

Among the various treatments under study Weed free recorded significantly higher values of major parameters where as, in herbicidal treatments, the maximum growth and yield attributes were recorded with treatment Pendimethalin @1.5kg ai/ha (PE) + Imazethapyr @ 75g ai/ha at 20-30DAS followed by Pendimethalin @1.5kg ai/ha (PE) + Quizalofop ethyl @ 50g ai/ha at 20-30DAS.The same treatment recorded better weed control efficiency and lowest weed index. The nutrient uptake by weeds was more in weedy condition. However, total nutrient uptake by crop was observed maximum with application of Pendimethalin @1.5kg ai/ha (PE) + Imazethapyr @ 75g ai/ha at 20-30DAS . Application of Pendimethalin @1.5kg ai/ha (PE)+ Imazethapyr @ 75g ai/ha at 20-30DAS was found most economical with maximum values of GMR (106802 Rs ha^{-1}), NMR (73539 Rs ha^{-1}) and B:C ratio (3.21).

CHAPTER I

INTRODUCTION

1.1 Background Information

Groundnut or peanut is commonly called the poor man's nut. It is an important oilseed and food crop, native to South America and has never been found uncultivated. The botanical name for groundnut, *Arachis hypogaea* Linn. is derived from two Greek words, *Arachis* meaning a legume and *hypogaea* meaning below ground, referring to the formation of pods in the soil. Groundnut is an upright or prostrate annual plant. It is generally distributed in the tropical, sub-tropical and warm temperate zones. Ethnological studies of the major Indian tribes of South America document the widespread culture of groundnut and provide indirect evidence for its domestication long before the Spanish Conquest. When the Spaniards returned to Europe they took groundnuts with them. Later traders were responsible for spreading the groundnut to Asia and Africa where it is now grown between the latitudes 40°N and 40°S (Pattee and Young,1982).

Groundnut (*Arachis hypogaea* L.) is grown in most of countries of the world and plays an important role in world economy. Groundnut is known by several vernaculars as peanut, monkey-nut or goober nut etc. (Reddy, 1988).

The oil content of the groundnut seed varies from 44 to 50 per cent depending on the varieties and agronomic practices. Groundnut oil is edible oil. It finds extensive use as a cooking medium both as refined oil and Vanaspati Ghee. It is also used in soap making, manufacturing cosmetics, lubricants, olein, stearin and their salts. Kernels are also eaten raw, roasted or sweetened. They are rich in protein and vitamins A and B. The cake is utilized for making reconstituted food because of its high protein content. It is also good organic manure and nutritious cattle feed. (Nagraj,1995).

Their calorific value is 349 per 100 g (Anon, 2012a). The residual oil cake contains 7 to 8 per cent of N, 1.5 per cent of P_2O_5 and 1.2 per cent of K_2O and is used as a fertilizer. It is an important protein supplement in cattle and poultry rations. It is also consumed as confectionary product. The cake can be used for manufacturing artificial fiber. The haulms (plant stalks) are fed (green, dried or silage) to livestock. Groundnut shell is used as fuel for manufacturing coarse boards, cork substitutes etc. Groundnut is also of value as rotation crop. Being a legume with root nodules, it can fix atmospheric nitrogen and therefore improve soil fertility. (Anon. 2012b).

There are three types of groundnut plants based on the growth habit given as below (Anon., 2012b).

Spanish (bunch) group

In this group, the plants are grow erect, possess light-green leaves, have round, plump non-dormant seeds, with light-rose testa, small pods, rarely have more than two seeds per pod, produce pods in clusters at the base of the plant, and popularly cultivated type.

Virginia bunch and runner type

In this group, the branches crawl either partially or completely on the surface of the soil, produce large pods all along them, possess dark-green foliage, and have oblong, dormant brownish seeds and late maturing but yield higher than bunch types.

Valencia bunch type

In this type sparse branching habit shown. It possesses dark green foliage and seeds are long or short with seed coats purple, red, and russet or tan. Also many pods may have three to four seeds.

Area and Production

Groundnut is grown on large scale in almost all the tropical and sub-tropical countries of the world (Anon, 2002).

Developing countries account for 96 per cent of the global groundnut area and 92 per cent of the global production. Asia accounts for 58 per cent of the global groundnut area and 67 per cent of the groundnut production with an annual growth rate of 1.28 per cent for area, 2.00 per cent for production and 0.71 per cent for productivity. World peanut production totals 27 million tonnes during 2014-2015, (http:www.agrochart.com/en/) with India being the world's second largest producer after China (Anon.2015a).

In India, groundnut production and productivity has seen wide fluctuations in recent years, mainly due to changing rainfall patterns and stiff competition with other cash crop and availability and preference for cheaper edible oils. During the year 2015-2016, there was a production of 71.80 lakh tonne of groundnut from an area of 44.45 lakh ha with a yield of 1753 ka ha^{-1} (Anonymous 2015 a).In kharif , total area under groundnut crops is 57.28 lakh tons and in summer area under groundnut crop is7.40 lakh ha with production 14.52 lakh tonne. In Maharashtra, this crop is cultivated in *rabi* and *summer* on 3.09 lakh ha with a production of 3.34 lakh tonne (Anonymous.2015 b.)

1.2 Importance and need of study

Groundnut is grown mainly in *kharif* season in India, where in it encounters severe infestation of weed especially during the early stages of growth, because the seedling emerges 7 to 10 days after sowing coupled with the slow growth in the initial stages. The weeds emerge fast and grow rapidly competing with the crop severely for the resources vig. nutrients, light, and space and also transpire lot of valuable conserved water from the soil. On an average the loss of groundnut production in the country due to weeds has been estimated to the tune of 33 per cent (Mani *et.al* 1968) and 70 per cent (Prasad, 2002). Thus, weed control during initial stage is essential to get optimum crop yield.

Weed competition in early stages of crop growth affects the yield potential of the crop. Knowledge about competitive aspects of weeds and the critical stages at which the weeds compete to the

maximum extent with the crop is an important aspect which needs to be understood for effective weed control. The co-existence of weeds with the crop plants cause considerable reduction in yield in crop plants by affecting both the growth and yield components.

Though, physical methods of weed control are very effective, but they have certain limitations such as non-availability of labour during peak period, high labour cost and unfavorable environmental conditions, such as rainfall. Under such conditions, the chemical weed control plays an important role in groundnut and enhances the groundnut yield substantially. Looking to the above facts the experiment was planned to manage the weeds in groundnut with post emergence herbicides. Keeping this in view, the present studies on “Studies on tank mix application of post-emergence herbicides for efficient weed control in Groundnut (*Arachis hypogaea L.*)” was initiated at Oilseed Research Unit farm, Dr. PDKV, Akola during *Kharif* 2016.

1.3 Objectives of study

With changing scenario of weed management farmers need pre and post emergences herbicides and there is an urgent need to evaluate the performances of new herbicides for grassy weeds, sedges and broad leaf weeds control in groundnut. Hence present investigation was conducted to study the “Studies on tank mix application of post-emergence herbicides for efficient weed control in Groundnut (*Arachis hypogaea*)” with the following objectives

1. To study the relative performance of herbicides for control of weeds in Groundnut.
2. To study the effect of herbicides on growth and yield of Groundnut.
3. To study the economics of the treatments.

1.4 Scope and limitations of the study

Success of crop depends largely on effective weed control under weed management strategy, cultivation is effective but cost and

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

1.5 Hypothesis

Improved weed control practices that include chemical weed control with newer formulations and herbicide mixtures. The hypothesis is that weeds can be controlled efficiently and yield maintained at a lower rate of input practice by the better used management strategy.

CHAPTER II

REVIEW OF LITERATURE

In this chapter, an attempt has been made to present a brief review of the important research work done by different workers in past pertaining to the present investigation.

2.1 Crop weed competition

Pannu *et al*. (1989) reported that weed free check depleted 250.85, 36.80 and kg N, P_2O_5 and K_2O ha^{-1} respectively. The nutrient uptake by the crop was higher than that of weeds under weed control treatments. Considering the losses due to weeds, amount of N, P and K required by the crop to produce 100 kg of pods were 8.54, 1.37 and 7.27 kg with hand weeding and 29.56, 4.36 and 30.57 kg with no weeding. Minimum N, P, K uptake by weeds was in hand weeded plot followed by Pendimethalin 1.5 kg ha^{-1} and 0.5 kg ha^{-1} of Fluazifop-p-butyl in groundnut.

Aslam *et al*. (1989) found that the critical period for competition between weed and groundnut crop was 10-30 days after emergence.

Patel *et al.* (1990) reported that weed free check recorded maximum pod yield of 24.9 q ha^{-1}. The pod yield 1910 kg ha^{-1} was obtained when hand weeding was done but unweeded plot recorded the lowest yield of 749 kg ha^{-1} in groundnut. (Geetalakshmi *et al.,* 1990).

Kalaisevaln *et al.* (1991) reported that studies on crop weed competition in groundnut revealed that weed free condition from 15 to 40 DAS is essential for getting maximum yield.

Rajsingh and Patel (1991) revealed that removal of weeds upto 60 days after sowing resulted in the highest groundnut pod yields of 1.42 to 1.46 t ha^{-1} compared to unweeded control. Application of trifluralin at 1.5 kg a.i. ha^{-1} showed excellent control of grass and broad leaved weeds keeping crop free from weeds upto 30 to 40 days.

Mahadkar *et al*. (1993) reported that competition of weeds with the crops was observed to be very high during 50 to 60 days period. This period was found to be critical period for crop weed competition. Competition with the crops was observed to be very high during 30-60 days period. This period was found to be critical period for crop weed competition. Weed competition during the first 30 days period of crop growth in groundnut was found critical under *Kharif* rainfed condition. (Suresh and Nanjappa, 1994).

Staats and Klett (1993) noticed that one application of trifluralin 4 kg a.i. ha^{-1} and 9 kg a.i. ha^{-1} controlled more than 99 per cent of the weeds compared to the unweeded check in groundnut .

Majumdar *et al.* (2009) reported that the weed should be controlled from the 15 days after emergence and it should be controlled up to 50 days after emergence to avoid losses above 5 per cent in groundnut.

2.2 Weed flora in groundnut

Selvamani and Sankaran (1989) found that *Cyperus rotundus* Linn. was dominant (60%) during *Kharif* and *Trianthemaportula castrum* L. was dominant with 55 per cent of total weed population during late *rabi*. The important weed flora of the experimental site included *Echinochlova colonum, Elecusine indica, Brachiaria reptans, Digitaria ciliaris, Dactylocteniuma egyptium, Cyperus iria, Cyperus rotundus, Ageratum conyzoides, Crozophora rottleri and Commelina benghalensis* was observed in groundnut. (Prusty *et al*.1990).

Singh and Bajpai (1991) found *Echinocola spp., Cyperus rotundus, Panicum spp., Xantium strumarium* and *Eclipta alba*as the important weed in groundnut.

Pawar *et al.* (1991) observed the important weeds in groundnut comprised of prominent monocots, annual grasses such as *Dinebra arabica, Eragrotis minor and* a perennial *Cyperus rotundus.* The survey of dicot weeds indicated the dominance of *Acalyphia indica,*

Amaranthus spp., Commelina bengalensis, Euphorbia spp. and *Phyllanthus niruri.*

Mahadkar *et al*. (1993) in a survey on weed flora during rainy season groundnut noticed *Cynodon dactylon Pers*., *Echinochloa colonum* L., *Echinochloa crusgalli* (L.) Beauv., *Amaranthus viridis* L., *Ageratum conyzoides*, *Commelina benghalensis* L., *Celosia argentia*, *Cassia tora*, *Convolvulus arvensis*, *Euphorbia hirta*, *Portulaca oleraceae* L., *Tridax procumbens* L*., Xanthium strumarium* and *Cyperus rotundus* Linn.

Devidayal *et al.* (1994) observed *Cyperus rotundus* L., *Echinochloa colonum* L. Link. *Dactyloctenium aegyptium* Beauv., *Commelina benghalensis* L., *Euphorbia hirta* L., *Phyllanthus niruri* L., *Portulaca oleracea* L. and *Tridax procumbens* L. in groundnut during *Kharif* season. Similar weed flora was also observed by Subramaniyan and Arulmozhi (1998) at Vidyachalam, Tamil Nadu.

Prabhakaran *et al.* (1996) made observation on the weed flora of groundnut fields and reported that, out of 55 weed species 14 were monocots and remaining 41 species were of dicots belonging to 21 families. The weeds associated with groundnut in the experimental field were *Boerhavia diffusa, Trainthema portulacastrum, Eclipta alba, Amaranthus viridis, Parthenium hysterophorus, Gynandropsis pentaphylla, Cyperus rotundus, Panicum repens* and *Dactylocteniuma egyptium.*

Ghosh (2000a) observed eight times higher grasses and four times higher broad leaf weeds than sedges. The main weeds were *Echinochloa crusgalli* (23.4%) *Dactylocteniuma egyptium* (17.8%), *Elecusine indica* (7.4%), *Digitaria filiformis* (5.4%), *Brachiaria* spp. (3.5%), *Ageratum conyzoides* L. (18.2%) and *Cyperus iria* L. (7.5%) in groundnut field.

Attarde *et al*. (2001) reported the major weeds in groundnut like *Cyperus rotundus, Cynodon dactylon* and *Isochaemum pilosum*, *Eragrostis* spp., *Echinochlova crusgalli*, *Parthenium hysterophorus* L. and *Euphorbia* spp. The major weeds in groundnut are *Digitaria sanguinalis* L*.,*

Commelina benghalensis, Cyperusro tundus, Digeria arvensis, Acrachnera cemosa and Mollugo verticillata.

Kasar *et al*. (2009) reported that the prominent weeds observed in the experimenta groundnut field mainly comprised *Euphorbia geniculata, Physalis minima, Digera arvensis, Lagasca mollis, Acalypha indica, Phyllanthus niruri,* among the dicot and *Denebra arabica, Commelina benghalensis, Poa annum, Cyperus rotundus,* and *Cynodon dactylon* among the monocots.

Vaghasia and Nadiyadhara (2013) reported that the various weeds observed in groundnut field during *Kharif* season, were among the narrow leaved weeds the *Echinochloa colonum, Dinebra retroflexa, Dactyloctenium aegyptium* and *Brachiaria* Spp. were more rampant. The broad leaved weeds like, *Commelina benghalensis, Digera arvensis, Indigo feraglandulosa* and *Amaranthus viridis* was marked their presence in good numbers.

Etejere *et al.* (2013) observed that weed species *Brachiaria deflexa, Cleome viscose, Cochlospermum planchoni, Dactylocteniuma egyptium,* and *Daniellia oliveri* were the most abundant in groundnut.

Sing *et al.* (2014) reported that the field was infested with complex weed flora comprising both grassy (69 %) and as well as broad leaf weeds (31%). The grassy weeds viz., *Echinochloa* spp., *Dinebra retroflexa* and *Brachiaria* spp. and broadleaf weeds like, *Indigofera glandulosa, Commelina benghalensis, Phyllanthus niruri, Euphorbia hirta, Digera arvensis* and *Tridax procumbens* were predominant in groundnut.

2.3 Losses caused by weeds

Rajan *et al*. (1985) found the reduction in pod yield was 42.8 per cent due to unchecked weeds. The dry matter production by weed was maximum in no weeding treatment in groundnut.

Dharam Singh *et al.* (1992) found the yield loss due to weed infestation varied from 17-84 per cent in groundnut.

Bhan and Mishra (1993) reported that crop weed competition up to 60 DAS resulted in 40 to 50 per cent reduction in yield of groundnut.

Kori *et al.* (1997) reported that yield loss due to weed infestation amounts to 70 per cent in groundnut.

Sukhadia *et al.* (1998) reported that weeds reduces the yield of groundnut to the tone of 80 per cent among the different constraints.

Kasar *et al.* (2006) reported that the loss of yield in groundnut due to weed is reported in the range of 17 to 96 per cent.

Jat *et al.* (2011) reported that groundnut weed comprise diverse plant species from grasses to broad-leaf weed and sedges, and cause substantial yield losses (15-75%) which are more in rainfed Spanish bunch type than in irrigated Virginia type groundnut.

Priya *et al*. (2013) reported that groundnut weed comprise diverse plant species from grasses to broad-leaf weed and sedges and cause substantial yield losses (15-75%) which are more in bunch type than in Virginia groundnut.

2.4 Methods of weed control

Various methods are used to control weed in groundnut which have their own merits and demerits. The final choice of any weed control method will depend largely on effectiveness and economics of practice.

2.4.1 Cultural method of weed control (weed free)

Murty *et al.* (1994) observed that hand weeding twice at 15 and 30 DAS plus three intercultural at 15, 30 and 45 DAS gave highest pod yield followed by fluchloralin 1.0 kg ha^{-1} plus three intercultivation at 15, 30 and 45 DAS in groundnut.

Singh *et al*. (1997) at Pantanagar reported that two hand weeding plus hoeing gave maximum pod yield of groundnut (2472 kg ha^{-1} in 1993 and 2619 kg ha^{-1} in 1994) followed by halloxytop methyl (0.75 kg ha^{-1} and Alachlor 3.0 kg ha^{-1} in 1994).

Patel *et al.* (1997) reported that interculture with hand weeding at 30 days followed by hand weeding at 50 days after sowing recorded maximum weed control efficiency in groundnut.

Sukhadia *et al*. (1998) conducted the field experiment at Junagadh and reported that treatment with intercultivation and hand weeding at 20 and 40 days after sowing recorded lower dry weight of weeds, higher weed control efficiency, lower weed persistence index and higher crop resistance index. This treatment also gave the highest pod yield (1066 kg ha^{-1}) and haulm yield (2247 kg ha^{-1}) yield of spreading groundnut.

Kori *et al*. (2000) at Dharwad noticed that hand weeding at 70 DAS + Intercultivation at 30 and 45 Days after sowing shown significantly higher pod yield (19.35 q ha^{-1}) over Trifluralin @ 0.5 a.i ha^{-1} + Intercultivation at 30 DAS (14.96 q ha^{-1}). Hand weeding twice (20 and 40 DAS) shown higher pod yield (25.3 q ha^{-1}) compared to trifluralin @ 720 g per ha (23.8 q ha^{-1}).

Kumar (2008) at Madhurai reported that higher pod yield (2.18 t ha^{-1}) and kernel yield (1.71 t ha^{-1}) were recorded by maintaining 3.3 lakh plants ha^{-1} (Datta *et al*. 2001).

Kasar *et al.* (2006) observed that the cultural method not only reduces weed population but also recorded higher pod and haulm yield of *rabi* groundnut.

Kasar *et al.* (2009) reported that at harvest cultural method of weed control i.e. weed free check as well as two hoeing and two hand weeding at 20 and 40 DAS reduced weed population and weed dry matter significantly in groundnut field.

Patro *et al.* (2014) reported that weed free check (two hand weeding at 20 and 40 DAS and manually uprooting of weeds at 60 DAS) was found more effective to control weeds in groundnut and recorded lowest weed density, weed dry matter , weed index and highest weed control efficiency.

2.4.2 Chemical method of weed control

When labour is scarce and expensive the use of herbicides holds good promise from the point of less cost and efficient weed control from the sowing itself. Most weeds emerge before crop and that necessitates the use of pre-emergence and post-emergence herbicides.

2.4.2.1 Pre-emergence application

2.4.2.1.1 Pendimethalin

Kondap *et al*. (1989) found that application of pendimethalin @ 1.5 kg a.i ha^{-1} showed equal performance in pod yield (16.51 q ha^{-1}) with hand weeding at 15 and 35 days after sowing (18.4 q ha^{-1}) and was found better in controlling grassy weeds in groundnut. Application of Alachlor at 1.5 kg a.i. ha^{-1} with one hand weeding recorded the highest pod yield (30.21 q ha^{-1}) followed by Alachlor at 1.5 kg a.i. ha^{-1} with hoeing (30.01 q ha^{-1}). (Sudhakar and Muniappa. 1990).

Girijesh *et al*. (1991) reported that pendimethalin @ 0.5 and 0.75 kg a.i. ha^{-1} also resulted in significantly reduction weed population and their dry matters in groundnut.

Itnal *et al*. (1993) reported that pre-emergence application of Pendimethalin or Alachlor 1 kg ha^{-1} followed by one hand weeding at 30 DAS were found most effective not only in control of weeds but also in obtaining higher yield of groundnut as compared to other treatments expect weed free check.

Hiremath *et al*. (1997) found that pre-emergence application of Pendimethalin @ 1.5 kg a.i. ha^{-1} and Oxyfluorfen @ 0.2 kg a.i. ha^{-1} effectively checked both C_3 and C_4 weeds there by exhibiting the highest weed control efficiency and recorded the lowest weed index thus improving the pod yields in groundnut.

Singh *et al*. (1997) reported that the pre-emergence application of Alachlor @ 3.0 kg ha^{-1} and Halloxyfop methyl @ 0.75 kg ha^{-1} proved significantly superior to that of Alachlor @ 2.5 kg ha^{-1}.

Pendimethalin @ 1.0 kg ha^{-1} and Halloxyfop methyl @ 1.0 kg ha^{-1} among herbicides in reducing the dry matter accumulation of weeds at all the stages of growth and the same was observed for pod yield of groundnut.

Subramaniyan and Arulmozhi (1998) reported that among the different pre-emergence herbicide, application of Metolachlor @ 1.0 kg a.i ha^{-1} significantly produced maximum dry pod yield (2280 kg ha^{-1}) over Pendimethalin (2126 kg ha^{-1}) and Oxadiazon (2087 kg ha^{-1}).

Sumathi *et al*. (2000) reported that application of Pendimethalin 0.75 kg a.i. ha^{-1} applied at pre-emergence + 1 hand-weeding at 30 days after sowing had a pronounced effect on control of weeds, reduced the weed dry matter and led to higher yield attributes, pod yield, weed control efficiency, lower benefit : cost ratio, higher weed Index and all these parameters were comparable to that of hand-weeding twice at 20 and 40 days after sowing.

Ghosh (2000b) reported that use of Pendimethalin, Butachlor, thiobencarb each at 1.5 kg ha^{-1} and one hand weeding at 20 DAS also caused significant yield improvement in groundnut over weedy check.

Kumar *et al.* (2013) found that pre-emergence application of Pendimethalin @1kg a.i. ha^{-1} + 1 hand weeding + post emergence application of Imazethapyr @ 50 g a.i. ha^{-1} at 20 days after sowing produced higher pod yield (4147 kg ha^{-1}) than other treatments in groundnut.

Gunry *et al.* (2014) reported that the herbicidal treatments maximum gross return (Rs.80550), net return (Rs.55937) and B:C ratio (3.27) were recorded in the treatment received pre-emergence application of Pendimethalin at 1.0 Kg a.i. ha^{-1} along with one hand weeding.

Kalaichelvi *et al*. (2015) reported that number of pods per plant and seed pod yield of groundnut was significantly higher with pre-emergence application of Pendimethalin at 0.75 kg ha^{-1}.

2.4.2.2 Post-emergence application

2.4.2.2.1 Imazethapyr

John *et al*. (1991) reported that application of Imazethapyr as pre or post-emergence herbicide at 3, 5 or 7 weeks after the crop emergence at 0.071 kg ha^{-1} controlled common lambs quarters 85 %, prickly sida 92 % and tall morning glory species 77 %. The highest weed control efficiency (97.3 %) was observed under post emergent application of 2, 4-D at 0.75 kg a.i. ha^{-1} (Raj singh and Patel, 1991) in groundnut.

James (1997) reported that application of Imazethapyr at rates of 0.05 to 0.07 kg ha^{-1} controlled >90 % *Palmer amaranth* in 2 or 3 year. Acifluorfen alone or in combination with Bentazon or 2,4-D and Lactose alone controlled 90 % *Palmer amaranth* in 2 of 3 years. Bentazon or Pyridate failed to provide good control < 60 %, while 2,4-D provided good control (80 %) in only 1 of 3 years in groundnut.

Kalpana and Velayutham (2004) reported that application of Imazethapyr at 100 g a.i ha^{-1} as post-emergence plus two hand weeding at 30 and 40 DAS recorded significantly higher weed control efficiency and grain yield (1318 kg ha^{-1}) in soybean.

Sasikala et al. (2004) observed that pre-emergence application of Pendimethalin fb Imazethapyr gave higher weed control efficiency in groundnut.

Kushwah and Vyas (2005) reported that application of Imazethapyr 10 % SL @ 75 g ha^{-1} was found most effective in reducing weed biomass and resulting higher weed control efficiency over other pre and post emergence herbicides. Quizalofop ethyl 5 EC @ 50 g ha^{-1} was also found effective with fairly low weed shoot biomass during both the years and controlled particularly the monocot weeds effectively in groundnut.

Kushwah and Vyas (2006) reported that post-emergence application of Imazethapyr in groundnut at 75 g a.i. ha^{-1} reduced the

population of *Caseulia axillaris*, *Anotis monthulani*and *Acalyph aindica* significantly as compared to all pre and rest of the post-emergence herbicides under investigation. Quizalofop-ethyl 5 EC at 50 g ha^{-1} was significantly effective against *Commelina benghalensis* and *Echinochloa colona*.

Dixit (2006) reported that post emergence application of Imazethapyr 10% SL @ 75 g ha^{-1} was found suitable to control weeds in groundnut crop.

Dubey *et al*. (2010) reported that combined application of Imazethapyr at lower rate 100 g ha^{-1} with Chlorimuron 24 g ha^{-1} paralyzed the weed growth identically (98.1%) to that of hand weeding twice (98.6%) and attained the superior values of yield attributes (13.5 pods/plant, 2.4 kernels/pod) as well as higher pod and haulm yields (12.83 and 21.21 q ha^{-1}).

Malunjkar *et al.* (2012) reported that pre-emergence application of Pendimethalin 1.0 kg ha^{-1} + post-emergence application of Imazethapyr 75 g ha^{-1} at 20 DAS recorded maximum weed control efficiency (74%), minimum weed population (42.67 m^2) and weed day matter (185 gm m^2). The same treatment combination recorded significantly higher dry pod yield (1997 kg ha^{-1}), gross returns (Rs. 46445 ha^{-1}) net returns (Rs. 28705 ha^{-1}) and B: C ratio 2.44.

Kumar *et al.* (2013) reported that highest weed control efficiency (88.25%) was recorded with Pendimethalin + one hand weeding at 45 DAS + Imazethapyr @ 50 g a.i. ha^{-1} at 20 DAS in groundnut.

Sudharshana *et al.* (2013) observed that highest pod yield was recorded in Imazethapyr at recommended dose where seed inoculation was done compared to Imazethapyr double dose in groundnut.

Singh *et al.* (2014) reported that combined application of Imazethapyr at lower rate 100 g a.i. ha^{-1} with Chlorimuron 24 g a.i. ha^{-1} paralyzed the weed growth significantly (98.12%) to that of hand weeding twice (98.62%) and attained the superior values of yield attributes

(pods/plant 13.51) as well as higher pod and haulm yields (12.83 and 21.22 q ha^{-1}) over rest of the treatments.

Kar *et al.* (2015) reported that the maximum suppression of targeted weed density vis-a-vis weed biomass was obtained with the (Imazethapyr 10% SL @ 150 g a.i. ha^{-1}). It showed delayed maturity due to bit phytotoxicity on groundnut.

2.4.2.2.2 Quizalofop ethyl

Chaitanya *et al*. (2012) reported that the pre-emergence application of Pendimethalin @ 1.0 kg a.i. ha^{-1} along with post-emergence application of Quizalofop ethyl @ 50 g a.i. ha^{-1} at 25 DAS recorded a lower weed growth and higher yield of *kharif* groundnut compared to farmers practice and other weed management practices and was economically more viable.

Dixit *et al.* (2012) reported that post-emergence application of Quizalofop ethyl herbicide @ 1000 ml ha^{-1} at 20 DAS was found suitable, safe, effective and economic to control grassy monocot weeds in groundnut crop and it did not show any symptoms of phytotoxic effect on follow up *rabi* crops i.e. wheat, gram and mustard**.**

Chaitanya *et al.* (2013) revealed that the pre-emergence application of Pendimethalin @ 1.0 kg a.i ha^{-1} along with post-emergence application of Quizalofop ethyl @ 0.75 kg ha^{-1} at 25 DAS recorded a higher growth and yield of groundnut.

Samat and Mishra (2014) reported that the maximum dry weed biomass at harvest was 250.3 g m^{-2} in weedy check followed by Quizalofop ethyl @ 0.75 kg ha^{-1} at 25 DAS. The weed control efficiency was highest (72.3 %) in application of Quizalofop ethyl @ 1.0 kg ha^{-1} with one hand weeding , which gave maximum benefit : cost ratio of 2.49 and net return of Rs.53067 ha^{-1} with additional income of Rs.36534 ha^{-1} over weedy check in groundnut.

2.4.2.3 Integrated weed control method

Integrated weed management in which all suitable technique including the use of herbicides in a compatible manner to reduce weed population and maintain at lower than economic injury level. The pre-emergence herbicides would suppress the weeds only for a limited period. Due to dissipation of applied herbicides, the new flushes of weeds which emerge at later stages are not controlled. To attain weed control at critical stage of crop growth, the integration of post emergence herbicides and mechanical methods hold a great promise.

Gnanmurthy and Balasubramaniyan (1998) observed the highest pod yield of groundnut (23.54 q ha^{-1}) with application of Metolachlor + hand weeding at 30 DAS which was 45.3 per cent higher as compared to unweeded control.

Malligawad *et al*. (2000) reported that herbicide application followed by intercultivation at 30 and 45 DAS. Hand weeding at 30 DAS resulted in 6.98 to 9.67 per cent higher dry pod yield over herbicide application only and 3.94 to 6.01 per cent higher pod yield over herbicide application in addition to inter cultivation in groundnut.

Kori *et al*. (2000) reported that weed free check recorded the highest pod yield (28.55 q ha^{-1}) and was on par with Trifluralin @ 1.5 kg ha^{-1} + Intercultivation at 30 and 45 DAS (23.63 q ha^{-1}) whereas significantly lower pod yield of 9.91 q ha^{-1} was recorded in unweeded control.

Patra and Nayak (2001) from Bhubaneswar reported that integrated weed control practice of pre-emergent application of Alachlor @ 2 kg a.i ha^{-1} at 1 day after sowing, followed by post emergent application of Fluchloralin @ 1 kg a.i ha^{-1} one day after interculture recorded higher weed control efficiency (87.9 %). Pre-emergence application of Metolachlor @ 1.0 kg ha^{-1} + 1 hand weeding on 30 DAS significantly improved the pod equivalent and the land equivalent ratio. (Manickam *et al.* 2001)

Walia *et al*. (2007) reported that integration of hand weeding with pre-plant application of Fluchloralin 0.675 kg and Trifluralin 0.75 kg as well as pre-emergence application of Pendimethalin 0.75 kg ha^{-1} increased pod yield by 39.1, 43.0, 54.6, 54.5, 55.9 % than unweeded control and 14.7, 17.9, 27.5, 27.4 % than alone application of Fluchloralin 0.675 kg ha^{-1}.

Kalhapure *et al*. (2013) reported that significantly highest growth and yield attributes in groundnut over all the other treatments *viz*. plant height, dry matter weight of plant, number of pods/plant and pod yield/hectare. Though highest gross monetary returns (1,09,845^{-1}ha) was recorded in treatment weed free check, maximum net monetary returns (61,460 ha^{-1}) and B:C ratio (2.42) were recorded in the treatment application of Pendimethalin 1.5 kg ha^{-1} as pre-emergence + Imazethapyr 0.150 kg ha^{-1} as post-emergence + one hand weeding at 40 DAS which was found most economically feasible weed management practice for groundnut.

Patel *et al*. (2013) reported that two hand weeding (HW) + 2 inter cultivations (IC) at 20 and 40 DAS and Pendimethalin 1 kg ha^{-1} were found more effective in reducing weed population, dry weight of weeds and weed index with higher weed control efficiency in groundnut.

Sharma *et al*. (2015) reported that Pendimethalin @ 0.9 kg ha^{-1} as pre-emergence (PE) + Imazethapyr @ 75 g ha^{-1} as post-emergence (PoE) herbicides 20 days after sowing (DAS) resulted in significantly higher growth attributes, yield attributes, quality parameters, and net returns over the unweeded control, was found at par with hand-weeding and inter-culturing at 20 and 40 DAS, and Pendimethalin @ 0.9 kg ha^{-1} as pre-emergence + hand-weeding and inter-culturing at 40 DAS. However,

significantly highest NPK in soil after crop harvest was recorded with Oxadiargyl @ 90 g ha^{-1} asPoE at 20 DAS + hand-weeding and inter-culturing at 40 DAS.

2.5 Effect of weed management on nutrient uptake and nodulation

Kori *et al*. (1997) higher nutrient uptake by crop and lower by weed was noticed in integrated weed management practices than the cultural methods. Where as in unweeded control reverse trend was observed in groundnut.

Chaudhari *et al*. (2007) revealed that the weed free condition throughout the crop growth period in groundnut (*Arachis hypogaea* L.) drastically reduced with dry matter, N, P and K uptake by weeds and increased the pod yield, N, P and K uptake by groundnut crop.

Vashist *et al*. (2008) reported that significantly the highest uptake of N, P and K was recorded with hand weeding at 20 and 40 DAS and increase in the number of nodules per plant in groundnut.

Dubey M. (2013) reported that the application of Imazamox 100 g ha^{-1} with adjuvant 1000 ml ha^{-1} as early post-emergence significantly increase in the number of nodules per plant and effective nodules per plant in soybean.

Kumbar *et al*. (2014) reported that herbicide treatments recorded the significantly higher nutrient uptake in groundnut as compared to unweeded control whereas, unweeded control lowered the nutrient uptake of groundnut by 44% as compared to hand weeding.

2.6 Economics of weed control

Girijesh and Patil (1991) reported that application of Pendimethalin @ 0.75 kg a.i. ha^{-1} as pre-emergence spray supplemented with interculture at 21 DAS was found to be very effective and economical in controlling weeds.

Raj singh and Patel (1991) found that pre-emergence application of Alachlor at 1.5 kg a.i ha^{-1} resulted in the highest net returns (Rs.6, 266 ha^{-1}).

Mahale *et al.* (1992) observed that integrated weed control using either Butachlor at 2.0 kg a.i ha^{-1} or Paraquat at 1.0 kg a.i ha^{-1} supplemented with one hand weeding recorded as Rs. 3710 ha^{-1} and Rs. 3464 ha^{-1} respectively as additional net profit.

Reddy and Padmalatha (1994) reported that the maximum net returns of Rs. 11701 ha^{-1} was obtained with Pendimethalin at 1.0 kg a.i ha^{-1} + hand weeding at 30 DAS in 1990, compared to control (Rs.9245 ha^{-1}).

Guggari *et al.* (1995) reported that pre-emergence application of Butachlor @ 0.75 kg a.i. ha^{-1} fallowed by one hand weeding and intercultivation at 35 DAS recorded significantly higher B:C ratio (1.75).

Prabhakaran *et al.* (1996) reported that pre-emergence application of Pendimethalin @ 1.0 kg ha^{-1} with two Intercultivation at 30 and 40 DAS results in the maximum net returns (Rs. 10013 ha^{-1}).

Kathmale *et al.* (1997) recorded the maximum net returns due to application of Butachlor + One hand weeding + one intercultivation (Rs. 6556 ha^{-1}) and it was closely followed by Thyobencarb + one hand weeding + one intercultivation (Rs. 6513 ha^{-1}) and the lowest was recorded in unweeded control (Rs. 2269 ha^{-1}).

Malligawad *et al.* (2000) recorded the maximum net returns of Rs. 25,303 ha^{-1} from Pendimethalin @ 1 kg a.i ha^{-1} + Intercultivation at 30 and 45 DAS, one hand weeding at 30 DAS and BC ratio of 2.52 over unweeded check of Rs. 7525 ha^{-1} and 1.57 respectively.

Nandurkar *et al.* (2000) the lowest weed biomass higher pod yield (19.27 q^{-1}) and net returns (Rs. 21667.5 ha^{-1}) were recorded due to pre emergence application of stomp @ 7.0 ml/l of water plus post-

emergence of 2,4-D @ 4.0 g/l of water plus two hoeing given at 20 and 40 DAS.

Patra and Nayak (2001) found that the maximum cost benefit ratio was found with pre-emergence application of Fluchloralin @ 1.0 kg a.i. ha^{-1} or Pendimethalin @ 1.0 kg a.i. ha^{-1} or Pendimethalin @ 1.0 kg a.i. ha^{-1} or Alachlor @ 2.0 kg a.i. ha^{-1}, followed by post-emergent application of Fluchloralin @ 1.0 kg a.i. ha^{-1} at one day after interculture (1.77) was found promising. Pre-emergence application of Pendimethalin @ 0.75 kg a.i. ha^{-1} supplemented with hoeing at 25 DAS was found cheaper and most effective in controlling weeds. (Bhondave *et al. (*2009) also reported similar result).

Kambale *et al.* (2003) the pre-emergence application of pendimethalin @ 0.75 kg a.i. plus one hand weeding (15 DAS) plus one hoeing (30 DAS) gave highest B:C ratio.

Sardana and Sheoran (2009) reported that Metolachlor (pre-emergence) @ 1.5 lit ha^{-1} + One hand weeding at 30 DAS or Fluchloralin @ 0.75 lit ha^{-1} were most effective and economic for weeds management in groundnut.

Agasimani *et al.* (2010) reported that pre-emergence application of Butachlor (2353 kg ha^{-1}) or Pretilachlor (2287 kg ha^{-1}) or Alachlor (2187 kg ha^{-1}) @ 1.5 kg ha^{-1} coupled with two intercultivation at 30 and 40 DAS + one hand weeding at 45 DAS gave significantly superior pod yield and Net monetary returns as against weedy check (1300 kg ha^{-1}).

Mishra *et al. (*2013) reported that application of Odyssey recorded higher value of yield attributes (pods/plant, seeds/pod, seed index), grain and straw yields and gross return net return and B:C ratio in soybean.

Vaghasia and Nadiyadhara (2013) found that Application of new formulation of Odyssey 70 % WG at 70 g ha^{-1} + MSO adjuvant @ 2ml/litre of water as early post emergence herbicide increased the pod

yield, haulm yield and kernel yield (1411,2783 and 1010 kg ha^{-1}, respectively) and this was at par with early post emergence application of Imazethapyr 10% SL @ 100 g ha^{-1} + MSO adjuvant @ 2.0 ml/litre of water and Quizolofop ethyl 5% EC 50 g ha^{-1} in groundnut.

Kumbar *et al*. (2014) reported that the net return and B: C ratio were higher in Fluazifopp-butyl 167 g a.i. ha^{-1} (Rs. 37,350 and Rs. 1.25) than hand weeding (Rs. 33,010 and Rs. 0.99). For management of weeds in groundnut, the new post-emergence herbicides namely Fluazifop-p-butyl 13.4 EC at 134 g a.i. ha^{-1}, Quizalofop-p-ethyl 5 EC at 50 g a.i. ha^{-1} (both graminicide at 20 DAS for control of grasses) and Imazethapyr 10 SL at 100 g a.i. ha^{-1} (20 DAS, for broad spectrum weed control) appeared good from the point of yield and economics.

Dixit *et al*. (2016) reported that application of pre-emergence Pendimethalin 1 kg a.i. ha^{-1} + post emergence application of Imazethapyr @ 75 g a.i. ha^{-1} (750 ml ha^{-1}) at 20 DAS gave comparable pod yield (1207 kg ha^{-1}) and maximum net return on invested rupee (B.C. ratio 2.2) in groundnut.

CHAPTER III

MATERIAL AND METHODS

This chapter deals with the details of materials used during the course of investigation and methods adopted in conducting the present investigation entitled “Studies on tank mix application of post-emergence herbicides for efficient weed control in Groundnut (*Arachis hypogaea*)”.

3.1 Experimental site

The field experiment was conducted during *Kharif* season of the year 2016-2017 in the field at the Farm of Oilseed Research Unit, 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 (%)	24	Bouycous hydrometer method (Piper,1966)
2)	Silt (%)	32	
3)	Clay (%)	44	
4)	Textural class	Clayey	
II	**Chemical composition**		
1)	Available Nitrogen (kg ha^{-1})	225.29	Alkaline permanganate method (Asija and Subhiah, 1956)
2)	Available Phosphorus (kg ha^{-1})	17.92	Olsen’s method (Jackson, 1967)
3)	Available Potassium (kg ha^{-1})	384.62	Walkely photometer (Jackson, 1967)
4)	Organic carbon (%)	0.40	Walkely and Blacks rapid titration method (Jackson, 1967)
5)	Ph	7.9	pH meter (Jackson, 1967)
6)	EC(dsm^{-1})	0.36	Electric conductivity bridge (Jackson, 1967)

The composite soil samples from 0-30 cm soil layer were 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 physico-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 five 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	2013-2014	Fallow	Safflower	Fallow
2	2014-2015	Sunflower	-	Groundnut
3	2015-2016	Sunflower	Safflower	Fallow

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 18.59^{0}C and 34.75^{0}C, respectively. The humidity ranges from 30.75 per cent and 61.62 percent in summer and rainy season, respectively. Akola, thus has hot dry summer and moderately cold winter. The hailstorms are not common in this area. 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 2016-2017 under study has been furnished in Table.3 and graphically showed in Fig.1 (a, b, c, d).

Table 3: Weekly Weather data for the year 2016 recorded at Meteorological Observatory Department of Agronomy Dr. PDKV., Akola

Actual - 2016-2017 Normal – 1971-2010

Weeks	Dates	Actual 2016								Normal						1971-2010			
		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
26	25-1Jul	34.1	32.8	24.2	24.6	5.3	3.5	13.4	8.3	80	80	55	58	7.3	5.5	38.2	49.9	167.4	2.3	2.0
27	2-8	33.5	30.7	24.4	24.8	5.2	1.1	12.9	10.0	81	86	58	70	6.8	4.7	34.7	53.1	220.5	2.4	3.0
28	9-15	32.3	28.1	23.7	23.6	3.8	2.3	12.0	11.6	84	90	62	73	5.5	3.9	52.2	212.8	433.3	2.8	6.0
29	16-22	32.0	31.5	23.9	24.9	3.3	4.7	11.2	7.3	84	83	65	62	5.6	4.3	58.6	5.7	439.0	2.6	1.0
30	23-29	31.7	29.8	23.3	23.6	4.3	2.5	11.9	4.7	85	91	64	72	5.3	3.8	44.2	104.5	543.5	2.6	6.0
31	30-5 Aug	31.1	29.4	23.1	23.9	3.6	2.3	11.7	7.5	88	86	66	71	4.6	4.0	49.3	65.3	608.8	2.5	4.0
32	6-12	30.2	30.4	22.9	24.0	3.5	3.6	11.6	6.6	87	84	69	66	4.2	4.0	59.9	10.5	619.3	2.9	2.0
33	13-19	30.5	31.0	22.8	23.4	4.4	5.3	11.7	11.5	86	85	66	58	4.5	5.6	40.6	0.0	619.3	2.2	0.0
34	20-26	30.5	30.0	22.6	23.4	4.3	5.8	11.0	4.1	88	83	66	64	4.3	4.0	46.7	13.7	633.0	2.0	2.0
35	27-2 Sep	30.4	31.9	22.7	24.5	4.4	4.5	10.6	4.5	86	85	64	62	4.2	3.9	47.1	6.5	639.5	2.4	1.0
36	3-9	31.1	31.3	22.5	22.6	5.7	8.5	9.1	8.4	85	85	61	47	4.7	6.2	28.5	1.5	641.0	1.5	0.0
37	10-16	32.2	31.8	22.4	23.6	7.1	3.4	9.0	5.5	85	86	56	59	5.1	4.2	18.9	28.5	669.5	1.1	3.0
38	17-23	33.4	30.9	22.3	23.3	7.2	4.3	8.5	2.8	83	94	53	70	5.3	3.4	24.6	62.9	732.4	1.4	3.0
39	24-30	33.7	30.8	21.9	23.0	7.6	6.0	5.4	4.9	83	92	50	71	4.9	4.4	24.4	30.3	762.7	1.5	1.0
40	1-7 Oct	33.9	29.1	20.2	22.8	8.1	4.6	7.5	1.8	81	92.1	45	73	5.5	3.2	21.8	61.5	824.2	1.1	4.0
41	8-14	34.1	31.2	18.7	21.3	4.2	7.6	4.1	3.0	76	89.9	40	59	5.3	4.1	16.0	29.0	853.2	0.9	1.0
42	15-21	33.9	32.9	18.1	16.5	8.4	8.9	4.4	0.4	74	80.4	36	28.9	5.5	4.4	3.1	0.0	853.2	0.4	0.0
43	22-28	33.1	32.4	18.5	15.8	8.4	8.4	4.1	0.9	73	80.4	36	33.7	5.3	4.7	10.0	0.0	853.2	0.6	0.0
44	29-4 Nov	33.0	31.4	15.8	14.3	8.7	8.7	4.7	0.4	72	80.9	31	34.1	5.3	4.4	2.3	0.0	853.2	0.3	0.0

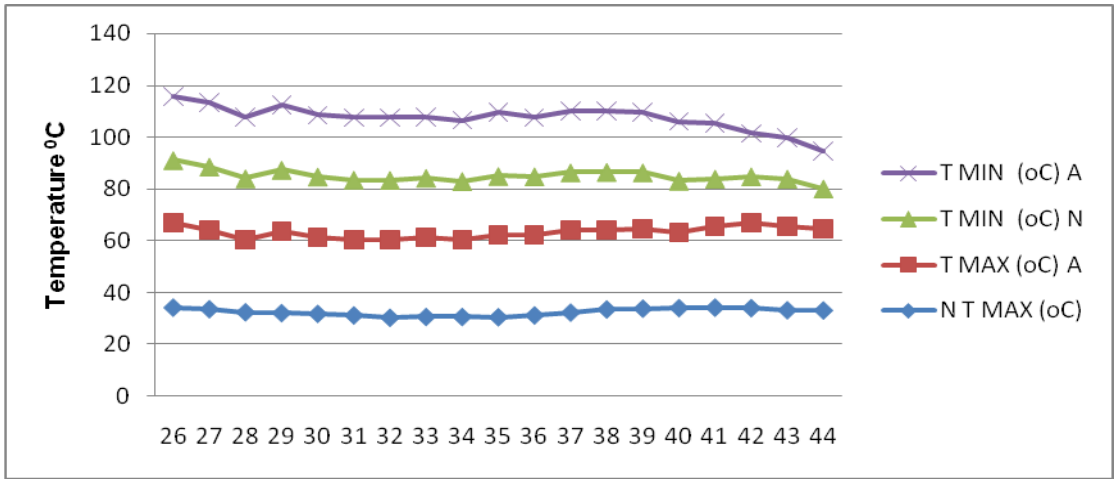


Fig. 1(a). Weekaly weather data of temperature

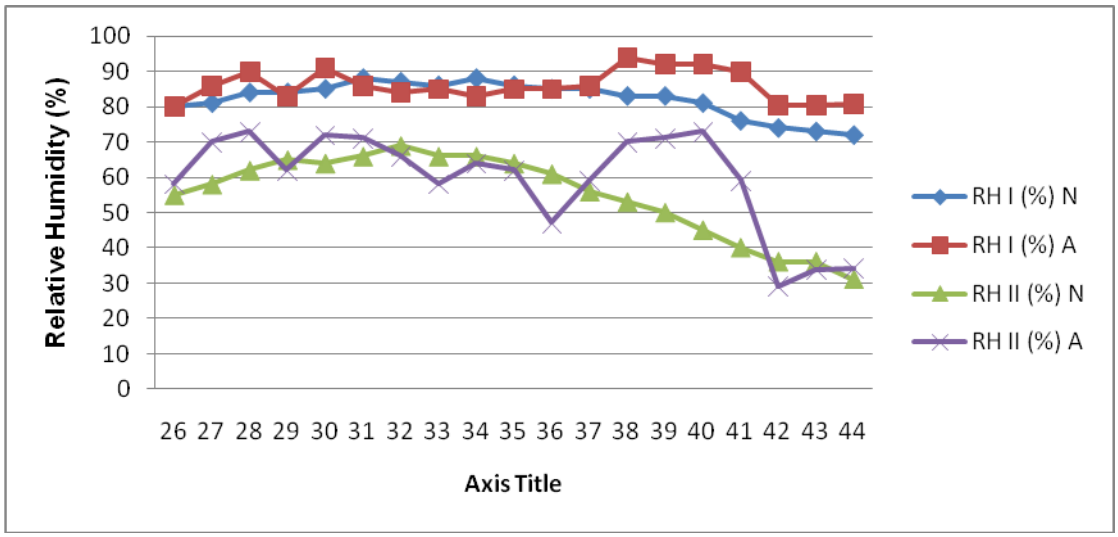


Fig. 1(b). Weekaly weather data of relative humidity

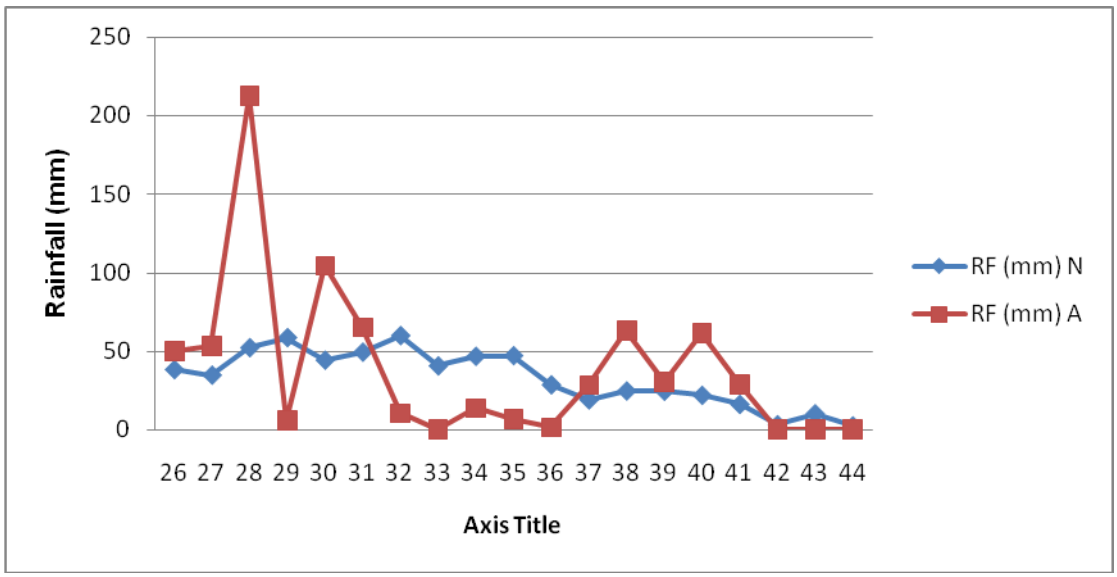


Fig. 1(c). Weekaly weather data of rainfall

Experimental details

3.4.1 Design and treatments

The present experiment was laid out in Randomized Block Design (RBD) with ten treatments replicated three times. Allocation of treatment at each plot in each replication was done by randomization. The treatments were allotted to different plots are shown in Fig. 2.

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

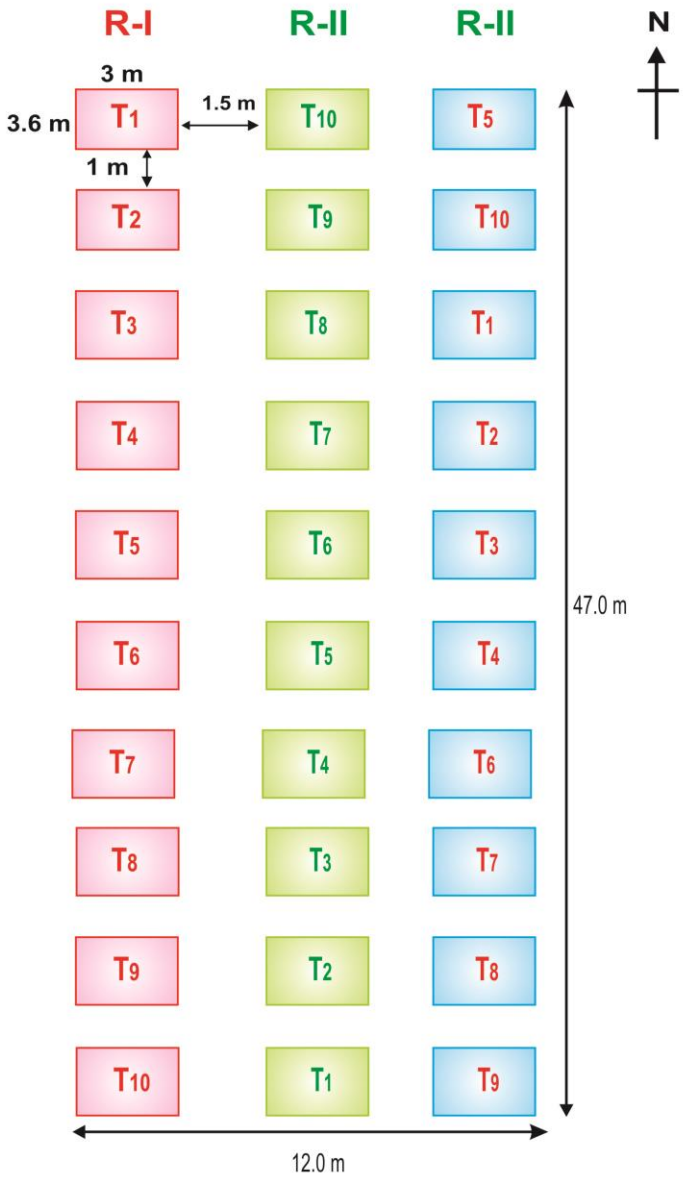
Table 4: The details of different treatments

Abbreviation	Treatment
T_1	Pendimethalin@1.5kg ai/ha(PE)+Imazethpyr@75g ai/ha at 20-30 DAS
T_2	Pendimethalin @1.5kg ai/ha(PE)+Quizalofop ethyl @50g ai/ha at 20-30 DAS
T_3	Pendimethalin@1.5kgai/ha(PE)+Imazethpyr(50%)+Quizalofop ethly (50%) at 20-30 DAS
T_4	Pendimethalin@1.5kgai/ha(PE)+Imazethpyr(60%)+Quizalofop ethyl (40%) at 20-30DAS
T_5	Pendimethalin@1.5kgai/ha(PE)+Imazethpyr(40%)+Quizalofop ethyl (60%) at 20-30DAS
T_6	Imazethpyr(50%)+Quizalofop ethyl (50%) at 20-30DAS
T_7	Imazethpyr(60%)+Quizalofop ethyl (40%) at 20-30DAS
T_8	Imazethpyr(40%)+Quizalofop ethyl (60%) at 20-30DAS
T_9	Weedy check.
T_{10}	Weed free.

PE : Pre- emergence, PoE : Post emergence.

3.4.2 Other experimental details

1. Gross plot size : 3.60 x 3.00 m^2
2. Net plot size : 3.00 x 2.80 m^2
3. Spacing : 30 cm x 10 cm
4. Crop and variety : Groundnut, TAG-24
5. Seed rate : 100-125 kg ha^{-1}
6. Number of plots : 30
7. Season : *Kharif* 2016-17.
8. Date of sowing : 29thJune, 2016



Design : Randomized block design (RBD)
Treatments : (10)
Replication : (3)

Fig. 2. Plan of layout

Plate1. General view of Experimental Plot

9. Method of sowing : Dibbling
10. Date of Harvesting : 29th Oct, 2016
11. Experimental design : Randomized Block Design (RBD)
12. Fertilizer dose : 25:50:00 NPK Kg ha^{-1}

The field was ploughed with the help of tractor drawn soil turning plough after *rabi* crop was harvested. It was followed by two harrowing with bullock drawn blade harrow, to break the clods and to attain a fine soil tilth. The stubbles were picked up and collected. The field was thus kept ready for sowing.

3.4 Cultural Operations

A chronological sequence of the various cultural operations carried out in the experimental plot during the growing season of the crop is presented in Table 5.

3.4.1 Intercultural operation

Hoeing with 15 cm blade hoe was done twice followed by two hand weeding for control of weeds and to keep the soil loose. Earthing up operation was done immediately after second hoeing with the help of manual labour.

3.4.2 Fertilizer application

The nitrogen, phosphorus and potassium @ 25:50:00 kg ha^{-1} was applied through urea (46%N) and single super phosphate (16%P_2O_5). The entire dose of fertilizer was applied at time of sowing.

3.4.3 Seed

Groundnut variety TAG-24 was used for sowing and its maturity period is 100 to 110 days.

3.4.4 Seed treatment

Seed of groundnut was treated with Thirum 3 g kg^{-1} seed and Rhizobium culture @ 250 g per 10 kg seed just before sowing.

3.4.5 Sowing

Sowing of seed was done on 29thJune 2016 by dibling method at an optimum soil moisture level. The row to row distance of 30 cm and plant to plant distance of 10 cm was maintained.

3.4.6 Application of Herbicide

The herbicide pendimethalin was applied over the treatment plot within 24 hours after sowing as pre-emergence herbicide and other mix herbicide, Imazethapyr and Quizalofopethyl were applied 25 DAS in standing crop as post emergence herbicide

Table 5. cultural operation undertaken in the experimental plot

Sr. no	Field operations	frequency	Date of operation
A.	**Preparatory tillage**		
1	Tractor cultivation	1	21-05-2016
2	Harrowing	1	06-06-2016
3	Stubble collection	1	16-06-2016
4	FYM application	1	07-06-2016
5	Leveling and layout	1	18-06-2016
B.	**Cultural operation**		
1	Marking	1	29-06-2016
2	Sowing	1	29-06-2016
3	Pre-emergence application of pendimethalin of treatment(T_1,T_2,T_3,T_4,T_5)		30-06-2016
4	Fertilizer application	1	29-06-2016
5	Gap filling	1	10-07-2016
6	Weeding (weed free plot)	2	15-07-2016
7	Earthling up (weed free plot)	1	05-08-2016
8	Irrigation	2	20-07-2016, 07-08-2016
C	**Post planting**		
1	Post emergence application of Pendimethalin @1.5kg/ha +imazethapyr@75g/hafor treatment (T_1)	1	25-07-2016
2	Post emergence application of Pendimethalin @1.5kg/ha+ Quizalofop ethyl@50g/ha for treatment (T_2)	1	25-07-2016
3	Post-emergence application of Pendimethalin@1.5kg/ha+Imazethapy(50%) +	1	25-07-2016

	Quizalofop ethyl (50%)for treatment (T_3)		
4	Post emergence application of Pendimethalin @1.5kg/ha+Imazethapy(60%)r+Quizalofop ethyl(40%) for treatment (T_4)	1	25-07-2016
5	Post emergence application of Pendimethalin @1.5kg/ha+Imazethapyr(40%)+Quizalofop ethyl(60%) for treatment (T_5)	1	25-07-2016
6	Post emergence application of Imazethapyr (50%)+Quizalofop ethyl(50%) for treatment (T_6)	1	25-07-2016
7	Post emergence application of Imazethapyr (60%)+Quizalofop ethyl(40%) for treatment (T_7)	1	
8	Post emergence application of Imazethapyr (40%)+Quizalofop ethyl(60%) for treatment (T_8)	1	25-07-2016
D.	**Plant protection**		
1	Spraying of Quinolphos	1	30-07-2016
2	Spraying of Profex super	1	10-08-2016
E.	**Harvesting**		
1	Uprooting and plucking pods	1	29-10-2016
2	Sun drying and storage	3	14-11-2016 15-11-2016 16-11-2016

Table 6.Biometric observations undertaken/recorded during experimentation

Sr. No.	Field operations	Frequency	Days after sowing
A.	**Pre harvest studies**		
1.1	Emergence count	1	After emergence.
1.2	Mean plant height	5	20,40,60,80,and At harvest
1.3	No. of branches plant^{-1}	5	20,40,60,80,and At harvest
1.4	No. of nodules plant^{-1}	5	20,40,60,80,and At harvest
1.5	No. of developed pod plant^{-1}	1	At harvest
1.6	No. of undeveloped pod plant^{-1}	1	At harvest
1.7	Dry matter accumulation	5	20,40,60,80,and At harvest
1.8	Final plant stand	1	At harvest
B	**Post-harvest studies**		
	Yield and yield attributes		
2.1	Pod yield plant^{-1}	1	After harvest
2.2	Pod yield plot^{-1}	1	After harvest
2.3	Pod yield ha^{-1}	1	After harvest
2.4	Haulm yield plot^{-1}	1	After harvest
2.5	Haulm yield ha^{-1}	1	After harvest
2.6	Test weight (g)	1	After harvest

2.7	Harvest index (%)	1	After harvest
2.8	Economics of the treatment	1	After harvest
C	**Qualities studies**		
2.9	Shelling percentage	1	After harvest
2.10	Oil yield ha^{-1}	1	After harvest
D	**Chemical studies**		
2.11	Initial soil status	1	Before sowing
2.12	NPK uptake by crop & Weed kg^{-1}	1	After harvest
E	**Weed Studies**		
1.	Weed count (m^{-2}) (Monocot & dicot)	5	20, 40, 60, 80 and at harvest
2.	Dry matter of weed (m^{-2})	5	20, 40, 60, 80 and at harvest
3.	Weed control efficiency (%)	1	20, 40, 60, 80 and at harvest
4.	Weed Index	1	At harvest

3.4.7 Mechanical weed control

Cultural methods of weed control such as hand weeding and hoeing is carried out as per treatment.

3.4.8 Harvesting and Drying

Harvesting was done on 29th October 2016 by uprooting the plants and then picking the pods. On next day sun drying was done and last up to two days after harvesting.

3.4.9 Details of Herbicide application

A) Pendimethalin

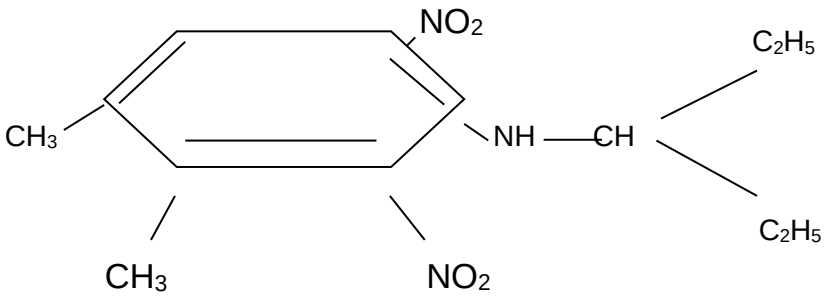
Common name : Pendimethalin

Trade name : Stomp / Prowl / Pendalin / Tata panida

Origin : American Cyanamid Co. U.S.A.

Chemical name : N- (1-ethylpropyl)-3, 4-dimethyl-2, 6-dinitrobenzenamine.

Structural formula



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

B) Imazethapyr

a) Trade Name	:	Pursuit
b) Origin	:	Shanghai TenglongAgrochem Co., Ltd.
c) Chemical Name	:	(±)-2-[4,5-dihydro-4-methyl-4-(1-methylethyl)-5-oxo-1*H*-imidazol-2-yl]-5-ethyl-3-pyridinecarboxylic acid
d) Group of herbicide	:	Imidazolinone
e) Common Name	:	Imazethapyr
f) Type of herbicide	:	Selective

g) Formulation : 10 % SL

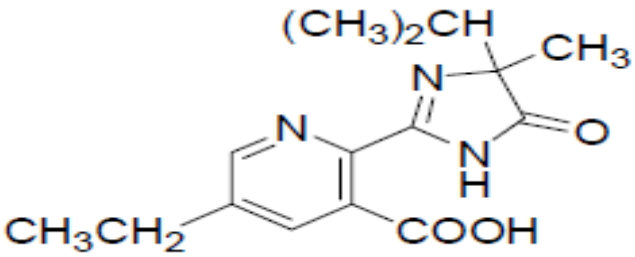
h) General dose : 0.1 kg ha^{-1}

i) Application : post-emergence

j) Molecular formula : $C_{15}H_{19}N_3O_3$

k) Molecular weight : 289.3

l) Structural formula



Mode of action

It inhibits the Acetolactate synthatase (ALS) or acitohydroxy acid synthatase (AHAS) inhibitors.

Weed control:

Many annual BLW (broadleaf weeds) species and several annual grasses, especially when applied PPI, PRE, or early post (2 leaf stage of weeds): green and yellow foxtails, barnyard grass, witch grass, cocklebur, velvet leaf, common ragweed, wild mustard, red root, pig weed, lambsquarters, smart weed.

Solubility : In water emulsifiable

Boiling point : 100 ^{0}C

C) Quizalofop-ethyl (Rao 2000)

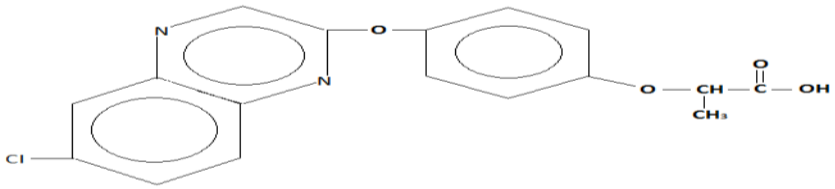
Common name : Quizalofop-ethyl

Trade name : Targa super

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

Chemical name : (R)-2{4-(6-choro-2-quinoxalinyl)oxy} phenoxyl} Propanoic acid

Structural formula



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

3.4.10 Plant protection measures

Timely plant protection measures were under taken to control pests like jassids and leaf minor during the growth period of the crop.

3.5 Weed studies

3.5.1 Weed count

The total numbers of weed present per m^{-2} area in a permanently marked spot were counted by using quadrat in each plot at 20, 40, 60, 80 and at harvest. They were further classified into grasses, sedges and broad leaved weeds, before subjecting to statistical analysis.

3.5.2 Dry matter of weed

Dry weight of weeds was recorded at four stages namely 20, 40, 60, 80 and at harvest. The weed were cut close to the ground level in m^{-2} area selected at random each time. Weeds were dried at 65^0 C and the dry weight was recorded.

3.5.3 Weed index

Weed index defined as the reduction in yield due to the presence of weed in comparison to weed free. Weed index was calculated by using the formula given by Gill and Vijay Kumar (1969).

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

Where,

X = Total seed yield from the weed free check

Y = Total seed yield from the treatment for which weed index has to be calculated.

3.5.4 Weed control efficiency (%)

Weed control efficiency denotes the magnitude of weed reduction due to the weed control treatment. The weed control efficiency was calculated as fallows.

Weed control efficiency = $\frac{Wpc-Wpt}{Wpc} X100$

Where,

Wpc = Weed population in unweeded control.

Wpt = Weed population in treatment for which weed control efficiency is to be calculated.

3.5.5 Phytotoxicity of herbicide

It was noted according to 0-10 scale method.

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

Effect	Rate	Description of crop
None	0	No injury, normal
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

3.6 Pre-harvest observation

3.6.1 Details of observation

The details of observation recorded in research project are given and the techniques followed for recording each observation is described separately.

3.6.2 Sampling technique

At 20, 40, 60, 80 DAS and at harvest of groundnut, five plants were selected random from each net plot and following observations were recorded.

3.6.3 Initial plant stand

Numbers of plants in the plot were recorded after 15 days after sowing.

3.6.4 Final plant stand

Final plant stand were recorded taking actual count of plants in each net plot at the time of harvest.

3.6.5 Plant height

The average plant height (cm) was measured from the base of the plant to the tip of the main stem (20, 40, 60, 80 and at Harvest).

3.6.6 Dry matter production

At each sampling after recording the observations detailed above, the plants were partitioned into stem, leaves and fruiting parts (pods) and were dried at 65^0 C in hot air oven to a constant weight. The oven dry weight of each plant part was recorded. The data then obtained was used to estimate the total dry matter production per plant (20, 40, 60, 80 and at harvest).

3.6.7 Number of branches

The number of branches (primary and secondary) borne on the stem was counted and recorded.

3.6.8 Number of nodules

Plants collected for the dry matter accumulation study were used for nodulation study. The roots of sample plants were taken out carefully first washed to remove the sticking soil particles and then nodules were counted.

3.6.9 Number of developed and undeveloped pods

The plants, which were selected for growth studies, were used for the study of developed and undeveloped pods at maturity stage. The number of developed and undeveloped pods was counted and recorded.

3.7 Yield studies (Yield attributes)

The following yield components were recorded from the five randomly selected plants from the net plot at harvest.

3.7.1 Pod yield per plant and per hectare

The mean pod yield per plant was computed by recording the weight of dry pods from the observation plants. Similarly, the pod yield per net plot was recorded by weighing the dry pod per plot treatment wise. The pod yield per hectare was calculated from the pod yield per plot.

3.7.2 Yield of haulm per plot and per hectare

The haulm from each net plot was sun dried for about a week after harvest, tied in bundles, weighed with a spring balance and the weight was recorded treatment wise. The haulm yield per hectare was computed from the yield per plot.

3.7.3 100 kernels weight

The kernels obtained by shelling of the pods were thoroughly dried in sun and 100 kernels per treatment were counted randomly and their weight was recorded.

3.8 Quality studies

3.8.1 Shelling percentage

100 gm of dry pods from each net plot were shelled, kernels were weighed a shelling percentage was computed for each treatment.

3.8.2 Oil percentage

Oil percentage was determined with the help of NMR apparatus (Nuclear Magnetic Resonance) treatment wise by using the kernels obtained in shelling.

3.9 Chemical studies

3.9.1 Initial soil status

Soil sample of 0-30 cm depth were collect from each plot before sowing the crop and analyzed separately for organic carbon, total nitrogen, available phosphorus and available potassium. The samples were collected using screw auger, dried in shade and ground in mortar with pastel and sieved accordingly before analysis.

3.9.2 Estimation of N, P and K content in the plant and weed samples

The total nitrogen in the composite sample was estimated by modified kjeldhal's method (Jackson, 1967) and expressed in percentage on dry weight basis. Nitrogen per cent and total dry weight of weeds were used to calculate the total uptake of nitrogen at 60 DAS and at harvest and was expressed as kg ha^{-1}.

For analysis of phosphorous and potassium in the plant sample, triacid mixture (400 ml of concentrated HNO_3 + 40 ml of concentrated H_2SO_4 + 120 ml of 70 % concentrated $HClO_4$) was used to digest the composite plant and weed samples.

Phosphorous content in the plant and weed samples was determined by Venadomolybdate phosphoric yellow colour method using spectrophotometer at 470 nm as described by Jackson (1967) and was expressed as percentage of phosphorous. Using the phosphorous content, total uptake of phosphorous at 60 DAS and at harvest was calculated and expressed in kg ha^{-1} hectare.

Potassium content in the plant and weed samples were determined by Flame photometer method and were expressed as percentage potassium. Based on potassium content in the plant, the total uptake of potassium at 60 DAS and at harvest was computed and expressed in kg ha^{-1}.

3.10 Economic Analysis

The prices in rupees of the inputs that were prevailing at the time of their use were considered for working out the cost

of cultivation. Net returns per ha was calculated by deducting the cost of cultivation per ha from gross income ha^{-1}. Then benefit cost ratio was worked out.

3.10.1 Cost of cultivation

Cost of cultivation was calculated based on prices of inputs and labour charges existing during course of investigation (Appendix-II).

3.10.2 Net profit

Net profit per ha was calculated on the basis of gross income and Cost of cultivation ha^{-1}.

3.10.3 B:C ratio

Benefit cost ratio was calculated by using the formula given below.

$$\text{B:C ratio} = \frac{\text{Gross monetory retun (Rs. ha}^{-1})}{\text{Cost of cultivation (Rs. ha}^{-1})}$$

3.11 Statistical analysis

Fisher's method of analysis of variance was applied for the analysis and interpretation of data as given by Gomez (1984). The level of significance used in 'F' and 't' test was P= 0.05, critical difference was calculated wherever 'F' test was significant.

3.12 Place / duration / season of experiment

The study was conducted during *kharif* season of 2016-2017 under rainfed condition at the field of Oilseed Research Unit farm, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola.

CHAPTER IV

RESULT AND DISCUSSION

During the experiment entitled “Studies on tank mix application of post-emergence herbicides for efficient weed control in Groundnut (*Arachis hypogaea L.*)” weed studies, pre-harvest and post-harvest observations were statistically analyzed and are presented in this chapter.

4.1 WEED STUDIES

4.1.1 Influence of weed control treatments on weeds

4.1.1.1 Weed flora

In order to find out an effective weed control measure, it is very important to identify the weeds species present in experimental field. The correct identification helps to group them into different classes. The weeds of specific group normally respond to the particular treatment because of their morphological and genetically characters and growth similarities. The efforts were made to identify the weed prevailing in the experiment at field. The list of weed is given in Table 7. The weeds in the experimental area were classified as monocot and dicot weeds.

A. Monocot weeds

Most of the grasses are classified are as monocot which ranges tufted erect or creeping annuals to large perennials. Their stems are circular in section with distinct nodes at regular interval from which narrow leaves arise alternately in two rows. The lower portion of the leaf is the sheath overlaps at the tip of young grass stem to from a pseudo stem which protect the shoot apex. The leaf is thin and linear with parallel venation. The distinct junction of the blade and sheath is membranous, often hairy out growth known as ligule.

B. Dicot weeds

Dicotyledonous weeds are usually broad leaved with broad and often toothed lamina having reticulate venation. The leaves usually have distinct blades and may be arranged in basal resets or along the stem singly, in pairs or rarely in whorls. These weeds are having tap root system with profusely branched stem with apical meristem.

Table 8. Major weed Flora Observed in Experimental Plot

Local name	English name	Botanical name	Family
Monocot weeds			
Haryali	Bermuda grass	*Cynadon dactylon*	Gramineae
Kunda	-	*Ischaemum pilosum*	Gramineae
Smooth crab grass	Crab grass	*Digitaria sanguinalis*	Gramineae
Panicum spp.	Fall panicum	*Panicum spp.*	Gramineae
Kena	Day flower	*Commelina benghalensis*	Commelianaceae
Dicot weeds			
Congress grass	Rag weed	*Parthenium hysterophorus*	Compositeae
Aghada	Prickly chaff flower	*Achyranthus aspera*	Amaranthaceae
Chotidudhi	Spurge	*Euphorbia hirta*	Euphorbiaceae
Mothidudhi	Spurge	*Euphorbia geniculata*	Euphorbiaceae
Hazardani	Niruri	*Phyllanthus niruri*	Euphorbiaceae
Kombda	Cox comb	*Celosia argentia*	Amaranthaceae
Kunjar	Amaranthus	*Digera arvensis*	Amaranthaceae
Kambarmodi	Tridex	*Tridex procumbens*	Compositeae
Sedges			
Nagarmotha	Nut sedge	*Cyperus rotundus*	Cyperaceae

4.2.1 Effect of various treatment on weed population

The effects of various treatments on weed population were assessed at different growth stages of groundnut crop. The weeds are classified into monocots and dicot.

Table 9. Monocot weed count no./m^2 as influenced by different weed control treatments

Treatment	20 DAS	40 DAS	60 DAS	80 DAS	At Harvest
T_1- Pendimethalin @1.5 kg a.i/ha (PE) + Imazethapyr @ 75 g a.i/ha at 20-30 DAS	3.67	6.33	14.33	15.67	17.33
T_2- Pendimethalin @1.5 kg a.i/ha (PE) + Quizalofop ethyl @ 50 g a.i/ha at 20-30DAS	4.33	7.67	16.67	17.67	18.67
T_3- Pendimethalin @ 1.5 kg a.i/ha (PE) + Imazethapyr (50%) + Quizalofop ethyl (50%) at 20-30 DAS	5.67	8.00	19.00	19.67	20.67
T_4- Pendimethalin @ 1.5 kg a.i/ha (PE) + Imazethapyr (60%) +Quizalofop ethyl (40%) at 20-30 DAS	6.00	8.67	16.00	20.00	21.00
T_5- Pendimethalin @ 1.5 kg a.i/ha (PE) + Imazethapyr (40%) +Quizalofop ethyl (60%) at 20-30DAS	6.67	8.33	17.00	18.67	19.67
T_6- Imazethapyr (50%) + Quizalofop ethyl (50%) at 20-30 DAS	25.33	10.33	21.33	22.00	23.33
T_7- Imazethapyr (60%) + Quizalofop ethyl (40%) at 20-30 DAS	23.67	12.33	20.67	21.33	22.00
T_8- Imazethapyr (40%) + Quizalofop ethyl (60%) at 20-30 DAS	28.33	12.67	21.33	22.33	23.33
T_9- Weedy check	37.00	61.33	74.33	76.33	70.33
T_{10}- Weed free	1.67	2.33	1.67	1.33	1.33
S.E(m)±	0.99	0.71	1.03	1.23	0.80
C.D.at 5%	2.87	2.11	3.08	3.67	2.40
G.M	14.23	13.80	22.23	23.50	23.76

All the weed control treatment significantly suppressed both monocot and dicot weeds over weedy check during the study.

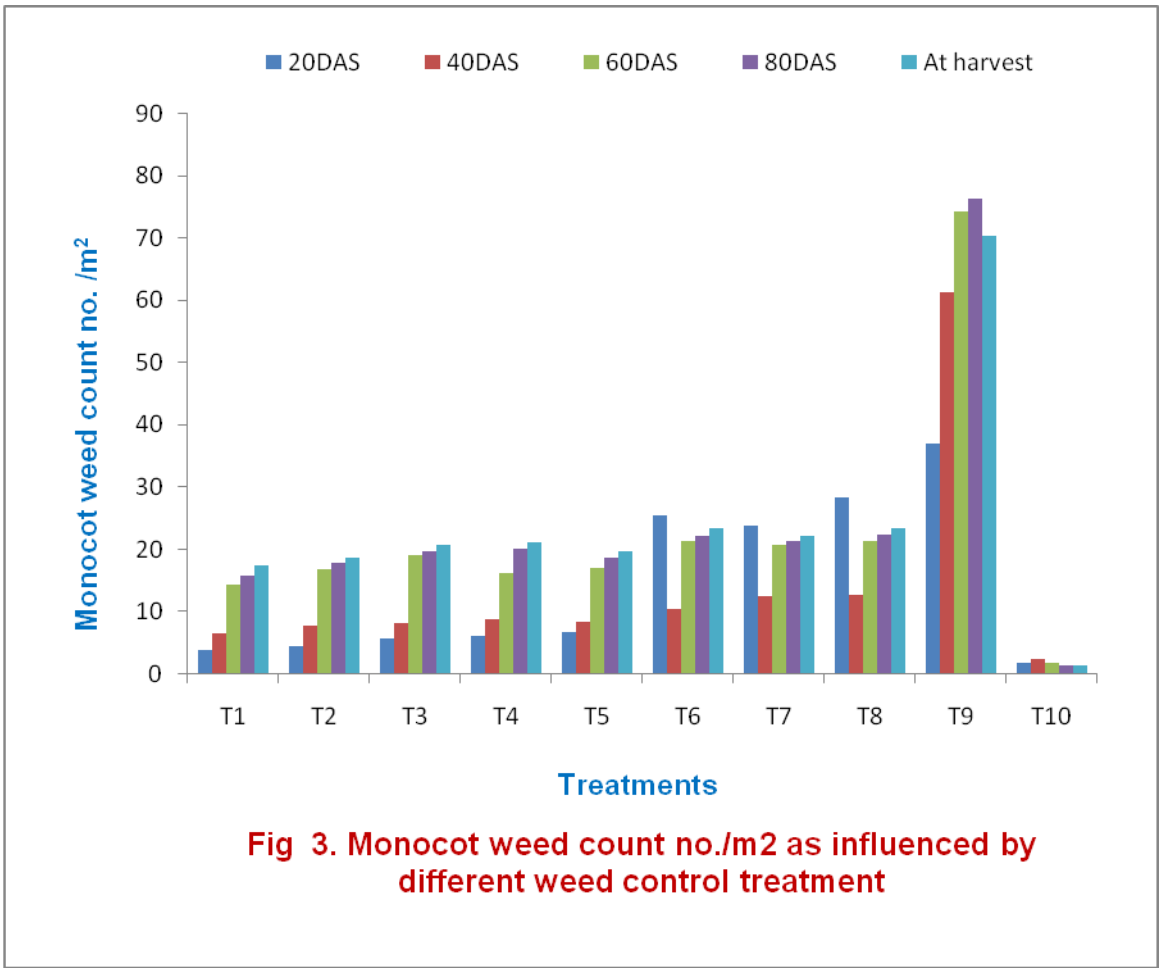


Fig 3. Monocot weed count no./m2 as influenced by different weed control treatment

A perusal of the data presented in Table 9. and fig. 3 showed that number of monocot weeds were affected significantly at all the periodical intervals due to different treatments. The treatment Weed free (T_{10}) recorded significantly lower number of monocot weeds over rest of the treatments.

The data revealed that among the herbicidal treatments at 20 DAS monocot weeds/m^2 were significantly lower in Pendimethalin @ 1.5 kg a.i. ha^{-1} PE (T_1,T_2,T_3,T_4,T_5.) sprayed as pre-emergence, which were superior to all other treatments because of the reduction in weed population at initial stage.

The lowest density of monocot weeds were recorded with Weed free (T_{10}) and Pendimethalin @ 1.5 kg a.i. ha^{-1} (T_1,T_2,T_3,T_4,T_5) and which were statistically at par with each other and significantly superior over rest of the herbicidal tested. The weedy check treatment (T_9) recorded significantly highest weed population.

Significantly lowest monocot weed population from 40 DAS up to harvest were recorded in treatment Weed free (T_{10}) The next best treatment was Pendimethalin @1.5kg a.i/ha (PE) + Imazethapyr @ 75 g a.i/ha (T_1) which were statistically at par with Pendimethalin @ 1.5kg a.i/ha (PE) + Quizalofop ethyl @ 50g a.i/ha (T_2), Pendimethalin @1.5kg a.i/ha (PE) + Imazethapyr (50%) + Quizalofop ethyl (50%) (T_3), Pendimethalin @ 1.5kg a.i/ha (PE) + Imazethapyr (40%) + Quizalofop ethyl (60%) (T_5) and Pendimethalin @ 1.5kg a.i/ha (PE) + Imazethapyr (60%) + Quizalofop ethyl (40%) (T_4) and found superior over Imazethapyr (50%) + Quizalofop ethyl (50%) (T_6), Imazethapyr (60%) + Quizalofop ethyl (T_7) and Imazethapyr (40%) +Quizalofop ethyl (60%) (T_8) Maximum number of weeds were observed in Weedy check (T_9).

Treatment Weed free (T_{10}) recorded significantly lowest weed count all the stages of crop growth, might be due to keeping weed free environment, while among the various herbicidal weed control treatments. Minimum monocot weed count /m^2 observed with treatment Pendimethalin @ 1.5 kg a.i. ha^{-1} (T_1,T_2,T_3,T_4,T_5.) at 20 DAS, this might be due to the pre-emergence application of pendimethalin, results in better weed control at

initial stage by inhibiting weed seed germination and seedling development. At 40 DAS, Pendimethalin @1.5kg a.i/ha(PE) + Imazethapyr @ 75 g a.i./ha (T_1) treatment recorded lowest monocot weed count, but found at par with Pendimethalin @ 1.5kg a.i/ha (PE) + Quizalofop ethyl @ 50g a.i/ha (T_2), Pendimethalin @ 1.5kg a.i/ha (PE) + Imazethapyr (50%) + Quizalofop ethyl (50%) (T_3), Pendimethalin @ 1.5kg a.i/ha (PE) + Imazethapyr (40%) + Quizalofop ethyl (60%) (T_5) and Pendimethalin @ 1.5kg a.i/ha (PE) + Imazethapyr (60%) + Quizalofop ethyl (40%) (T_4), Similar trend of results were noticed at 60, 80 and at harvest stage during the experimentation. This might be due to Pendimethalin @ 1.5kg a.i/ha (PE) + Imazethapyr @ 75g a.i/ha (T_1) that have longer effect on controlling monocot weed population.Similar results were also reported by Malunjkar et al. (2012).

4.2.2. Effect of treatments on dicot weeds

Data pertaining to dicot weed count/m^2 are presented in Table 10 and graphically depicted in Fig. 4

A perusal of the data presented in Table 10. showed that the number of dicot weeds were affected significantly at all the periodical intervals due to the different weed control treatments

The treatment Weed free (T_{10}) registered significantly lowest dicot weed population than rest of the weed management treatments. Initialy upto 40 DAS pre-emergence herbicides treatments i.e Pendimethalin @ 1.5 kg a.i. ha^{-1} (T_1,T_2,T_3,T_4,T_5.) recorded lowest values of dicot weeds than post emergence herbicidal treatments. The treatment weedy check (T_9) registered maximum dicot weed population during study.

The data presented in table 10 indicated that numbers of weeds were significantly influenced by different weed control treatment at all the stages of crop growth. The treatment of pre emergence and post emergence application of Pendimethalin @ 1.5 kg a.i/ha (PE) + Imazethapyr @ 75g a.i/ha (T_1) recorded least number of dicot weeds followed by pre emergence and post emergence application of Pendimethalin @ 1.5kg a.i/ha (PE) + Quizalofop ethyl @ 50 g a.i/ha (T_2), however these treatments were at par with each other at all the stages of

Table 10. Dicot weed count no./m² as influenced by different weed control treatments

Treatment	20 DAS	40 DAS	60 DAS	80 DAS	At Harvest
T_1 - Pendimethalin @1.5 kg ai/ha (PE) + Imazethapyr @ 75 g ai/ha at 20-30 DAS	5.33	4.33	8.67	12.33	13.33
T_2 - Pendimethalin @1.5 kg ai/ha (PE) + Quizalofop ethyl @ 50 g ai/ha at 20-30DAS	5.67	5.33	9.33	13.00	14.33
T_3 - Pendimethalin @ 1.5kg ai/ha (PE) + Imazethapyr (50%) + Quizalofop ethyl (50%) at 20-30 DAS	6.33	7.67	10.67	14.67	15.67
T_4- Pendimethalin @ 1.5 kg ai/ha (PE) + Imazethapyr (60%) + Quizalofop ethyl(40%) at 20-30 DAS	6.00	6.00	11.00	15.33	16.33
T_5 - Pendimethalin @1.5 kg ai/ha (PE) + Imazethapyr (40%) + Quizalofop ethyl (60%) at 20-30DAS	7.33	7.00	10.67	14.00	15.67
T_6 – Imazethapyr (50%) + Quizalofop ethyl (50%) at 20-30 DAS	16.33	8.33	14.33	16.00	17.67
T_7- Imazethpyr (60%) + Quizalofop ethyl (40%) at 20-30 DAS	17.67	9.33	13.33	15.67	18.00
T_8- Imazethapyr (40%) + Quizalofop ethyl (60%) at 20-30 DAS	18.33	9.00	12.33	14.67	18.33
T_9 - Weedy check	28.00	32.00	38.67	40.33	41.33
T10-Weed free	1.67	1.33	1.67	2.67	2.67
S.E(m)±	0.77	0.94	0.91	0.68	0.37
C.D.at 5%	2.30	2.81	2.71	2.03	1.12
G.M	11.26	9.03	13.06	15.86	17.33

growth and significant over rest of the treatments. The treatment Pendimethalin @ 1.5 kg ai/ha (PE) + Imazethapyr (50%) + Quizalofop ethyl (50%) (T_3), Pendimethalin @ 1.5 kg ai/ha (PE) + Imazethapyr (60%) + Quizalofop ethyl (40%) (T_4) and Pendimethalin @ 1.5kg ai/ha (PE) + Imazethapyr (40%) + Quizalofop ethyl (60%) (T_5) from 40 DAS to at harvest found at par with treatments Imazethapyr (50%) + Quizalofop ethyl (50%) (T_6), Imazethapyr (60%) + Quizalofop ethyl (T_7) and Imazethapyr (40%) + Quizalofop ethyl (60%) (T_8) at all stages of crop growth. The maximum number of dicot weeds was observed in Weedy check (T_9) as compared to

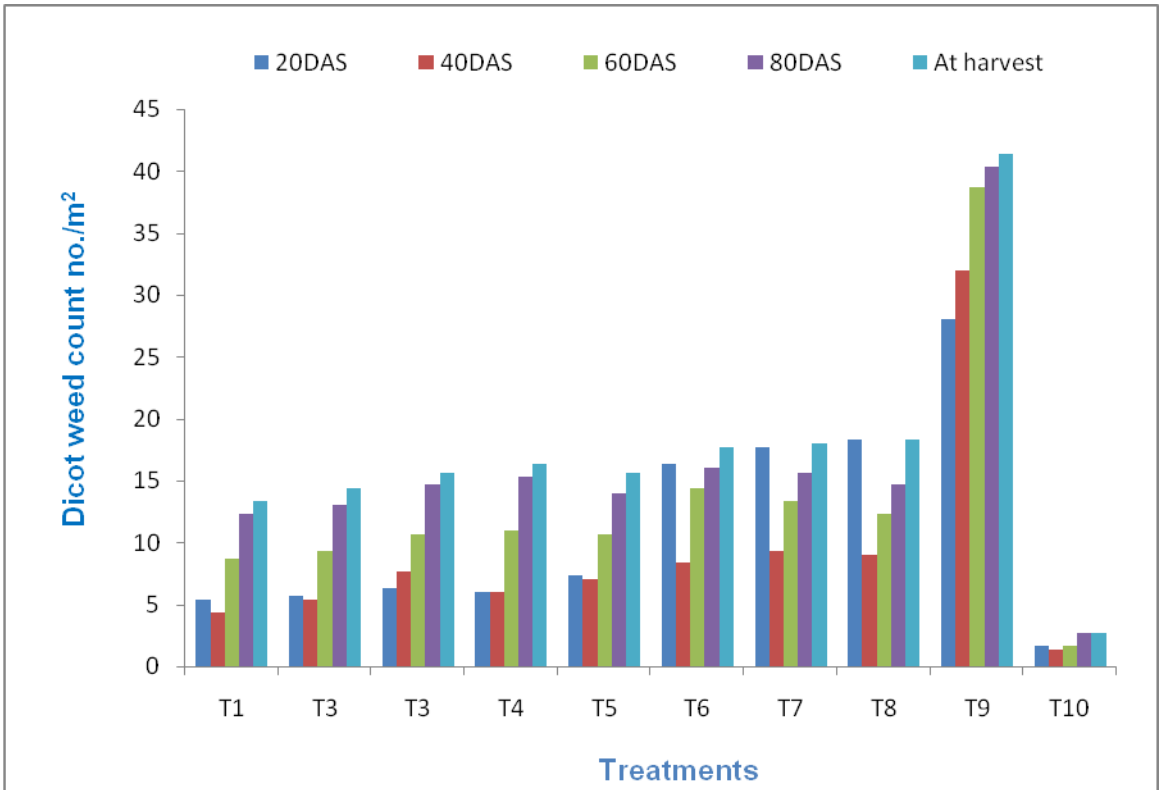


Fig.4. Dicot weed count no./m2 as influenced by different weed control treatment

other treatments at all stages of crop growth and weed free check recorded weed free condition throughout crop growth period. Similar results were also reported by Malunjkar et al. (2012).

4.2.3 Effect of treatments on total weeds

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

Table 11. Total weed count no./m^2 as influenced by different weed control treatments

Treatment	20 DAS	40 DAS	60 DAS	80 DAS	At Harvest
T_1 - Pendimethalin @1.5 kg ai/ha (PE) + Imazethapyr @ 75 g ai/ha at 20-30 DAS	9.00	10.67	23.00	28.00	30.67
T_2 - Pendimethalin @ 1.5 kg ai/ha (PE) + Quizalofop ethyl @ 50 g ai/ha at 20-30DAS	10.00	13.00	26.00	30.67	33.00
T_3 - Pendimethalin @ 1.5kg ai/ha (PE) + Imazethapyr (50%) + Quizalofop ethyl (50%) at 20-30 DAS	12.00	15.67	29.67	34.33	36.33
T_4 - Pendimethalin @ 1.5 kg ai/ha (PE) + Imazethapyr (60%) + Quizalofop ethyl (40%) at 20-30 DAS	12.00	14.67	27.00	35.33	37.33
T_5 - Pendimethalin @ 1.5 kg ai/ha (PE) + Imazethapyr (40%) + Quizalofop ethyl (60%) at 20-30DAS	14.00	15.33	27.67	32.67	35.33
T_6 – Imazethapyr (50%) + Quizalofop ethyl (50%) at 20-30 DAS	41.67	18.67	35.67	38.00	41.00
T_7- Imazethapyr (60%) + Quizalofop ethyl (40%) at 20-30DAS	41.33	21.67	34.00	37.00	40.00
T_8- Imazethapyr (40%) + Quizalofop ethyl (60%) at 20-30DAS	46.67	21.67	33.67	37.00	41.67
T_9- Weedy check	65.00	93.33	113.00	116.67	111.67
T_{10}- Weed free	3.33	3.67	3.33	4.00	4.00
S.E(m)±	1.38	1.34	1.53	1.47	0.89
C.D.at 5%	4.12	3.98	4.55	4.37	2.66
G.M	25.50	22.83	35.30	39.36	41.10

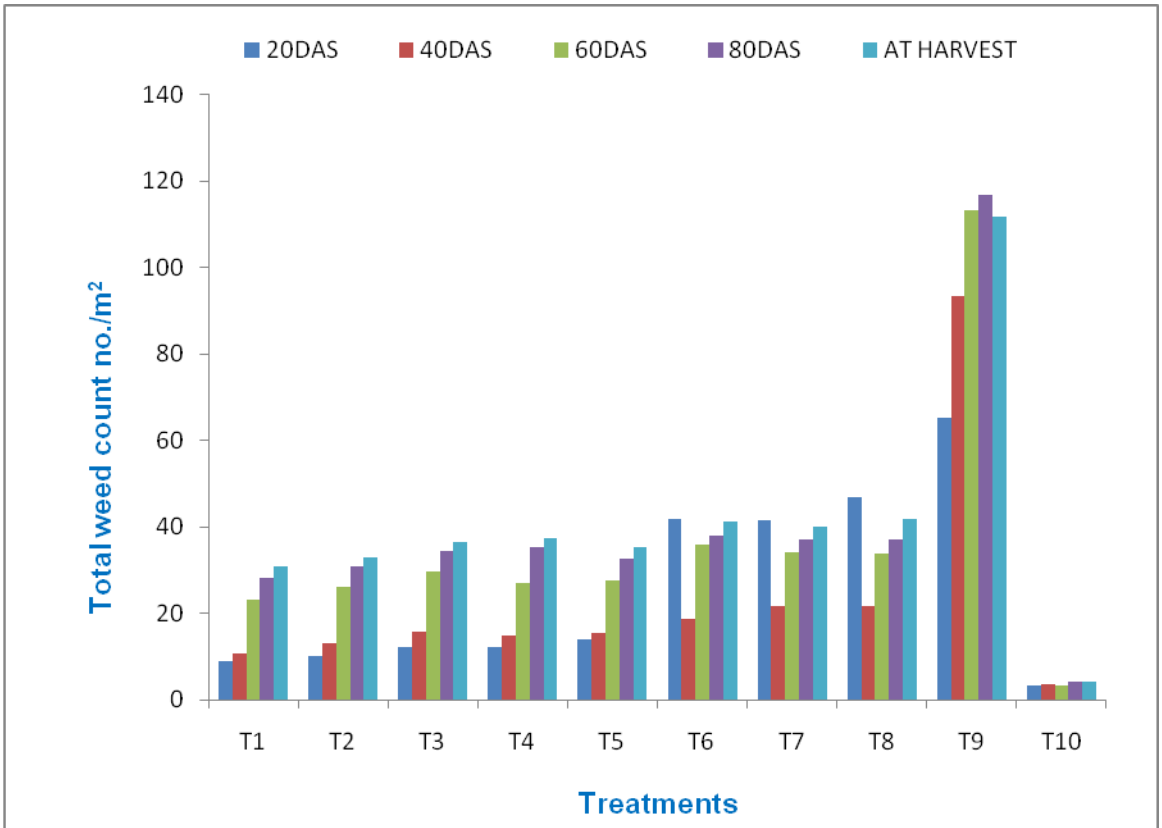


Fig.5. Total weed count no./ m2 as influenced by different weed control treatment

A perusal of the data presented in Table 11 showed that number of total weeds were affected significantly at all the periodical intervals due to different treatments.

At 20 DAS significantly lowest total weeds count was observed in treatment Weed free (T_{10}) and pre emergence application of Pendimethalin @1.5kg ai/ha (T_1, T_2, T_3, T_4 and T_5). Than rest of the herbicidal treatment tested. The treatment Weedy check (T_9) recorded significantly highest weed count at 20 DAS.

At 40 DAS, significantly reduction in total weeds count was reduced in treatment Weed free (T_{10}). Among the different herbicidal treatments Pendimethalin @ 1.5kg ai/ha (PE) + Imazethapyr @ 75 g ai/ha (T_1), Pendimethalin @ 1.5kg a.i/ha (PE) + Quizalofop ethyl @ 50 g a.i/ha (T_2), Pendimethalin @ 1.5kg ai/ha (PE) + Imazethapyr (50%) + Quizalofop ethyl (50%) (T_3), Pendimethalin @ 1.5kgai/ha (PE) Imazethapyr (60%) + Quizalofop ethyl (40%) (T_4), Pendimethalin @ 1.5kg ai/ha (PE) + Imazethapyr (60%) + Quizalofop ethyl (40%) (T_5) showed effective control on weed than rest of the herbicidal treatments.

Significantly minimum number of total weed count was noticed in treatment Weed free (T_{10}) than rest of the treatments at 60 DAS. While among the herbicidal treatments Pendimethalin @1.5kg ai/ha (PE) + Imazethapyr @ 75 g ai/ha (T_1), recorded significantly lowest total weed population than other herbicidal application during the study. The treatments Pendimethalin @ 1.5kg a.i/ha (PE) + Quizalofop ethyl @ 50 g a.i/ha (T_2), Pendimethalin @ 1.5kg ai/ha (PE) + Imazethapyr (50%) + Quizalofop ethyl (50%) (T_3), Pendimethalin @ 1.5kg ai/ha (PE) + Imazethapyr (60%) + Quizalofop ethyl (40%) (T_4), Pendimethalin @ 1.5kg ai/ha (PE) + Imazethapyr (40%) + Quizalofop ethyl (60%) (T_5), Imazethapyr (50%) + Quizalofop ethyl (50%) (T_6),) and Imazethapyr (60%) + Quizalofop ethyl (40%) (T_7), Imazethapyr (40%) + Quizalofop ethyl (60%) (T_8) showed more or less similar values of total weed population.

At 80 DAS, total number of weeds were significantly lower in treatment Weed free (T_{10}) followed Pendimethalin @ 1.5kg ai/ha (PE) + Imazethapyr @ 75g ai/ha (T_1), Pendimethalin @ 1.5kg a.i/ha (PE) +

Quizalofop ethyl @ 50g a.i/ha (T_2), Pendimethalin @ 1.5kg ai/ha (PE) + Imazethapyr (50%) + Quizalofop ethyl (50%) (T_3), Pendimethalin @ 1.5kg ai/ha (PE) + Imazethapyr (60%) + Quizalofop ethyl (40%) (T_4), Pendimethalin @ 1.5 kg ai/ha (PE) + Imazethapyr (40%) + Quizalofop ethyl (60%) (T_5), Imazethapyr (50%) + Quizalofop ethyl (50%) (T_6),) and Imazethapyr (60%) + Quizalofop ethyl (40%) (T_7), Imazethapyr (40%) + Quizalofop ethyl (60%) (T_8) in which treatment Pendimethalin @ 1.5kg ai/ha (PE) + Imazethapyr @ 75 g ai/ha (T_1), Pendimethalin @ 1.5kg a.i/ha (PE) + Quizalofop ethyl @ 50g a.i/ha (T_2), Pendimethalin @ 1.5kg ai/ha (PE) + Imazethapyr (50%) + Quizalofop ethyl (50%) (T_3), Pendimethalin @ 1.5kg ai/ha (PE) + Imazethapyr (60%) + Quizalofop ethyl (40%) (T_4), Pendimethalin @ 1.5kg ai/ha (PE) + Imazethapyr (40%) + Quizalofop ethyl (60%) (T_5) were found at par with each other.

At harvest stage, treatment Weed free (T_{10}) found significantly superior in reducing the total weeds population than rest of the treatments. The application of Pendimethalin @ 1.5 kg ai/ha(PE) +Imazethapyr @ 75 g ai/ha (T_1), showed its superiority in lowering down the weed population over, Pendimethalin @ 1.5kg ai/ha (PE) + Quizalofop ethyl @ 50g ai/ha (T_2), Pendimethalin @1.5kg ai/ha (PE) + Imazethapyr (50%) + Quizalofop ethyl (50%) (T_3), Pendimethalin @ 1.5 kg ai/ha (PE) + Imazethpyr (60%) + Quizalofop ethyl (40%) (T_4), Pendimethalin @ 1.5kg ai/ha (PE) + Imazethpyr (40%) + Quizalofopethyl (60%) (T_5), Imazethapyr (50% + Quizalofop ethyl (50%) (T_6),) and Imazethapyr (60%) + Quizalofop ethyl (40%) (T_7), Imazethapyr (40%) + Quizalofop ethyl (60%) (T_8) among these treatments, and Pendimethalin @ 1.5kg ai/ha (PE) + Imazethapyr @ 75 g ai/ha (T_1), Pendimethalin @ 1.5 kg ai/ha (PE) + Quizalofop ethyl @ 50 g ai/ha (T_2), Pendimethalin @ 1.5 kg ai/ha (PE) + Imazethapyr (50%) + Quizalofop ethyl (50%) (T_3), Pendimethalin @ 1.5 kg ai/ha (PE) + Imazethpyr (60%) + Quizalofop ethyl (40%) (T_4), Pendimethalin @ 1.5 kg ai/ha (PE) + Imazethpyr (40%) + Quizalofopethyl (60%) (T_5) were found statistically comparable with each other. The treatment weedy check (T_9) recorded maximum number of total weeds at all the stages of crop growth.

The weed free (T_{10}) treatment recorded significantly lowest total weed count at all crop growth stages, might be due to keeping weed free environment up to harvest, while in herbicidal treatments lowest total weed count was observed under treatment application of Pendimethalin @1.5kg ai/ha (T_1, T_2, T_3, T_4 and T_5) at 20 DAS. This might be due to pre emergence application of Pendimethalin which gave better weed control at initial stage by inhibiting seed germination and seedling development. At 40, 60, 80 DAS and at harvest lowest total weed population was observed under Pendimethalin @1.5 kg ai/ha (PE) + Imazethapyr @ 75 g ai/ha (T_1) This might be due to pre-emergence and post-emergence application of herbicides that have longer effect on controlling weed population.

Total weed population was reduced significantly due to various weed control treatments at all stages of crop growth. This might be due to the pre-emergence and post-emergence application of herbicides which were effective in timely reducing total weed population.Similar results were also reported by Malunjkar *et al. (*2012).

4.2.4 Effect of treatments on dry matter production by weed

Data appurtanant to weed dry matter accumulation are presented in Table 12. and graphically showed in Fig. 6.

Weed dry weight was recorded prior to implementation of weed control measures. In general the dry matter of weed was minimum at 20 DAS and was increased and reached to maximum at 80 DAS and slightly reduced at harvest.

At 20 DAS, treatment Weed free (T_{10}) showed significantly less weed dry weight over rest of the treatments. The pre-emergence Pendimethalin @ 1.5 kg a.i. ha^{-1} ((T_1, T_2, T_3, T_4 and T_5) recorded less dry matter of weed as compare to post emergence application of herbicides. Among the post emergence treatments, Imazethpyr (50%) +Quizalofop ethyl (50%) (T_6) recorded less dry matter than application of Imazethapyr (60%) + Quizalofop ethyl (40%) (T_7) and Imazethapyr (40%) + Quizalofop ethyl (60%) (T_8) but these treatments were at par with each other.

Treatment Weedy check (T_9) recorded significantly higher weed dry matter accumulation.

Table 12. Total weed dry matter accumulations (g/m^2) as influenced by different treatments

Treatment	20 DAS	40 DAS	60 DAS	80 DAS	At Harvest
T_1- Pendimethalin @ 1.5 kg ai/ha (PE) + Imazethapyr @ 75 g ai/ha at 20-30 DAS	5.26	7.92	15.17	22.55	31.02
T_2- Pendimethalin @ 1.5 kg ai/ha (PE) + Quizalofop ethyl @ 50 g ai/ha at 20-30DAS	5.36	8.89	15.51	22.88	32.11
T_3- Pendimethalin @ 1.5 kg ai/ha (PE) + Imazethapyr (50%) + Quizalofop ethly(50%) at 20-30 DAS	5.74	9.62	16.03	23.11	32.94
T_4- Pendimethalin @1.5kg ai/ha (PE) +Imazethapyr (60%)+ Quizalofop ethyl(40%) at 20-30 DAS	5.89	9.55	18.94	25.22	34.45
T_5- Pendimethalin @ 1.5 kg ai/ha (PE) + Imazethapyr (40%) + Quizalofop ethyl (60%) at 20-30DAS	6.01	9.40	18.53	25.86	36.29
T_6- Imazethapyr (50%)+ Quizalofop ethyl (50%) at 20-30 DAS	15.14	12.89	23.19	32.13	40.38
T_7-Imazethapyr (60%) + Quizalofop ethyl (40%) at 20-30 DAS	16.68	13.59	24.05	34.21	44.36
T_8- Imazethapyr (40%)+ Quizalofop ethyl (60%) at 20-30 DAS	17.38	12.86	25.02	28.90	46.59
T_9- Weedy check	23.69	44.76	81.90	83.25	168.27
T_{10}-Weed free	0.60	1.06	1.57	2.26	3.81
S.E(m)±	0.60	0.82	0.76	1.33	1.75
C.D.at 5%	1.80	2.43	2.27	3.97	5.20
G.M	10.17	13.05	23.99	30.03	47.02

The weed dry matter at 40, 60, 80 DAS and at harvest had significantly influenced by different weed control treatments in which Weed free (T_{10}) treatment recorded significantly lowest weed dry matter. The different herbicidal treatments applied, in Pendimethalin @ 1.5 kg ai/ha (PE) + Imazethapyr @ 75 g ai/ha (T_1), which were statistically at par with, Pendimethalin @ 1.5 kg ai/ha (PE) + Quizalofop ethyl @ 50 g ai/ha (T_2),

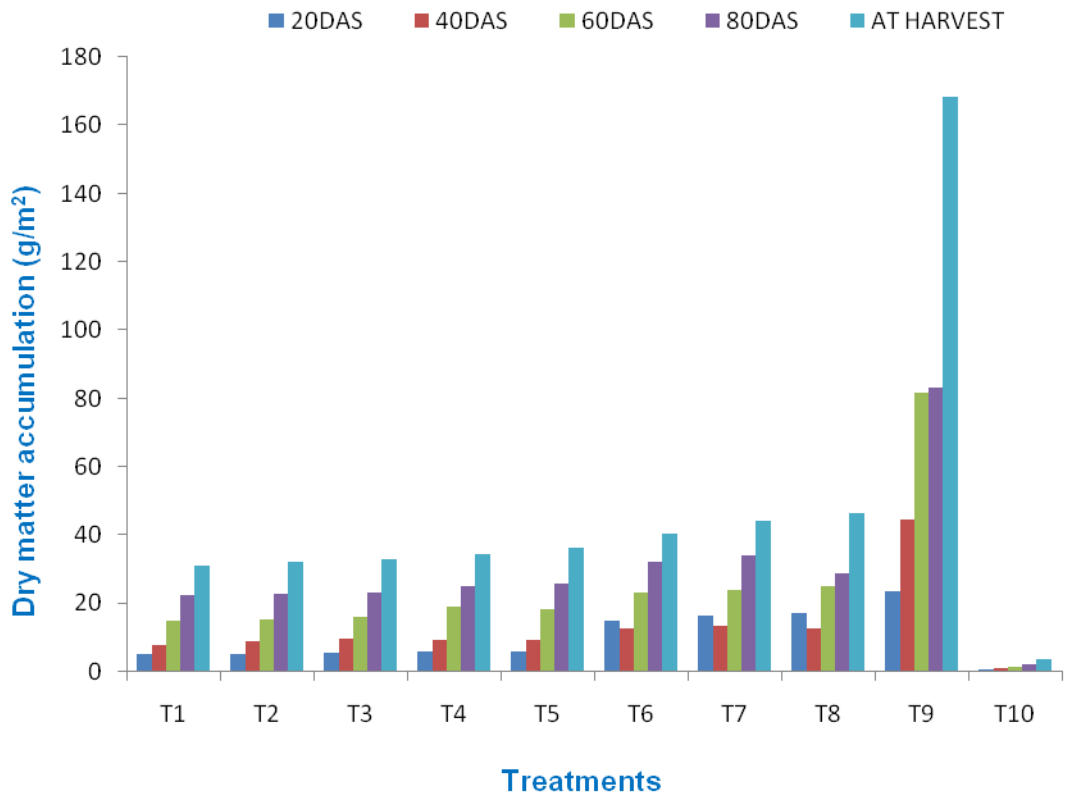


Fig.6. Weed dry matter accumulations (g/m2) as influenced by different treatments

Pendimethalin @ 1.5 kg ai/ha (PE) + Imazethapyr (50%) + Quizalofop ethyl (50%) (T3), Pendimethalin @ 1.5 kg ai/ha (PE) + Imazethapyr (60%) + Quizalofop ethyl (40%) (T_4), Pendimethalin @ 1.5 kg ai/ha (PE) + Imazethapyr (40%) + Quizalofop ethyl (60%) (T_5), and recorded significantly minimum weed dry weight over Imazethapyr (50%) +Quizalofop ethyl (50%) (T_6), Imazethapyr (60%) + Quizalofop ethyl (40%) (T_7) and Imazethapyr (40%) + Quizalofop ethyl (60%) (T_8). However Weedy check plot recorded significantly higher weed dry weight.

The lowest weed dry matter was observed in Weed free (T_{10}) because of keeping weed free environment during different stages of crop growth. Among the herbicidal treatments, highest reduction of weed dry matter was found in Pendimethalin @ 1.5 kg ai/ha (PE) + Imazethapyr @ 75 g ai/ha (T_1). This might be due to the pre-emergence and post-emergence application of herbicides that have longer effect on controlling weed population and brought significant reduction in weed dry matter as compared to weedy check.

4.4.5 Weed control efficiency

Weed control efficiency influenced by different weed control treatments are presented in Table 13

The weed free (T_{10}) treatment recorded highest weed control efficiency from 20 DAS up to at harvest stage , because of keeping weed free environment and found significantly superior over rest of all herbicidal treatments.

Among the herbicidal treatments data revealed that at 20 DAS, the highest weed control efficiency of pre emergence application of Pendimethalin 1.5 kg a.i. ha^{-1} in treatments (T_1), (T_2), (T_3) (T_4) and (T_5) were found at par with each other and Imazethapyr (50%) +Quizalofop ethyl (50%) (T_6), Imazethapyr (60%) + Quizalofop ethyl (40%) (T_7) and Imazethpyr (40%) + Quizalofop ethyl (60%) (T_8) treatment lowest weed control efficiency was observed with treatment.

Maximum weed control efficiency found at 40, 60, 80 DAS and at harvest in treatment Pendimethalin @ 1.5 kg ai/ha (PE) +

Imazethapyr @ 75 g ai/ha (T_1) followed by Pendimethalin @ 1.5 kg ai/ha (PE) + Quizalofop ethyl @ 50 g ai/ha (T_2), Pendimethalin @ 1.5 kg ai/ha (PE) + Imazethapyr (50%) + Quizalofop ethyl (50%) (T3), Pendimethalin @ 1.5 kg ai/ha (PE) + Imazethapyr (60%) + Quizalofop ethyl (40%) (T_4), and Pendimethalin @ 1.5 kg ai/ha (PE) + Imazethapyr (40%) + Quizalofop ethyl (60%) (T_5) treatments. The treatment pre emergence application of Pendimethalin 1.5 kg a.i. ha^{-1} in treatments (T_1), (T_2), (T_3) (T_4) and (T_5) initially record highest weed control efficiency due to pre emergence herbicides.

Table 13. Weed control efficiency (%) and weed index (%) as influenced by different treatments

Treatment	20 DAS	40 DAS	60 DAS	80 DAS	At Harvest	Weed Index
T_1- Pendimethalin @ 1.5 kg ai/ha (PE) + Imazethapyr @ 75 g ai/ha at 20-30 DAS	86.13	88.57	79.62	76.00	72.53	14.33
T_2 - Pendimethalin @ 1.5 kg ai/ha (PE) + Quizalofop ethyl @ 50 g ai/ha at 20-30 DAS	84.61	86.03	76.94	73.73	70.44	16.08
T_3 - Pendimethalin @ 1.5 kg ai/ha (PE) + Imazethapyr (50%) + Quizalofop ethyl (50%) at 20-30 DAS	81.54	83.23	73.68	70.59	67.46	19.10
T_4 - Pendimethalin @ 1.5kg ai/ha (PE) + Imazethapyr (60%) + Quizalofop ethyl (40%) at 20-30 DAS	81.55	84.28	76.08	69.72	66.57	21.97
T_5 - Pendimethalin @ 1.5 kg ai/ha (PE) + Imazethpyr (40%) + Quizalofop ethyl (60%) at 20-30DAS	78.43	83.46	75.44	72.00	68.35	22.28
T_6 - Imazethapyr (50%) + Quizalofop ethyl (50%) at 20-30DAS	35.93	79.91	68.43	67.44	63.28	27.86
T_7 – Imazethapyr (60%)+ Quizalofop ethyl (40%) at 20-30DAS	36.33	76.77	69.85	68.28	64.19	29.31
T_8 - Imazethapyr(40%) + Quizalofop ethyl (60%) at 20-30DAS	28.18	76.82	70.17	68.29	62.69	28.18
T_9- Weedy check	0.00	0.00	0.00	0.00	0.00	56.97
T_{10} -Weed free	94.86	96.08	97.07	96.57	96.41	0.00

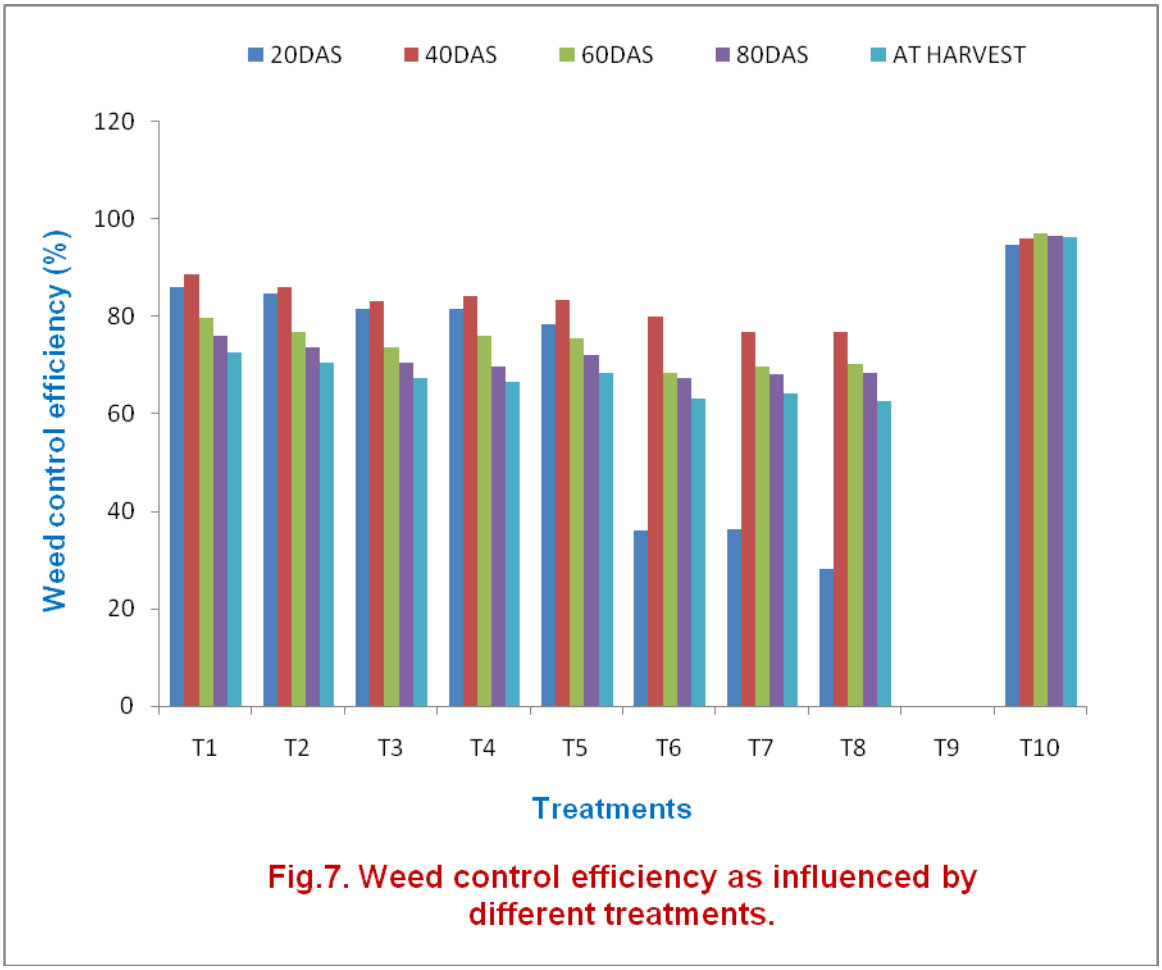


Fig.7. Weed control efficiency as influenced by different treatments.

The highest weed control efficiency was recorded in treatment Weed free (T_{10}) from 20 DAS up to at harvest, because of keeping weed free environment, very less crop-weed competition, minimum weed biomass and found significantly superior over rest of all herbicidal treatments.

Among the various herbicidal treatments Pendimethalin @ 1.5kg ai/ha (PE) + Imazethapyr @ 75 g ai/ha (T_1) recorded maximum weed control efficiency at 40 DAS up to at harvest, might be due to pre-emergence and post-emergence application of herbicides that have longer effect on controlling the monocot as well as dicot weeds population and thereby increasing weed control efficiency. These results are in agreement with the results reported by Malunjkar *et al* (2012),Kumar *et al* (2013).

4.2.6 Weed Index

Data reported weed index (%) are presented in Table 13. weed index was computed as the yield reduction comparative to highest yielding treatment i.e. Weed free (T_{10}).

The herbicidal weed management treatment Pendimethalin @ 1.5 kg ai/ha (PE) + Imazethapyr @ 75 g ai/ha (T_1) recorded minimum weed index (14.33 %). It was followed by Pendimethalin @ 1.5 kg ai/ha (PE) + Quizalofop ethyl @ 50 g ai/ha (T_2) (16.08%), Pendimethalin @ 1.5 kg ai/ha (PE) + Imazethapyr (50%) + Quizalofop ethyl (50%) (T3) (19.10%), Pendimethalin @ 1.5 kg ai/ha (PE) + Imazethapyr (60%) + Quizalofop ethyl (40%) (T_4) (21.97%), Pendimethalin @ 1.5 kg ai/ha (PE) + Imazethapyr (40%) + Quizalofop ethyl (60%) (T_5) (22.28%), Imazethapyr (50%) + Quizalofop ethyl (50%) (T_6) (27.66%), Imazethapyr (40%) + Quizalofop ethyl (60%) (T_8) (28.18%), Imazethapyr (60%) + Quizalofop ethyl (40%) (T_7) (29..31%) and and Weedy check (T_9) (56.97 %).

Treatment Weedy check (T_9) recorded maximum weed index i.e. 56.97% indicating the reduction in groundnut pod yield due to presence of weeds throughout crop growth period.

Imazethapyr (60 %) + Quizolofop ethyl (40 %) PoE 20-30 DAS Phytotoxicity symptoms

Weedy check treatment

Weed free treatment

Plate 2. Effect of different treatment on weed

Lower is the weed index in chemical treatments, better the efficiency of that herbicide in controlling weeds, which provided favourable conditions for crop growth which ultimately increased the pod yield of groundnut crop as compared to weedy check treatment.

4.2.7 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 10 days after application of herbicide in respective treatment.

Table 14. Phytotoxicity symptoms on crop (score 0-10 scale)

Treatment	Rating
T_1- Pendimethalin @1.5kg ai/ha(PE) +Imazethapyr@75g ai/ha at 20-30 DAS	0
T_2 - Pendimethalin @1.5kg ai/ha(PE) +Quizalofop ethyl @50g ai/ha at 20-30 DAS	0
T_3 - Pendimethalin @1.5kg ai/ha(PE)+ Imazethapyr(50%) +Quizalofop ethly(50%) at 20-30 DAS	0
T_4 - Pendimethalin @1.5kg ai/ha(PE) +Imazethapyr (60%) +Quizalofop ethyl(40%) at 20-30 DAS	1
T_5 - Pendimethalin @1.5kg ai/ha(PE) +Imazethapyr(40%) +Quizalofop ethyl (60%) at 20-30DAS	0
T_6 - Imazethapyr(50%)+Quizalofop ethyl (50%) at 20-30DAS	0
T_7 - Imazethapyr(60%)+Quizalofop ethyl (40%) at 20-30DAS	1
T_8 - Imazethapyr(40%)+Quizalofop ethyl (60%) at 20-30DAS	0
T_9- Weedy check	0
T_{10} -Weed free	0

0 – No injury, normal.

1 – Slight stunting, injury discoloration

2 –Some stand loss, stunting or discoloration

3 –Injury more pronounce but not persistent

4 –Moderate injury, recovery possible

The data in table 14 revealed that the herbicides under study shown any phytotoxicity symptoms on crop growth during the experimentation only treatment with tank mix of Imazethapyr (60%)

+Quizalofop ethyl(40%) showed phytotoxicity symptoms on the leaves of groundnut due to higher dose of selective herbicide, effect on growth of plant were recorded.

4.3 Crop studies

4.3.1 Emergence count and plant stand of groundnut

The data relevant that initial plant stand and final plant stand as influenced by different weed management treatments are presented in Table 15.

Table 15. Emergence count and final plant stand at harvest as influenced by different treatments

Treatment	Initial plants stand		Final plants stand	
	Per net Plot	Per Ha	Per Net Plot	Per Ha
T_1 -Pendimethalin @1.5kg ai/ha(PE) +Imazethapyr@75g ai/ha at 20-30 DAS	346	320370	305	282716
T_2 - Pendimethalin @1.5kg ai/ha(PE) +Quizalofop ethyl @50g ai/ha at 20-30DAS	342	316358	300	277778
T_3 - Pendimethalin @1.5kg ai/ha(PE)+ Imazethapyr(50%) +Quizalofop ethyl (50%) at 20-30 DAS	340	314815	299	277160
T_4- Pendimethalin @1.5kg ai/ha(PE) +Imazethpayr (60%)+Quizalofop ethyl(40%) at 20-30 DAS	339	313580	299	276543
T_5- Pendimethalin @1.5kg ai/ha(PE) +Imazethapyr(40%) +Quizalofop ethyl (60%) at 20-30DAS	340	315123	300	277469
T_6 -Imazethapyr(50%)+Quizalofop ethyl (50%) at 20-30 DAS	335	310185	295	273148
T_7- Imazethapyr(60%)+Quizalofop ethyl (40%) at 20- 30 DAS	341	315741	299	277160
T_8- Imazethapyr(40%)+Quizalofop ethyl (60%) at 20-30 DAS	335	310185	296	273765
T_9 - Weedy check	336	311111	296	273765
T_{10}-Weed free	343	317593	302	279630
S.E(m)±	3.34	9114	2.89	2680
C.D.at 5%	NS	NS	NS	NS
G.M	339	314506	299	276913

Data revealed that different weed management treatments had no significant influence on initial and final plant stand, there by indicating uniform emergence and its persistence throughout the crop growth period.

The treatment differences therefore on different parameters under study were treatment effect and plant population was not a variable factor.

4.3.2 Plant height (cm)

The periodical data on plant height (cm) of groundnut as influenced by different weed management treatments are presented in Table 16 and graphically depicted in Fig. 8.

Table 16.Plant height (cm) at periodical growth stages influenced by different treatments

Treatment	20 DAS	40 DAS	60 DAS	80 DAS	At Harvest
T_1- Pendimethalin @ 1.5 kg ai/ha (PE) + Imazethapyr @ 75 g ai/ha at 20-30 DAS	7.76	19.95	22.47	23.27	26.23
T_2- Pendimethalin @ 1.5 kg ai/ha (PE) + Quizalofop ethyl @ 50 g ai/ha at 20-30DAS	7.64	19.53	22.43	22.97	25.37
T_3- Pendimethalin @ 1.5 kg ai/ha (PE) + Imazethapyr (50%) + Quizalofop ethly (50%) at 20-30 DAS	7.73	18.91	21.03	23.07	25.07
T_4 -Pendimethalin @1.5kg ai/ha(PE) +Imazethapyr (60%) +Quizalofop ethyl(40%) at 20-30 DAS	7.52	17.73	20.8	22.53	25.10
T_5- Pendimethalin @ 1.5 kg ai/ha (PE) + Imazethapyr (40%) + Quizalofop ethyl (60%) at 20-30DAS	7.32	17.24	20.79	21.93	24.70
T_6 –Imazethapyr (50%) + Quizalofop ethyl (50%) at 20-30 DAS	7.47	17.42	20.45	23.20	24.53
T_7- Imazethapyr (60%) + Quizalofop ethyl (40%) at 20-30 DAS	7.02	17.95	20.17	22.27	24.33
T_8-Imazethapyr (40%) + Quizalofop ethyl (60%) at 20-30 DAS	6.93	17.04	21.04	22.90	24.77
T_9 -Weedy check	6.95	16.67	19.34	20.60	23.33
T_{10}-Weed free	8.08	21.01	24.87	25.20	27.97
S.E(m)±	0.30	0.78	0.35	0.35	0.52
C.D.at 5%	NS	2.34	1.06	1.06	1.56
G.M	7.45	18.45	21.48	22.99	25.14

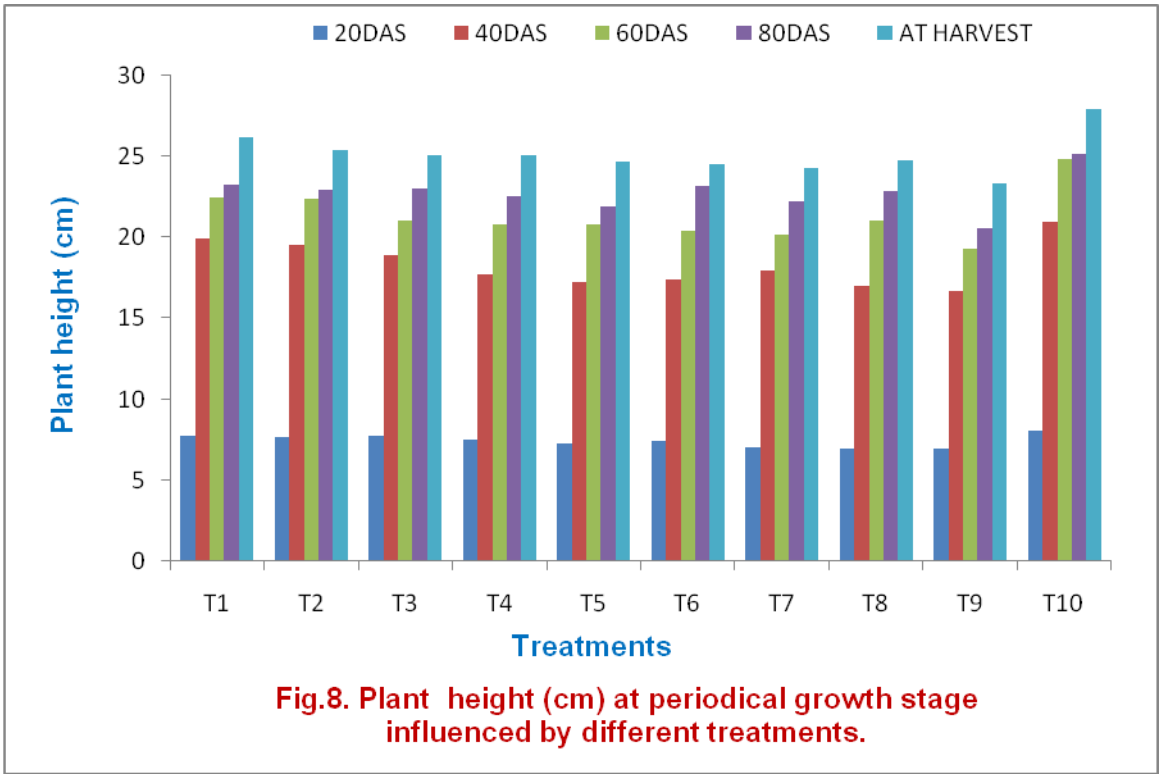


Fig.8. Plant height (cm) at periodical growth stage influenced by different treatments.

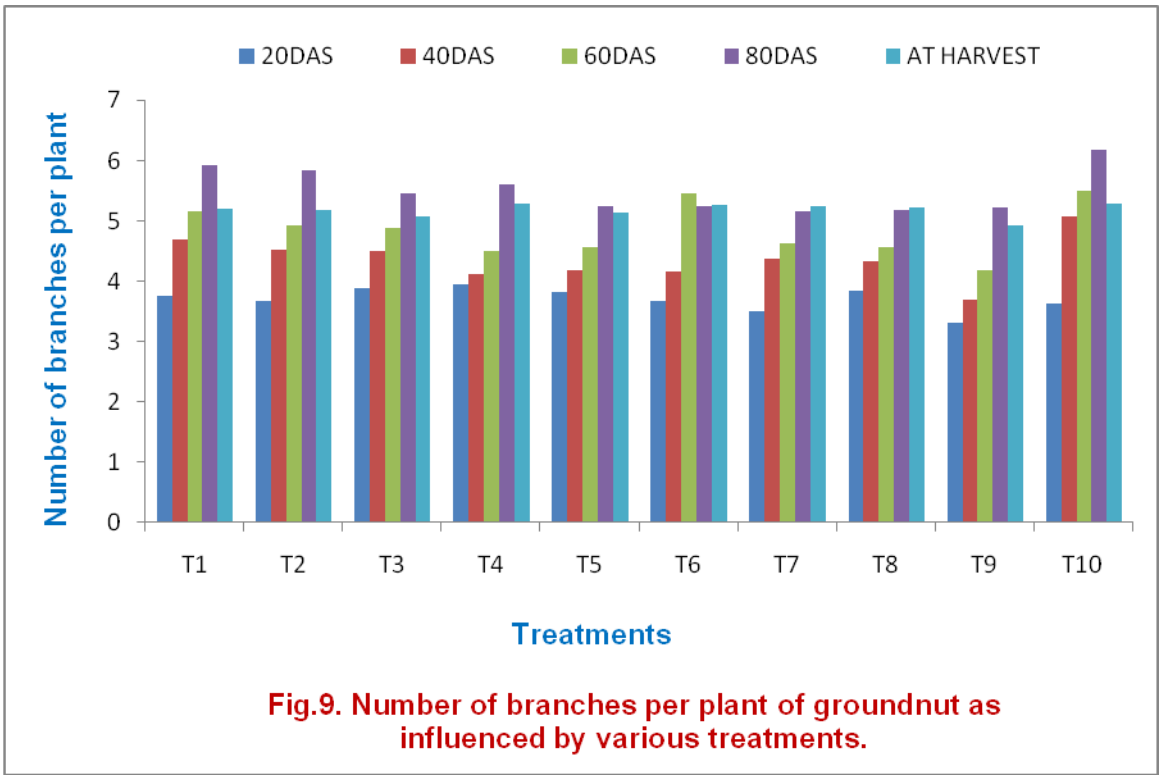


Fig.9. Number of branches per plant of groundnut as influenced by various treatments.

Plant height was gradually increased with advancement in crop age up to harvest stage. The rate of increase in plant height was rapid during early vegetative growth stage.

At 20 DAS, Treatment differences in respect of plant height were non significant initially at 20 DAS only and thereafter it was significantly influenced at all periodical interval up to harvest of crop.

Weed free (T_{10}) recorded significantly higher plant height over rest of the herbicidal treatments. The maximum plant height at 40, 60, 80 and at harvest were recorded with the pre-emergence and post-emergence treatments i.e. Pendimethalin @1.5 kg ai/ha (PE) + Imazethapyr @ 75 g kg a.i. ha^{-1} (T_1) which were statistically at par with Pendimethalin @ 1.5 kg ai/ha (PE) + Quizalofop ethyl @ 50 g a.i. ha^{-1} (T_2), Pendimethalin @ 1.5kg ai/ha (PE)+ Imazethapyr (50%) + Quizalofop ethyl (50%) a.i. ha^{-1} (T_3) as both these treatments achieved maximum plant height as compare to Pendimethalin @ 1.5 kg ai/ha (PE) + Imazethapyr (60%) + Quizalofop ethyl (40%) (T_4), Pendimethalin @ 1.5 kg ai/ha (PE) + Imazethapyr (40%) + Quizalofop ethyl (60%) (T_5), Imazethapyr (50%) + Quizalofop ethyl (50%) (T6), Imazethapyr (60%) + Quizalofop ethyl (40%) ($T_{7)}$, Imazethapyr (40%) + Quizalofop ethyl (60%) (T_8),The Weed check (T_9) recorded significantly supressed the plant height of groundnut.

The increase in plant height of groundnut under treatment Weed free(T_{10}) and treatment Pendimethalin @1.5 kg ai/ha(PE)+ Imazethapyr @75 g a.i. ha^{-1} (T_1) might be due to the least weed population observed in these treatments, which reduced the crop weed competition. Significant reduction in plant height was noticed in Weed check (T_9) treatment. This might be due to the maximum 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 kalhapure *et al. (*2013).

4.3.3 Number of branches per plant

Data in respect of mean number of branches as influenced by different treatment at various stages of crop growth are presented in table 17 and graphically presented in Fig 9.

Table 17. Number of branches per plant of groundnut as influenced by various treatments

Treatment	20 DAS	40 DAS	60 DAS	80 DAS	At Harvest
T_1 - Pendimethalin @ 1.5 kg ai/ha (PE) + Imazethapyr @75 g ai/ha at 20-30 DAS	3.75	4.69	5.15	5.92	5.19
T_2 -Pendimethalin @ 1.5 kg ai/ha (PE) + Quizalofop ethyl @ 50 g ai/ha at 20-30DAS	3.66	4.50	4.91	5.83	5.16
T_3 - Pendimethalin @ 1.5 kg ai/ha(PE)+ Imazethapyr (50%) + Quizalofop ethly (50%) at 20-30 DAS	3.88	4.49	4.88	5.44	5.06
T_4 - Pendimethalin @1.5 kg ai/ha(PE) + Imazethapyr (60%) + Quizalofop ethyl (40%) at 20-30 DAS	3.93	4.11	4.49	5.60	5.28
T_5 - Pendimethalin @ 1.5 kg ai/ha (PE) + Imazethapyr (40%) + Quizalofop ethyl (60%) at 20-30DAS	3.80	4.17	4.56	5.24	5.13
T_6 – Imazethapyr (50%) + Quizalofop ethyl (50%) at 20-30DAS	3.67	4.15	5.44	5.23	5.26
T_7 – Imazethapyr (60%) + Quizalofop ethyl (40%) at 20-30DAS	3.48	4.36	4.61	5.14	5.23
T_8 – Imazethapyr (40%) + Quizalofop ethyl (60%) at 20-30DAS	3.84	4.32	4.55	5.18	5.21
T_9 -Weedy check	3.30	3.68	4.17	5.21	4.92
T_{10} -Weed free	3.61	5.07	5.50	6.16	5.27
S.E(m)±	0.12	0.31	0.21	0.21	0.20
C.D.at 5%	NS	0.92	0.65	0.63	0.61
G.M	3.69	4.35	4.82	5.49	5.17

Data indicates that with the advancement in age of crop, the mean number of branches also increased progressively but increments was very small.

The effect of treatments on mean number of branches were found to be significant at all the stages of crop growth. The rate of increased in number of branches per plant were rapid during 20-80 DAS and slow after 80 DAS onwards. The mean number of branches at harvest were (5.17).

Treatment differences in respect of number of branches plant^{-1} were non significant initially at 20 DAS only and thereafter it was significantly influenced at all periodical interval up to harvest of crop.

Weed free (T_{10}) recorded significantly higher branches plant^{-1} over rest of the herbicidal treatments. The maximum number of branches plant^{-1} at 40, 60, 80 and at harvest were recorded with the pre- emergence and post-emergence treatments i.e Pendimethalin @ 1.5 kg ai/ha (PE) + Imazethapyr @75 g i.e. a.i. ha^{-1} (T_1) which were statistically at par with Pendimethalin @ 1.5 kg ai/ha (PE) + Quizalofop ethyl @ 50 g a.i. ha^{-1} (T_2), Pendimethalin @ 1.5 kg ai/ha (PE) + Imazethapyr (50%) + Quizalofop ethyl (50%) a.i. ha^{-1} (T_3) as both these treatments achieved maximum plant height as compare to Pendimethalin @ 1.5 kgai/ha (PE) + Imazethapyr (60%) + Quizalofopethyl (40%) (T_4), Pendimethalin @ 1.5kg ai/ha (PE) + Imazethapyr (40%) + Quizalofop ethyl (60%) (T_5), Imazethapyr (50%) + Quizalofop ethyl (50%) (T6), Imazethapyr (60%) + Quizalofop ethyl (40%) ($T_{7)}$, Imazethapyr (40%) + Quizalofop ethyl (60%) (T_8),The Weed check (T_9) recorded significantly Lowest number of branches the branches plant^{-1} of groundnut.

The increase in number of branches plant^{-1} of groundnut under treatment Weed free (T_{10}) and treatment i.e Pendimethalin @1.5kg ai/ha (PE) + Imazethapyr @ 75 g a.i. ha^{-1} (T_1) might be due to the least weed population observed in these treatments, which reduced the crop weed competition. Significant reduction in branches plant^{-1} was noticed in unweeded plot. This might be due maximum 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 kalhapure *et al. (*2013).

4.3.4 Number of nodules per plant

The data on mean number of root nodules as influenced by various treatments at different growth stages of crop growth are presented table 18 and graphically presented in Fig 10.

Table 18.Number of root nodules per plant of groundnut as influenced by various treatments

Treatment	20 DAS	40 DAS	60 DAS	80 DAS	At Harvest
T_1 - Pendimethalin @ 1.5 kg ai/ha (PE) + Imazethpyr @ 75 g ai/ha at 20-30 DAS	9.75	29.93	41.17	44.87	42.84
T_2 - Pendimethalin @ 1.5 kg ai/ha (PE) + Quizalofop ethyl @ 50 g ai/ha at 20-30DAS	9.71	29.69	40.91	44.19	42.75
T_3 - Pendimethalin @1.5 kg ai/ha (PE) + Imazethapyr (50%) + Quizalofop ethly (50%) at 20-30 DAS	9.62	29.15	40.80	43.71	41.91
T_4 - Pendimethalin @ 1.5 kg ai/ha (PE) + Imazethapyr (60%) + Quizalofop ethyl (40%) at 20-30 DAS	9.54	29.14	39.28	42.56	41.06
T_5 - Pendimethalin @ 1.5 kg ai/ha (PE) + Imazethapyr (40%) + Quizalofop ethyl (60%) at 20-30DAS	9.55	29.12	39.24	42.46	41.14
T_6 - Imazethapyr (50%) + Quizalofop ethyl (50%) at 20-30DAS	9.39	28.19	39.37	42.85	41.07
T_7 - Imazethapyr (60%) + Quizalofop ethyl (40%) at 20-30DAS	9.39	28.81	39.14	42.65	40.91
T_8 – Imazethapyr (40%) + Quizalofop ethyl (60%) at 20-30DAS	9.26	28.88	39.24	41.80	41.30
T_9 - Weedy check	9.20	27.84	35.83	36.01	34.78
T_{10} - Weed free	9.98	31.61	44.19	49.25	47.75
S.E(m)±	0.16	0.33	0.70	0.91	0.30
C.D.at 5%	NS	0.98	2.10	2.71	0.43
G.M	9.53	29.23	39.91	43.03	41.55

Treatment differences in respect of number of root nodules plant^{-1} were non-significant initially at 20 DAS only and thereafter it was significantly influenced at all periodical interval up to harvest of crop.

The weed free (T_{10}) treatment recorded significantly maximum number of root nodules plant^{-1} over rest of the herbicidal treatments. The maximum root nodules plant^{-1} at 40, 60, and 80 were recorded with the pre-emergence and post-emergence herbicidal

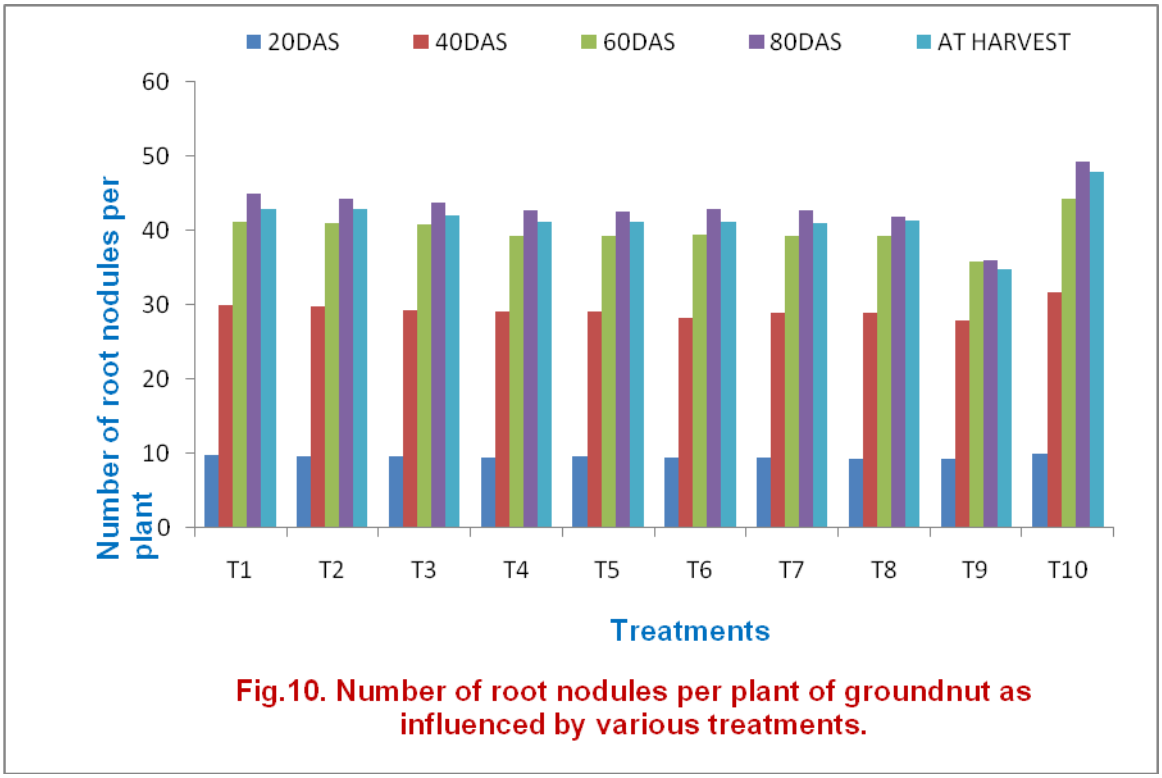


Fig.10. Number of root nodules per plant of groundnut as influenced by various treatments.

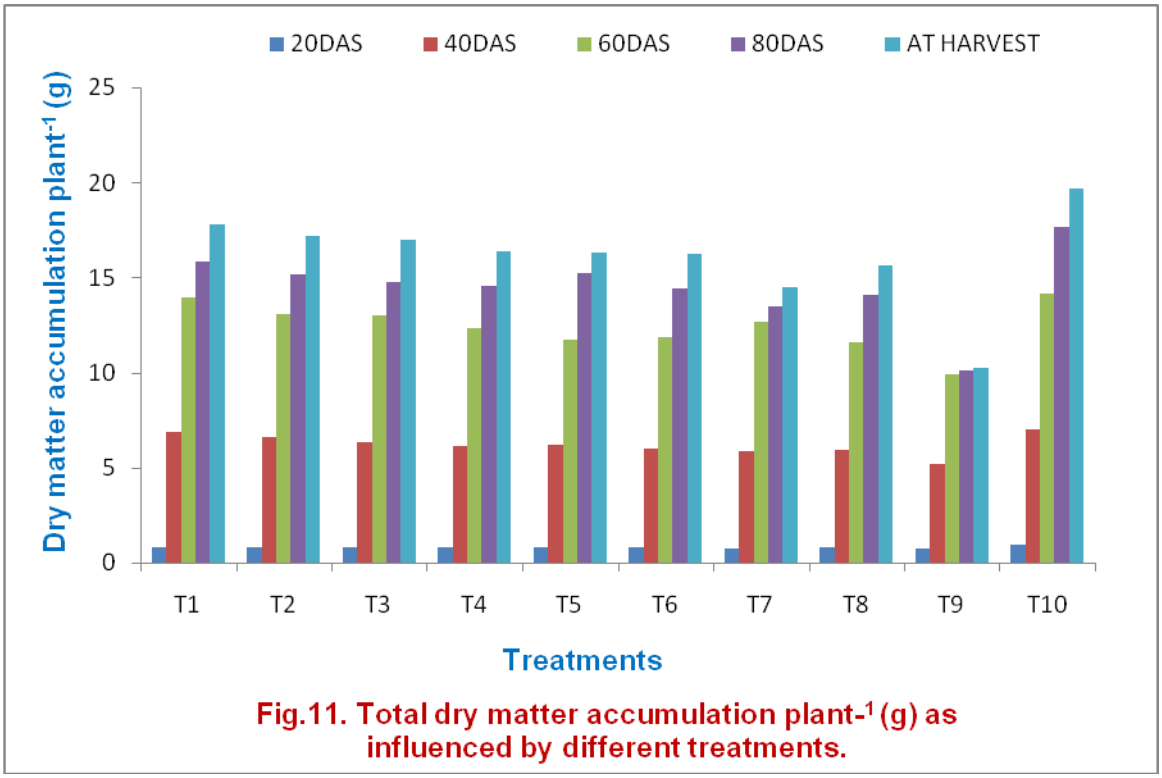


Fig.11. Total dry matter accumulation plant^{-1} (g) as influenced by different treatments.

treatment i.e. i.e Pendimethalin @ 1.5 kg ai/ha (PE) + Imazethapyr @ 75 g a.i. ha^{-1} (T_1) which was statistically at par with Pendimethalin @ 1.5 kg ai/ha (PE) + Quizalofop ethyl @ 50 g a.i. ha^{-1} (T_2), Pendimethalin @ 1.5 kg ai/ha (PE) + Imazethapyr (50%) + Quizalofop ethyl (50%) a.i. ha^{-1} (T_3) as both these treatments achieved maximum root nodule as compare to Pendimethalin @1.5 kgai/ha (PE) + Imazethapyr (60%) + Quizalofop ethyl (40%) (T_4), Pendimethalin @1.5 kg ai/ha (PE) + Imazethapyr (40%) + Quizalofop ethyl (60%) (T_5), Imazethapyr (50%) + Quizalofop ethyl (50%) (T6), Imazethapyr (60%) + Quizalofop ethyl (40%) ($T_{7)}$, Imazethapyr (40%) + Quizalofop ethyl (60%) (T_8). The Weed check (T_9) recorded significantly less number of the root nodules $plant^{-1}$ of groundnut. After 80 DAS root nodule decrease at harvest stage.

Different weed management practices significantly improved the root nodules over weedy check, this might be due to the increased stem size and root size as a result of reduced weed population in these treatments causing favourable soil moisture and nutrient availability which helps in rapid cell development. These results are in conformity with the findings of kalhapure *et al. (*2013).

4.3.5 Dry matter accumulation $plant^{-1}$

Data in respect of dry matter accumulation $plant^{-1}$ as influenced by different treatments are presented in Table 19 and graphically depicted in Fig. 11.

The data revealed that the total dry matter $plant^{-1}$ of groundnut increased gradually at every stages of crop growth up to maturity.

All the weed control treatments significantly influenced the dry matter accumulation $plant^{-1}$ at all the growth stages of crop.

At 20 DAS, treatment Weed free (T_{10}) recorded significantly maximum dry matter over rest of the treatments. The herbicidal treatment Pendimethalin @ 1.5 kg ai/ha (PE) + Imazethapyr @ 75 g kg a.i. ha^{-1} (T_1) Pendimethalin @ 1.5 kg ai/ha (PE) + Quizalofop ethyl @ 50 g a.i. ha^{-1} (T_2), and Pendimethalin @ 1.5 kg ai/ha (PE) + Imazethapyr (50%) + Quizalofop

ethyl (50%) a.i. ha^{-1} (T_3) which were statistically on par with each other and recorded high dry matter per plant, followed by Pendimethalin @ 1.5 kg ai/ha (PE) + Imazethapyr (60%) + Quizalofopethyl (40%) (T_4), Pendimethalin @ 1.5 kg ai/ha (PE) + Imazethapyr (40%) + Quizalofop ethyl (60%) (T_5), Imazethapyr (50%) + Quizalofop ethyl (50%) (T6), Imazethapyr (60%) + Quizalofop ethyl (40%) ($T_{7)}$, Imazethapyr (40%) + Quizalofop ethyl (60%) (T_8). Treatment Weedy check (T_9) recorded minimum plant dry weight.

Table 19. Total dry matter accumulation $plant^{-1}$ (g) as influenced by different treatments

Treatment	20 DAS	40 DAS	60 DAS	80 DAS	At Harvest
T_1 -Pendimethalin @ 1.5 kg ai/ha (PE) + Imazethapyr @ 75 g ai/ha at 20-30 DAS	0.83	6.85	13.97	15.86	17.79
T_2 -Pendimethalin @ 1.5 kg ai/ha (PE) + Quizalofop ethyl @ 50 g ai/ha at 20-30DAS	0.82	6.58	13.05	15.16	17.15
T_3 -Pendimethalin @ 1.5 kg ai/ha (PE) + Imazethapyr (50%) + Quizalofop ethyl (50%) at 20-30 DAS	0.80	6.36	13.02	14.77	16.96
T_4- Pendimethalin @ 1.5 kg ai/ha (PE) + Imazethapyr (60%) + Quizalofop ethyl (40%) at 20-30 DAS	0.79	6.14	12.33	14.55	16.36
T_5 - Pendimethalin @ 1.5 kg ai/ha (PE) + Imazethapyr (40%) + Quizalofop ethyl (60%) at 20-30DAS	0.81	6.19	11.74	15.22	16.33
T_6 –Imazethapyr (50%) + Quizalofop ethyl (50%) at 20-30 DAS	0.80	5.97	11.87	14.39	16.23
T_7 –Imazethapyr (60%) + Quizalofop ethyl (40%) at 20-30 DAS	0.76	5.84	12.65	13.49	14.46
T_8-Imazethapyr (40%) + Quizalofop ethyl (60%) at 20-30 DAS	0.81	5.92	11.57	14.11	15.60
T_9 -Weedy check	0.74	5.20	9.90	10.11	10.22
T_{10}-Weed free	0.91	6.98	14.14	17.66	19.70
S.E(m)±	0.03	0.15	0.32	0.56	0.30
C.D.at 5%	0.10	0.47	0.96	1.66	0.89
G.M	0.80	6.20	12.42	14.53	16.07

The crop accumulated plant dry matter at 40, 60, 80 DAS and at harvest significantly higher in treatment Weed free (T_{10}). Among the herbicidal treatment Pendimethalin @1.5 kg ai/ha (PE) + Imazethapyr @

75 g kg a.i. ha^{-1} (T_1) recorded significantly higher plant dry matter but statistically at par with treatment Pendimethalin @ 1.5 kg ai/ha (PE) + Quizalofop ethyl @ 50 g a.i. ha^{-1} (T_2) and Pendimethalin @ 1.5kg ai/ha (PE) + Imazethapyr (50%) + Quizalofop ethyl (50%) a.i. ha^{-1} (T_3) and it was followed by Pendimethalin @ 1.5 kg ai/ha (PE) + Imazethapyr (60%) + Quizalofop ethyl (40%) (T_4),

Pendimethalin @ 1.5 kg ai/ha (PE) + Imazethapyr (40%) + Quizalofop ethyl (60%) (T_5), Imazethapyr (50%) + Quizalofop ethyl (50%) (T6), Imazethapyr (60%) + Quizalofop ethyl (40%) ($T_{7)}$, Imazethapyr (40%) + Quizalofop ethyl (60%) (T_8). The treatment Weedy check (T_9) recorded significantly lower plant dry matter.

The higher dry matter accumulation in treatments Weed free (T_{10}) and Pendimethalin @1.5 kg ai/ha (PE) + Imazethapyr @ 75 g kg a.i. ha^{-1} (T_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 Weed check treatment. These results are in conformation with the findings of Kalhapure *et al*. (2013).

4.3.6 Days to 50 per cent flowering

The data pertaining to number of days required for 50 per cent flowering as influenced by different treatments are presented in Table 20. Mean number of days required for 50 per cent flowering were 30.04days.

The data presented in Table 20 showed that herbicide treatments had non-significant effect on number of days required for 50 per cent flowering. Flowering in groundnut might not be influenced with application of different herbicidal treatment, as flowering character of any crop is a genetically controlled.

Table 20. Days to 50 per cent flowering of *kharif* Groundnut as influenced by various treatments

Treatment	Days to 50% flowering
T_1 - Pendimethalin @ 1.5 kg ai/ha (PE) + Imazethapyr @ 75 g ai/ha at 20-30 DAS	31.00
T_2 - Pendimethalin @1.5 kg ai/ha (PE) + Quizalofop ethyl @ 50 g ai/ha at 20-30DAS	30.67
T_3 - Pendimethalin @ 1.5 kg ai/ha (PE) + Imazethapyr (50%) +Quizalofop ethly (50%) at 20-30 DAS	30.00
T_4 - Pendimethalin @ 1.5 kg ai/ha (PE) + Imazethapyr (60%) + Quizalofop ethyl (40%) at 20-30 DAS	29.67
T_5 - Pendimethalin @ 1.5 kg ai/ha (PE) + Imazethapyr(40%) + Quizalofop ethyl (60%) at 20-30DAS	30.67
T_6 – Imazethapyr (50%) + Quizalofop ethyl (50%) at 20-30DAS	30.00
T_7 - Imazethapyr (60%) + Quizalofop ethyl (40%) at 20-30DAS	30.00
T_8 – Imazethapyr (40%) + Quizalofop ethyl (60%) at 20-30DAS	30.67
T_9 - Weedy check	30.00
T_{10}-Weed free	31.33
S.E(m)±	0.62
C.D.at 5%	NS
G.M	30.04

4.4 Post harvest studies

4.4.1 Number of pods

Data pertaining to the number of developed and undeveloped pods per plant as influenced by the various treatments of weed control are presented in table 21 and graphically presented in Fig. 12.

The maximum number of developed pods were observed in weed free (T_{10}) treatment followed by pre-emergence and post-emergence application of Pendimethalin @1.5 kg ai/ha (PE) + Imazethapyr @ 75 g kg a.i. ha^{-1} (T_1), which was significantly better than rest of the treatments. The least number of developed pods were observed in Weedy check (T_9) because of greater competition of weeds.

The maximum number of undeveloped pods were observed in Weedy check (T_9) due to higher crop weed competition.

Table 21. Number of developed and undeveloped pods at harvest as influenced by various treatments

Treatment	Number of developed pods	Number of undeveloped pods
T_1 - Pendimethalin @1.5kg ai/ha(PE)+Imazethapyr@75g ai/ha at 20-30 DAS	24.53	5.60
T_2 - Pendimethalin @1.5kg ai/ha(PE)+Quizalofop ethyl @50g ai/ha at 20-30DAS	22.80	5.13
T_3 - Pendimethalin @1.5kg ai/ha(PE)+ Imazethapyr (50%) +Quizalofop ethly(50%) at 20-30 DAS	21.27	5.93
T_4 - Pendimethalin @1.5kg ai/ha(PE)+Imazethapyr (60%) +Quizalofop ethyl(40%) at 20-30 DAS	20.60	6.73
T_5 - Pendimethalin @1.5kg ai/ha(PE)+Imazethapyr (40%) +Quizalofop ethyl (60%) at 20-30DAS	20.93	5.73
T_6 - Imazethapyr(50%)+Quizalofop ethyl (50%) at 20-30DAS	18.53	6.20
T_7 - Imazethapyr(60%)+Quizalofop ethyl (40%) at 20-30DAS	17.53	6.60
T_8 - Imazethapyr(40%)+Quizalofop ethyl (60%) at 20-30DAS	20.20	6.07
T_9 - Weedy check	16.03	6.67
T_{10}- Weed free	25.37	5.20
S.E(m)±	1.19	0.46
C.D.at 5%	3.53	1.39
G.M	20.78	5.98

Treatment Weedy check (T_9) recorded lowest developed pod per plant because of higher weed crop competition. Weed free (T_{10}) and Pendimethalin @1.5kg ai/ha (PE) + Imazethapyr @ 75 g kg a.i. ha^{-1} (T_1) observed better developed pods due to less crop weed competition and better weed control practices.

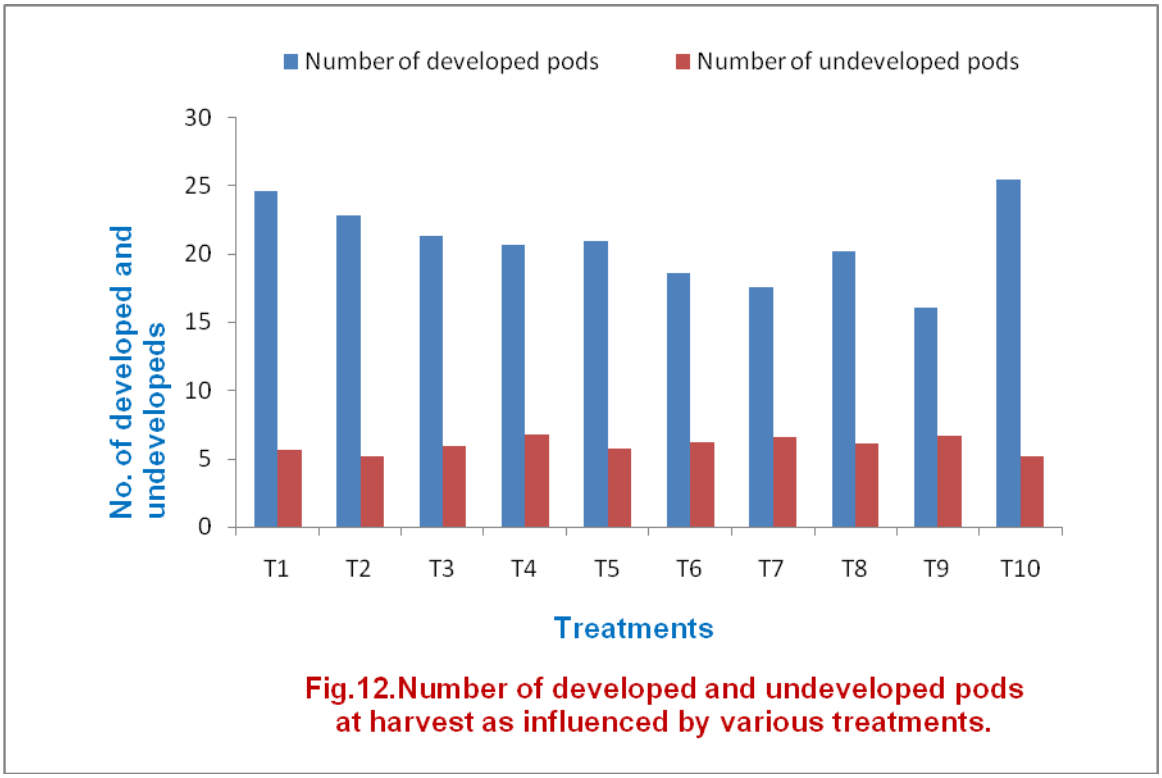


Fig.12.Number of developed and undeveloped pods at harvest as influenced by various treatments.

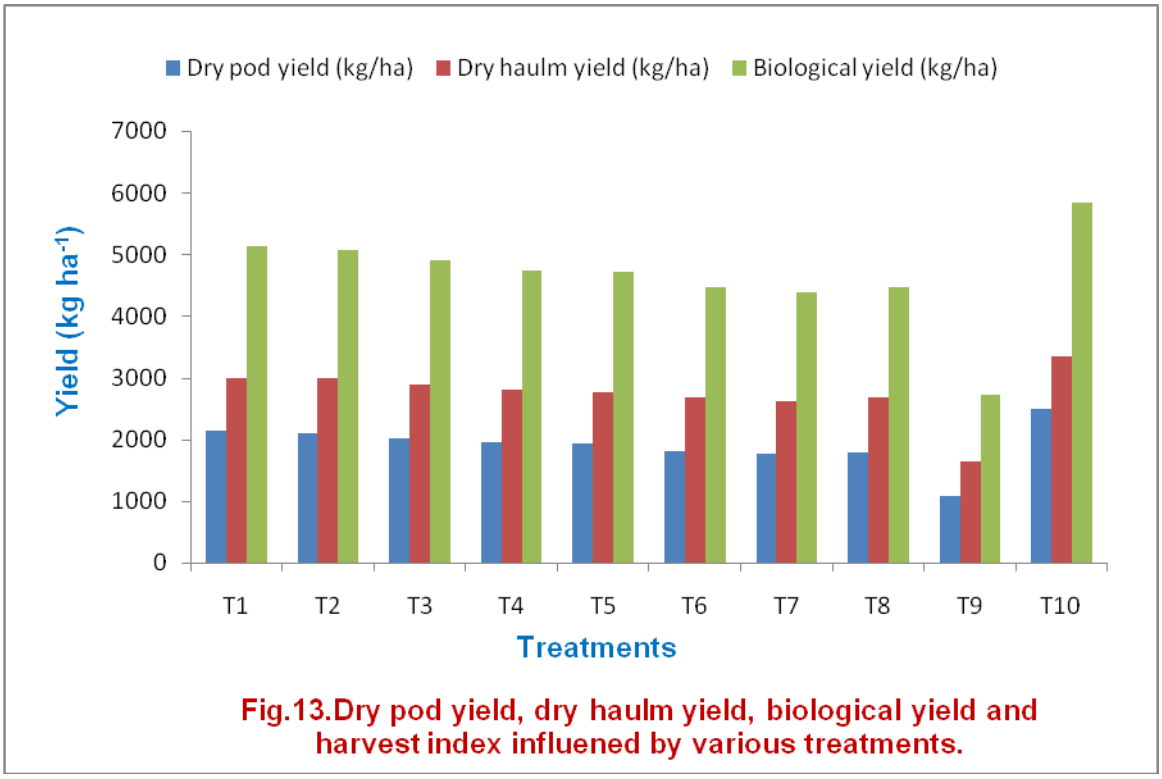


Fig.13.Dry pod yield, dry haulm yield, biological yield and harvest index influened by various treatments.

4.4.2 Yield studies

The data pertaining to pod yield and haulm yield are presented in Table 22 and graphically depicted in Fig. 13.

Table 22. Dry pod yield (kg ha^{-1}), haulm yield (kg ha^{-1}), biological yield (kg ha$^{-1)}$ and harvest index influenced by various treatments

Treatment	Dry pod yield (Kg/ha)	Dry Halum yield (Kg/ha)	Biological yield (Kg/ha)	Harvest Index(%)
T1- Pendimethalin @ 1.5 kgai/ha (PE) + Imazethapyr @ 75 g ai/ha at 20-30 DAS	2135	3000	5135	41.58
T_2 -Pendimethalin @ 1.5 kg ai/ha (PE) + Quizalofop ethyl @ 50 g ai/ha at 20-30DAS	2091	2984	5075	41.20
T_3 - Pendimethalin @ 1.5 kgai/ha (PE) + Imazethapyr (50%) +Quizalofop ethly(50%) at 20-30 DAS	2016	2881	4897	41.17
T_4 - Pendimethalin @ 1.5 kg ai/ha (PE) + Imazethapyr (60%) + Quizalofop ethyl(40%) at 20-30 DAS	1944	2794	4738	41.04
T_5- Pendimethalin @ 1.5 kg ai/ha (PE) + Imazethapyr (40%) + Quizalofop ethyl (60%) at 20-30DAS	1937	2770	4706	41.14
T_6 – Imazethapyr (50%) + Quizalofop ethyl (50%) at 20-30 DAS	1798	2679	4476	40.19
T_7-Imazethapyr (60%) + Quizalofop ethyl (40%) at 20-30DAS	1762	2615	4377	40.25
T_8- Imazethapyr (40%) + Quizalofop ethyl (60%) at 20-30 DAS	1790	2679	4468	40.05
T_9 - Weedy check	1072	1651	2723	39.40
T_{10}-Weed free	2492	3349	5841	42.67
S.E(m)±	21.98	41.37	45.15	0.50
C.D.at 5%	65.33	122.91	134.15	1.49
G.M	1903	2740	4643	40.86

4.4.2.1 Pods yield

Data related to pod yield (kg plot^{-1}) of groundnut was significantly influenced by various weed control treatments. The mean pod yield of groundnut was 1.59 kg plot^{-1}. Treatment Weed free (T_{10}) produced

significantly higher groundnut pod yield (2.09 kg plot^{-1}) followed by pre-emergence and post-emergence Pendimethalin @ 1.5 kg ai/ha (PE) + Imazethapyr @ 75 g kg a.i. ha^{-1} (T_1) (1.79 kg plot^{-1}), Pendimethalin @ 1.5 kg ai/ha (PE) + Quizalofop ethyl @ 50 g a.i. ha^{-1} (T_2) (1.76 kg plot^{-1}), Pendimethalin @ 1.5 kg ai/ha (PE) + Imazethapyr (50%) + Quizalofop ethyl (50%) a.i. ha^{-1} (T_3) (1.69 kg plot^{-1}), Pendimethalin @ 1.5 kg ai/ha (PE) + Imazethapyr (60%) + Quizalofop ethyl (40%) (T_4) (1.63 kg plot^{-1}), Pendimethalin @ 1.5 kg ai/ha (PE) + Imazethapyr (40%) + Quizalofop ethyl (60%) (T_5) (1.63 kg plot^{-1}), which was at par with each other. The minimum pod weight per plant was observed in Weedy check (T_9) treatment.

Data on mean yield of dry pods per hectare as affected by various treatments showed that Weed free (T_{10}) treatment gave highest pod yield (2496 kg ha^{-1}) followed by pre-emergence and post-emergence application Pendimethalin @ 1.5kg ai/ha (PE) + Imazethapyr @ 75 g kg a.i. ha^{-1} (2135 kg ha^{-1}), Pendimethalin @ 1.5 kg ai/ha (PE) + Quizalofop ethyl @ 50 g a.i. ha^{-1} (T_2) (2091 kg ha^{-1}) and Pendimethalin @ 1.5 kg ai/ha (PE) + Imazethapyr (50%) + Quizalofop ethyl (50%) a.i. ha^{-1} (T_3) (2016 kg ha^{-1}) which were statistically at par with each other and significantly higher over rest of treatments. The subsequent higher values of pod yield were recorded Imazethapyr (50%) + Quizalofop ethyl (50%) ($T_{6)}$ (1798 kg ha^{-1}) Imazethapyr (40%) + Quizalofop ethyl (60%) (T_8) (1790 kg ha^{-1}) Imazethapyr (60%) + Quizalofop ethyl (40%) (T_7) (1762 kg ha^{-1}), and. The lowest yield was recorded in Weedy check (T_9) (1072 Kg ha^{-1}). The post-emergence application of Imazethapyr (60%) +Quizalofop ethyl (40%) (T_7) recorded lowest pod yield as compared to other herbicidal treatment due to lowest weed control at different crop growth stage. These results are in accordance with the results reported by Kalhapure *et al*. (2013).

4.4.2.2 Haulm yield

Data pertaining to haulm yield of groundnut as influenced by different weed control treatments are presented in Table 22.

The mean haulm yield of groundnut was (2740 kg ha^{-1}). However the treatment Weed free (T_{10}) produced significantly more haulm yield (3349 kg ha^{-1}) as compared to rest of the treatments followed by pre-emergence and post emergence application Pendimethalin @ 1.5kg ai/ha (PE) + Imazethapyr @ 75g kg a.i. ha^{-1} (3000 kg ha^{-1}), Pendimethalin @1.5kg ai/ha (PE) + Quizalofop ethyl @ 50 g a.i. ha^{-1} (T_2) (2984 kg ha^{-1}) Pendimethalin @ 1.5kg ai/ha (PE) + Imazethapyr (50%) + Quizalofop ethyl (50%) a.i. ha^{-1} (T_3) (2881 kg ha^{-1}) Pendimethalin @ 1.5kg ai/ha (PE) + Imazethapyr (60%) + Quizalofop ethyl (40%) (T_4) (2794 kg ha^{-1}) Pendimethalin @ 1.5 kg ai/ha (PE) + Imazethapyr (40%) + Quizalofop ethyl (60%) (T_5) (2770 kg ha^{-1}), which were at par with each other and significantly higher over rest of treatments. The subsequent higher values of haulm yield was recorded Imazethapyr (50%) + Quizalofop ethyl (50%) (T_6) (2679 kg ha^{-1}) ,Imazethapyr (40%) + Quizalofop ethyl (60%) (T_8) (2679 kg ha^{-1}) Imazethapyr (60%) + Quizalofop ethyl (40%) (T_7) (2615 kg ha^{-1}) . The lowest yield was recorded in Weedy check (T_9) (1651 kg ha^{-1}). The post-emergence application of Imazethapyr (60%) +Quizalofop ethyl (40%) a.i. ha^{-1} (T_7) recorded lowest haulm yield as compared to other herbicidal treatment due to lowest weed control in crop growth stage. The lowest groundnut haulm yield was recorded by Weedy check (T_9) (1651 kg ha^{-1}).These results are in accordance with the results reported by Kalhapure *et al*. (2013).

4.4.2.3 Biological yields

Data showed that the biological yield of groundnut as influenced due to different weed control treatments are presented in Table 22. The highest biological yield was obtained in treatment Weed free (T_{10}) (5841 kg ha^{-1}) and lowest biological yield was recorded in Weedy check (T_9) (2723 kg ha^{-1}).

Increase in biological yield of groundnut might be due to less crop weed competition and luxurious crop growth in the herbicidal treatments Kalhapure *et al*. (2013**).**

4.4.2.4 Harvest Index

Data presented in Table 22 indicated that harvest index influenced by various weed control treatments. The highest harvest index was recorded in treatment weed free (T_{10}) (42.67%). followed by treatments Pendimethalin @ 1.5 kg ai/ha (PE) + Imazethapyr @ 75 g a.i. ha^{-1} (41.58%) while lowest in weed check (T_9) (39.40 %).

4.4.3 Qualities studies

4.4.3.1 100 kernels weight

Data in respect of index weight (100 kernel weight) as influenced by various treatments in table 23 and graphically presented in fig. 13 Above data showed that the highest index weight was observed in case of Weed free (T_{10}) (49.69 g) followed by pre-emergence and post-emergence applicationof Pendimethalin @1.5 kg ai/ha (PE) + Imazethapyr @ 75 g a.i. ha^{-1} (T_1) (43.61 g) which was significant over rest of treatment. The lowest index weight was recorded in Weedy check (T_9) (39.79 g) because of unfavorable condition for better growth of crop resulted in smaller kernel size.

4.4.3.2 Shelling percentage

The data regarding to shelling percentage as influenced by various treatments showed that shelling percentage was not influenced by various weed control treatment. The highest shelling percentage was observed in Weed free (T_{10}) (68.00%) followed by pre-emergence and post emergence applicationof Pendimethalin @1.5 kg ai/ha (PE) + Imazethapyr @ 75 g a.i. ha^{-1} (T_1) (67.19%) was due to better development of kernels. The lowest shelling percentage was observed in Weedy check (T_9) (60.72%) due to poor development of kernels.

4.4.3.3 Oil content and oil yield

The data pertaining to oil content did not show significant differences among treatments. Numerically maximum oil content in seed was observed in treatment Weed free (T_{10}) (48.32 %) followed by treatment

Pendimethalin @1.5 kg ai/ha (PE) + Imazethapyr @ 75 g a.i. ha^{-1}(T_1) (48.19 %) while treatment Weedy check (T_9) (47.04 %) recorded minimum oil content. But oil yield was significantly influenced by various treatments due to significant differences among treatments in respect of pod yield.

Table 23. 100 kernels weight, shelling percentage, and oil content an influenced by different treatments

Treatment	100 Kernels weight(g)	Shelling (%)	Oil content (%)	Oil yield (Kg/ha)
T_1 - Pendimethalin @ 1.5 kg ai/ha (PE) + Imazethapyr @ 75 g ai/ha at 20-30 DAS	43.61	67.19	48.19	1028.7
T_2 - Pendimethalin @ 1.5 kg ai/ha (PE) + Quizalofop ethyl @ 50 g ai/ha at 20-30DAS	41.73	64.29	47.19	986.8
T_3 - Pendimethalin @ 1.5 kg ai/ha (PE)+ Imazethapyr (50%) + Quizalofop ethly (50%) at 20-30 DAS	42.2	66.33	47.11	949.7
T_4- Pendimethalin @ 1.5 kg ai/ha (PE) + Imazethapyr (60%) + Quizalofop ethyl(40%) at 20-30 DAS	41.54	63.76	47.2	917.8
T_5 - Pendimethalin @ 1.5 kg ai/ha (PE) + Imazethapyr (40%) + Quizalofop ethyl (60%) at 20-30DAS	40.88	65.24	47.16	913.3
T_6 - Imazethapyr (50%) + Quizalofop ethyl (50%) at 20-30 DAS	41.2	66.82	47.12	847
T_7 - Imazethapyr (60%) + Quizalofop ethyl (40%) at 20-30DAS	41.25	66.95	47.14	830.6
T_8 - Imazethapyr (40%) + Quizalofop ethyl (60%) at 20-30 DAS	41.03	64.42	47.19	844.5
T_9 - Weedy check	39.79	60.72	47.04	504.4
T_{10} - Weed free	49.69	68	48.32	1204.2
S.E(m)±	0.44	2	0.3	11.54
C.D.at 5%	1.31	5.96	NS	16.33
G.M	42.29	65.37	47.36	902.7

The treatment Weed free (T_{10}) produced significantly more oil yield (1204.2 kg ha^{-1}) as compared to other treatments and followed Pendimethalin @ 1.5 kg ai/ha (PE) + Imazethapyr @ 75 g a.i. ha^{-1} (T_1) (1028.7 kg ha^{-1}), Pendimethalin @ 1.5 kg ai/ha (PE) + Quizalofop ethyl @

50 g a.i. ha^{-1} (T_2) (986.8 kg ha^{-1}) and Pendimethalin @ 1.5 kg ai/ha (PE) + Imazethapyr (50%) + Quizalofop ethyl (50%) a.i. ha^{-1} (T_3) (949.7 ha^{-1}) which were at par with each other and found significantly higher over rest of treatments. The subsequent higher values of oil yield were recorded Pendimethalin @ 1.5 kg ai/ha (PE) + Imazethapyr (60%) + Quizalofop ethyl (40%)(T_4) (917.8 kg ha^{-1}) Pendimethalin @ 1.5 kgai/ha (PE) + Imazethapyr (40%) + Quizalofop ethyl (60%) (T_5) (913.3 kg ha^{-1}), Imazethapyr (50%) + Quizalofop ethyl (50%) (T_6) (847.0 kg ha^{-1}) ,Imazethapyr (40%) + Quizalofop ethyl (60%)(T_8) (844.5 kg ha^{-1}) and Imazethapyr (60%) + Quizalofop ethyl (40%) (T_7) (830.6 kg ha^{-1}) and The lowest yield was recorded in Weedy check (T_9) (504.4 kg ha^{-1}).

Treatment Weed free (T_{10}) (1204.2 kg ha^{-1}) and Pendimethalin @ 1.5kg ai/ha (PE) + Imazethapyr @ 75g a.i. ha^{-1} (T_1) (1028.7 kg ha^{-1}) produced higher oil yield, this might be due to the better weed control associated with decrease in weed population, more oil content and improvement in yield contributing characters in these treatments.

4.5 Nutrient uptake by groundnut

4.5.1 Nitrogen uptake by groundnut

4.5.1.1 Nitrogen content in kernel and haulm

The data presented in Table 24. revealed that average nitrogen content of kernel and haulm were 4.36 and 1.65 per cent respectively.

The nitrogen content in kernel and haulm were not influenced by different herbicidal treatments. Treatment Weed free (T_{10}) recorded higher nitrogen content in kernel (4.66%) and haulm (1.86%) which closely followed by Pendimethalin @ 1.5 kg ai/ha (PE) + Imazethapyr @ 75 g a.i. ha^{-1}(T_1). The lowest N content was recorded in treatment Weedy check (T_9).

Table 24.Nitrogen uptake by crop (kg ha^{-1}) as influenced by different weed control treatments

Treatment	N content (%)		N uptake (kg ha^{-1})		Total nutrient uptake (kg ha^{-1})
	kernel	haulm	kernel	Haulm	
T_1 – Pendimethalin @ 1.5 kg ai/ha (PE) + Imazethapyr @ 75 g ai/ha at 20-30 DAS	4.55	1.77	97.14	53.1	150.24
T_2 – Pendimethalin @ 1.5 kg ai/ha (PE) + Quizalofop ethyl @ 50 g ai/ha at 20-30DAS	4.51	1.74	94.25	51.92	146.17
T_3 - Pendimethalin @ 1.5 kg ai/ha (PE) + Imazethapyr (50%) + Quizalofop ethly (50%) at 20-30 DAS	4.45	1.64	89.64	47.34	136.98
T_4 - Pendimethalin @ 1.5 kg ai/ha (PE) + Imazethapyr (60%) + Quizalofop ethyl (40%) at 20-30 DAS	4.37	1.61	84.91	44.98	129.89
T_5 - Pendimethalin @ 1.5 kg ai/ha (PE) + Imazethapyr (40%) + Quizalofop ethyl (60%) at 20-30DAS	4.26	1.63	82.56	45.15	127.71
T_6 – Imazethapyr (50%) + Quizalofop ethyl (50%) at 20-30DAS	4.29	1.6	77.06	42.77	119.83
T_7 - Imazethapyr (60%) + Quizalofop ethyl (40%) at 20-30DAS	4.32	1.64	76.17	42.8	118.97
T_8 – Imazethapyr (40%) + Quizalofop ethyl (60%) at 20-30DAS	4.35	1.66	77.85	44.46	122.32
T_9 - Weedy check	3.87	1.43	41.53	23.55	65.08
T_{10} -Weed free	4.66	1.86	116.13	62.18	178.31
S.E(m)±	0.02	0.04	0.44	0.99	0.86
C.D. at 5%	NS	0.1	1.32	2.94	2.55
G.M.	4.36	1.65	83.72	45.83	129.55

4.5.1.2 Nitrogen uptake (kg ha^{-1})

The data in Table 24 and graphically showed in Fig. 14 revealed that the mean uptake of nitrogen by kernel, haulm and total uptake were 83.72 kg ha^{-1}, 45.83 kg ha^{-1}, and 129.55 kg ha^{-1} respectively.

Maximum nitrogen uptake by kernel, haulm and total uptake were found with treatment Weed free (T_{10}) and being significantly superior over the rest of herbicidal treatments, followed by Pendimethalin @ 1.5 kg ai/ha (PE) + Imazethapyr @ 75 g a.i. ha^{-1} (T_1), Pendimethalin @ 1.5 kg ai/ha (PE) + Quizalofop ethyl @ 50 g a.i. ha^{-1} (T_2) and Pendimethalin

@1.5 kg ai/ha (PE) + Imazethapyr (50%) + Quizalofop ethyl (50%) a.i. ha^{-1} (T_3) Pendimethalin @ 1.5 kg ai/ha (PE) + Imazethapyr (60%) + Quizalofop ethyl (40%) (T_4), Pendimethalin @ 1.5 kgai/ha (PE) + Imazethapyr (40%) + Quizalofop ethyl (60%) (T_5) which were par with each other and found superior over. Imazethapyr (40%) + Quizalofop ethyl (60%) (T_8) Imazethapyr (50%) + Quizalofop ethyl (50%) (T_6), and Imazethapyr (60%) +Quizalofop ethyl (40%) (T_7) and Weedy check (T_9). Similar results were also reported by Chaudhari *et al*. (2007) and Kumbar et al. (2014).

4.5.2 Phosphorus uptake by groundnut

4.5.2.1 Phosphorus content in kernal and haulm of groundnut.

The data in respect of phosphorus content in kernal and haulm are presented in Table 25 revealed that, the mean of phosphorus content were 0.56 and 0.31 per cent in kernel and haulm, respectively.

The phosphorus content of kernel and haulm was not influenced by different treatments, while maximum phosphorus content (0.65%) and (0.36 %) were recorded in kernel and haulm by treatment Weed free (T_{10}) followed by Pendimethalin @ 1.5 kg ai/ha (PE) + Imazethapyr @ 75 g a.i. ha^{-1} (T_1), Pendimethalin @ 1.5 kg ai/ha (PE) + Quizalofop ethyl @ 50 g a.i. ha^{-1} (T_2) and Pendimethalin @1.5 kg ai/ha (PE) +Imazethapyr (50%) + Quizalofop ethyl (50%) a.i. ha^{-1} (T_3), Pendimethalin @ 1.5 kg ai/ha (PE) +Imazethapyr (60%)+Quizalofop ethyl (40%)(T_4), Pendimethalin @ 1.5 kg ai/ha (PE) + Imazethapyr (40%) +Quizalofop ethyl (60%) (T_5) Imazethapyr (50%) +Quizalofop ethyl (50%) (T_6), Imazethapyr (40%) +Quizalofop ethyl (60%) (T_8) and Imazethapyr (60%) +Quizalofop ethyl (40%) (T_7).The lowest phosphorus content was recorded with the treatment Weedy check (T_9).

4.5.2.2 Phosphorus uptake (kg ha^{-1})

Data in respect of phosphorus uptake by kernel, haulm, and total uptake are presented in Table 25 and graphically illustrated in Fig. 14. The mean uptake of phosphorus by kernel, haulm, and total uptake were 10.91 kg ha^{-1}, 8.57 kg ha^{-1} and 19.48 kg respectively.

Table 25. Phosphorus uptake by crop (kg ha^{-1}) as influenced by different weed control treatments

Treatment	P content (%)		P uptake (kgha^{1})		Total nutrient uptake (kg ha^{-1})
	kernel	haulm	kernel	Haulm	
T_1 – Pendimethalin @ 1.5 kg ai/ha (PE) + Imazethapyr @ 75 g ai/ha at 20-30 DAS	0.63	0.34	13.38	10.30	23.68
T_2 – Pendimethalin @ 1.5 kg ai/ha (PE) + Quizalofop ethyl @ 50 g ai/ha at 20-30DAS	0.61	0.32	12.83	9.65	22.48
T_3 - Pendimethalin @ 1.5kg ai/h (PE) + Imazethapyr (50%) + Quizalofop ethly(50%) at 20-30 DAS	0.59	0.3	11.89	8.74	20.63
T_4 - Pendimethalin @ 1.5 kg ai/ha (PE) + Imazethapyr (60%) + Quizalofop ethyl (40%) at 20-30 DAS	0.55	0.29	10.76	8.10	18.86
T_5 - Pendimethalin @ 1.5 kg ai/ha (PE) + Imazethapyr (40%)+ Quizalofop ethyl (60%) at 20-30DAS	0.53	0.3	10.26	8.22	18.48
T_6 – Imazethapyr (50%) + Quizalofop ethyl (50%) at 20-30 DAS	0.51	0.31	9.23	8.30	17.53
T_7 – Imazethapyr (60%) + Quizalofop ethyl (40%) at 20-30 DAS	0.55	0.3	9.75	7.93	17.68
T_8 – Imazethapyr (40%) + Quizalofop ethyl (60%) at 20-30 DAS	0.56	0.29	9.96	7.77	17.73
T_9 - Weedy check	0.46	0.28	4.93	4.62	9.55
T_{10} -Weed free	0.65	0.36	16.12	12.06	28.17
S.E(m)±	0.02	0.01	0.35	0.25	0.51
C.D. at 5%	0.05	0.03	1.03	0.74	1.51
G.M.	0.56	0.31	10.91	8.57	19.48

Maximum phosphorus uptake by kernel, haulm and total uptake were found with treatment Weed free (T_{10}) and being significantly superior over the rest of treatments, followed by Pendimethalin @ 1.5 kg ai/ha (PE) + Imazethapyr @ 75g a.i. ha^{-1} (T_1), Pendimethalin @ 1.5 kg ai/ha (PE) + Quizalofop ethyl @ 50 g a.i. ha^{-1} (T_2) and Pendimethalin @ 1.5 kg ai/ha (PE) + Imazethapyr (50%) + Quizalofop ethyl (50%) a.i. ha^{-1} (T_3) Pendimethalin @ 1.5 kg ai/ha (PE) + Imazethapyr (60%)+Quizalofop

ethyl (40%)(T_4),Pendimethalin @ 1.5 kg ai/ha (PE) + Imazethapyr (40%) + Quizalofop ethyl (60%) (T_5) which were at par each other and found superior over rest of the treatment. The lowest phosphorus uptake was recorded with the treatment Weedy check (T_9). It was due to higher seed yield and dry matter accumulation and greater availability of phosphorus which ultimately resulted in increase in phosphorus uptake. Similar results were also reported by Chaudhari *et al*. (2007) and Kumbar et al. (2014).

4.5.3 Potassium uptake by groundnut

4.5.3.1 Potassium content in kernel and haulm of groundnut

The data in respect of potassium content in kernel and haulm are presented in Table 26 revealed that, the values of potassium content attain the level of significance with mean of 1.55 and 1.25 per cent in kernel and haulm respectively.

The potassium content of kernel and haulm was not influenced by different treatments, however, treatment Weed free (T_{10}) recorded higher potassium content in kernel (1.76%) and in haulm (1.36 %), followed by treatment Pendimethalin @ 1.5 kg ai/ha (PE) + Imazethapyr @ 75 g a.i. ha^{-1} (T_1). The lowest potassium content was recorded with the treatment Weedy check (T_9).

4.5.3.2 Potassium uptake (kg ha^{-1})

The data revealed of potassium uptake by kernel, haulm and total uptake is presented in Table 26 and graphically depicted in Fig.14. The mean uptake of potassium by kernel, haulm and total uptake was 29.83 kg ha^{-1}, 34.55 kg $ha^{-1}$and 64.37 kg ha^{-1} respectively.

Maximum potassium uptake by kernel, haulm and total uptake was found with treatment Weed free (T_{10}) and observed highly superior over the rest of treatments, followed by Pendimethalin @ 1.5 kg ai/ha (PE) + Imazethapyr @ 75 g a.i. ha^{-1} (T_1), Pendimethalin @1.5 kg ai/ha (PE) + Quizalofop ethyl @ 50 g a.i. ha^{-1} (T_2) and Pendimethalin @1.5 kg ai/ha (PE) + Imazethapyr (50%) + Quizalofop ethyl (50%) a.i. ha^{-1} (T_3), Pendimethalin @1.5 kg ai/ha (PE) + Imazethapyr (60%) + Quizalofop ethyl (40%) (T_4),

Table 26. Potassium uptake by crop (kg ha^{-1}) as influenced by different weed control treatments

Treatment	K content (%)		K uptake (kg ha^{-1})		Total nutrient uptake (kg ha^{-1})
	kernel	haulm	kernel	Haulm	
T_1 – Pendimethalin @ 1.5 kg ai/ha (PE) + Imazethapyr @75 g ai/ha at 20-30 DAS	1.69	1.35	36.08	40.60	76.68
T_2 – Pendimethalin @ 1.5 kg ai/ha (PE) + Quizalofop ethyl @50 g ai/ha at 20-30DAS	1.65	1.31	34.58	39.19	73.77
T_3 - Pendimethalin @ 1.5 kg ai/ha (PE) + Imazethapyr(50%) + Quizalofop ethly(50%) at 20-30 DAS	1.5	1.27	30.24	36.68	66.92
T_4 -Pendimethalin @ 1.5 kg ai/ha (PE) + Imazethapyr (60%) + Quizalofop ethyl (40%) at 20-30 DAS	1.47	1.22	28.65	33.99	62.64
T_5 - Pendimethalin @ 1.5 kg ai/ha (PE) + Imazethapyr(40%) + Quizalofop ethyl (60%) at 20-30DAS	1.48	1.14	28.60	31.67	60.26
T_6 - Imazethapyr(50%)+Quizalofop ethyl (50%) at 20-30DAS	1.54	1.22	27.62	32.77	60.39
T_7 - Imazethapyr (60%) + Quizalofop ethyl (40%) at 20-30DAS	1.55	1.24	27.25	32.34	59.59
T_8 – Imazethapyr (40% + Quizalofop ethyl (60%) at 20-30DAS	1.46	1.23	26.13	33.04	59.17
T_9 - Weedy check	1.42	1.19	15.26	19.64	34.91
T_{10} -Weed free	1.76	1.36	43.86	45.55	89.41
S.E(m)±	0.07	0.03	1.39	0.95	1.75
C.D. at 5%	0.2	0.1	4.13	2.82	5.19
G.M.	1.55	1.25	29.83	34.55	64.37

Pendimethalin @1.5 kg ai/ha (PE) + Imazethapyr (40%) + Quizalofop ethyl (60%) (T_5) which were statistically at par with each other, and found superior over Imazethapyr(50%) +Quizalofop ethyl (50%)(T_6), Imazethapyr (60%) +Quizalofop ethyl (40%) (T_7), Imazethapyr (40%) +Quizalofop ethyl (60%)(T_8) but found on par with each other and the lowest potassium uptake was recorded with the treatment Weedy check (T_9). Similar results were also reported by Chaudhari *et al*. (2007) and Kumbar et al. (2014).

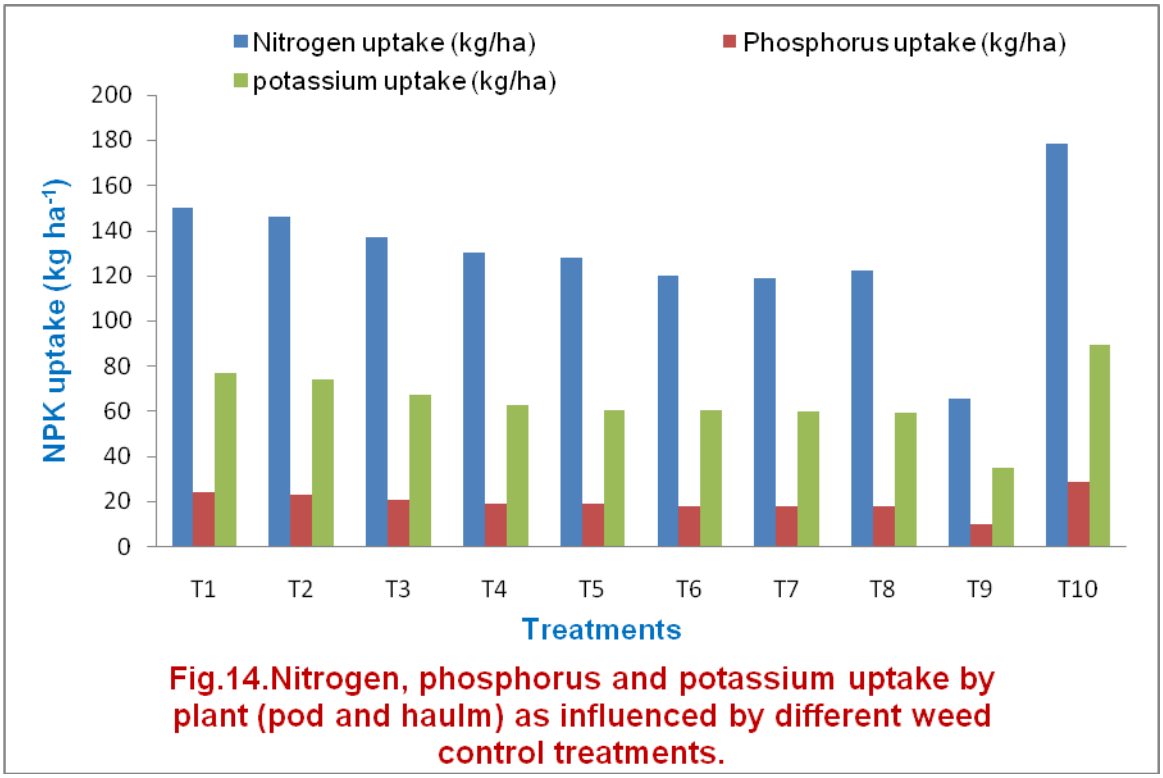


Fig.14.Nitrogen, phosphorus and potassium uptake by plant (pod and haulm) as influenced by different weed control treatments.

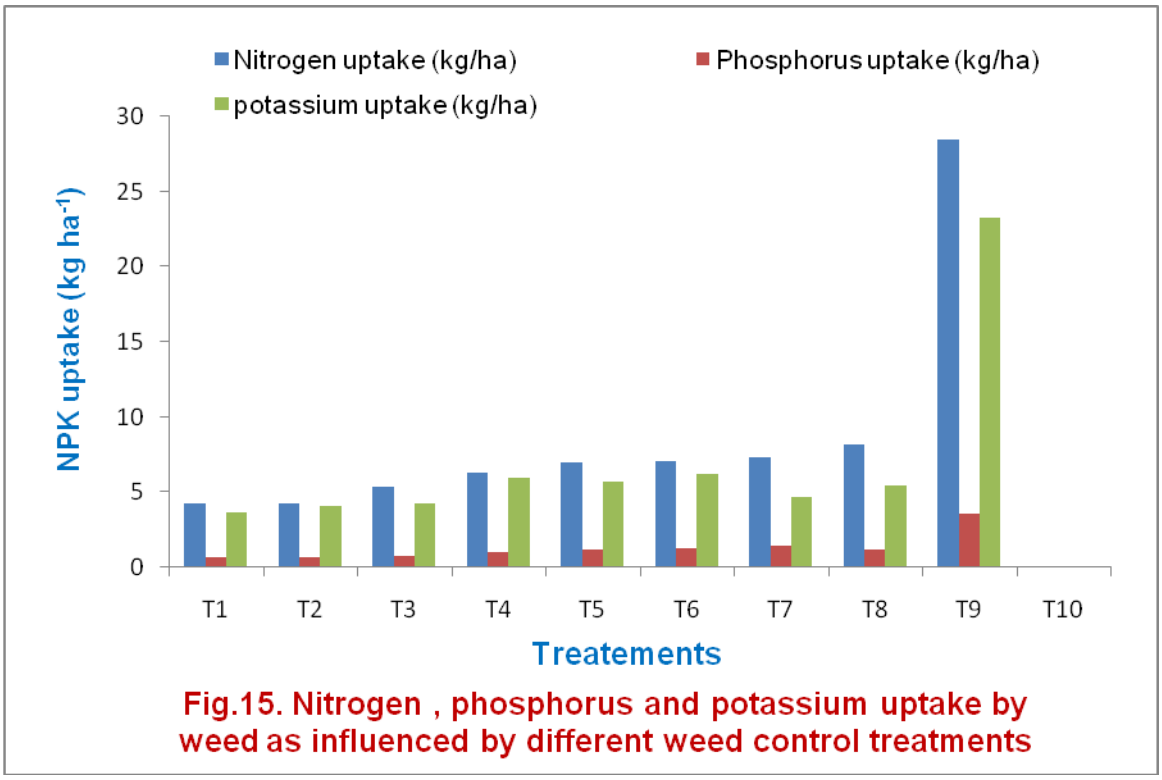


Fig.15. Nitrogen , phosphorus and potassium uptake by weed as influenced by different weed control treatments

4.6 Nitrogen, phosphorus and potassium uptake by weed.

Data regarding nitrogen, phosphorus and potassium uptake (kg ha^{-1}) by weeds as influenced by different treatments are presented in Table 27. and graphically showed in Fig.15.

Table 27. Nutrient uptake (N, P and k) by weeds (kg ha^{-1}) as influenced by various weed control treatments

Treatment	N (kg ha^{-1})	P (kg ha^{-1})	K (kg ha^{-1})
T_1 – Pendimethalin @ 1.5 kg ai/ha (PE)+ Imazethapyr @ 75 g ai/ha at 20-30 DAS	4.22	0.67	3.63
T_2 – Pendimethalin @ 1.5kg ai/ha (PE)+ Quizalofop ethyl @ 50 g ai/ha at 20-30DAS	4.25	0.72	4.11
T_3 - Pendimethalin @ 1.5 kg ai/ha (PE)+ Imazethapyr (50%) + Quizalofop ethly (50%) at 20-30 DAS	5.36	0.77	4.29
T_4 - Pendimethalin @1.5kg ai/ha(PE)+ Imazethapyr (60%) +Quizalofop ethyl(40%) at 20-30 DAS	6.30	1.03	5.94
T_5 - Pendimethalin @ 1.5 kg ai/ha (PE)+ Imazethapyr (40%) + Quizalofop ethyl (60%) at 20-30DAS	6.99	1.23	5.71
T_6 - Imazethapyr (50%) + Quizalofop ethyl (50%) at 20-30DAS	7.06	1.25	6.19
T_7 - Imazethapyr (60%) + Quizalofop ethyl (40%) at 20-30DAS	7.37	1.42	4.67
T_8 - Imazethapyr (40%) + Quizalofop ethyl (60%) at 20-30DAS	8.20	1.20	5.46
T_9 - Weedy check	28.45	3.56	23.23
T_{10}-Weed free	0.00	0.00	0.00
S.E(m)±	0.43	0.09	0.29
C.D. at 5%	1.29	0.28	0.86
G.M.	7.82	1.19	6.32

4.6.1 Nitrogen uptake by weed (kg ha^{-1})

The removal of nitrogen by weeds was significantly less in treatment Weed free (T_{10}). Among the herbicidal treatments Pendimethalin @ 1.5 kg ai/ha (PE) + Imazethapyr @ 75 g a.i. ha^{-1} (T_1), Pendimethalin @ 1.5 kg ai/ha (PE) + Quizalofop ethyl @ 50 g a.i. ha^{-1} (T_2) are statistically on par to each other recorded mínimum nitrogen uptake by weeds and which were significantly superior over Pendimethalin @1.5 kg ai/ha (PE) +

Imazethapyr (50%) + Quizalofop ethyl (50%) a.i. ha^{-1} (T_3), Pendimethalin @ 1.5 kg ai/ha (PE) + Imazethapyr (60%) + Quizalofop ethyl (40%) (T_4) ,Pendimethalin @1.5 kg ai/ha (PE) + Imazethapyr (40%) + Quizalofop ethyl (60%) (T_5). Imazethapyr (50%) + Quizalofop ethyl (50%) (T_6), Imazethapyr (60%) + Quizalofop ethyl (40%) (T_7) ,Imazethapyr (40%) + Quizalofop ethyl (60%) (T_8) Weedy check (T_9) removed significantly more nitrogen than rest of the treatments.

4.6.2 Phosphorus uptake by weed (kg ha^{-1})

The uptake of phosphorus by weeds was significantly lower in treatment Weed free (T_{10}). Among the herbicidal treatments Pendimethalin @1.5 kg ai/ha (PE) + Imazethapyr @ 75 g a.i. ha^{-1} (T_1) recorded mínimum phospuru uptake by weeds and also found significantly superior over Pendimethalin @1.5 kg ai/ha (PE) + Quizalofop ethyl @50 g a.i. ha^{-1} (T_2) Pendimethalin @1.5 kg ai/ha (PE) + Imazethapyr (50%)+Quizalofop ethyl (50%) a.i. ha^{-1} (T_3) Pendimethalin @ 1.5 kg ai/ha (PE) +Imazethapyr (60%) + Quizalofop ethyl (40%)(T_4) ,Pendimethalin @1.5 kg ai/ha (PE) + Imazethapyr (40%) + Quizalofop ethyl (60%) (T_5). Imazethapyr (50%) + Quizalofop ethyl (50%) (T_6), Imazethapyr (40%) + Quizalofop ethyl (60%) (T_8) , Imazethapyr (60%) + Quizalofop ethyl (40%) (T_7), noticed statistically on par with each other. The treatment Weedy check (T_9) consumed significantly more phosphorus than all the treatments.

4.6.3 Potassium uptake by weed (kg ha^{-1})

The removal of potassium by weeds was significantly lower in treatment Weed free (T_{10}) followed by the herbicidal treatment Pendimethalin @1.5 kg ai/ha (PE) + Imazethapyr @ 75 g a.i. ha^{-1} (T_1) recorded mínimum pottasium uptake by weeds and which was significantly superior over Pendimethalin @1.5 kg ai/ha (PE) + Quizalofop ethyl @ 50 g a.i. ha^{-1} (T_2) Pendimethalin @1.5 kg ai/ha (PE) + Imazethapyr (50%) + Quizalofop ethyl (50%) a.i. ha^{-1} (T_3) Pendimethalin @ 1.5 kg ai/ha (PE) + Imazethapyr (60%)+Quizalofop ethyl (40%) (T_4) ,Pendimethalin @ 1.5 kg ai/ha (PE) + Imazethapyr (40%) + Quizalofop ethyl (60%) (T_5). Imazethapyr (50%) + Quizalofop ethyl (50%) (T_6), Imazethapyr (40%) + Quizalofop ethyl (60%)(T_8), Imazethapyr (60%) + Quizalofop ethyl (40%)

(T_7) and Weedy check (T_9). While treatments Pendimethalin @ 1.5 kg ai/ha (PE) + Quizalofop ethyl @ 50 g a.i. ha^{-1} (T_2), Pendimethalin @ 1.5 kg ai/ha (PE) + Imazethapyr (50%) + Quizalofop ethyl (50%) a.i. ha^{-1} (T_3) Pendimethalin @ 1.5 kg ai/ha (PE) + Imazethapyr (60%)+Quizalofop ethyl (40%) (T_4) ,Pendimethalin @ 1.5 kg ai/ha (PE) + Imazethapyr (40%) + Quizalofop ethyl (60%) (T_5). Imazethapyr (50%) + Quizalofop ethyl (50%) (T_6), Imazethapyr (40%) + Quizalofop ethyl (60%)(T_8), Imazethapyr (60%) + Quizalofop ethyl (40%) (T_7) observed statistically comparable with each other. Treatment Weedy check (T_9) exhausted significantly more potassium uptake than rest of the treatments.

Among the different weed control measures Weedy check (T_9) recorded significantly higher(N,P and K) uptake by weed. The herbicidal treatment Pendimethalin @1.5 kg ai/ha(PE) + Imazethapyr @ 75 g a.i. ha^{-1} (T_1) recorded lower value of nutrient uptake by weeds than rest of herbicidal treatments followed by treatment Pendimethalin @ 1.5 kg ai/ha (PE) + Quizalofop ethyl @ 50 g a.i. ha^{-1} (T_2), Pendimethalin @ 1.5 kg ai/ha (PE) + Imazethapyr (50%) + Quizalofop ethyl (50%) a.i. ha^{-1} (T_3) Pendimethalin @ 1.5 kg ai/ha (PE) + Imazethapyr (60%) + Quizalofop ethyl (40%) (T_4), Pendimethalin @ 1.5 kg ai/ha (PE) + Imazethapyr (40%) + Quizalofop ethyl (60%) (T_5). 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. similar result noticed by Kori *et al*. (1997).

4.7. N, P and K content in soil (kg ha^{-1}) at harvest

Data on total nutrient content in soil (N, P and K) as affected by various weed control treatment are presented in table 28 and graphically presented in fig. 16.

The available N and K was non-significant due to distant weed management treatment. Among the herbicidal treatment maximum amount of available nutrient (N and K) found in pre-emergence and post emergence application of Pendimethalin @ 1.5 kg ai/ha (PE) + Imazethapyr @ 75 g a.i. ha^{-1} (T_1). Weed free (T_{10}) show maximum amount

of available nutrient due to weed free condition. The lowest amount of available nutrient was found in Weedy check (T_9) .

Table 28. Available N, P and K content in soil (kg ha^{-1}) at harvest as influenced by various weed control treatments

Treatment	N (kg ha^{-1})	P (kg ha^{-1})	K (kg ha^{-1})
T_1 – Pendimethalin @ 1.5 kg ai/ha (PE) + Imazethapyr @ 75 g ai/ha at 20-30 DAS	250.88	18.37	342.72
T_2 – Pendimethalin @ 1.5kg ai/ha(PE) + Quizalofop ethyl @ 50 g ai/ha at 20-30DAS	238.34	17.77	338.61
T_3 - Pendimethalin @ 1.5 kg ai/ha (PE) + Imazethapyr (50%) + Quizalofop ethly(50%) at 20-30 DAS	234.15	17.47	337.87
T_4 - Pendimethalin @ 1.5kg ai/ha (PE)+ Imazethapyr (60%) + Quizalofop ethyl(40%) at 20-30 DAS	234.15	16.95	337.12
T_5 - Pendimethalin @ 1.5 kg ai/ha (PE)+ Imazethapyr (40%) + Quizalofop ethyl (60%) at 20-30DAS	225.79	17.02	334.51
T_6 - Imazethapyr (50%) + Quizalofop ethyl (50%) at 20-30 DAS	217.43	16.50	330.77
T_7 - Imazethapyr (60%) + Quizalofop ethyl (40%) at 20-30 DAS	213.25	16.43	329.28
T_8 – Imazethapyr (40%) + Quizalofop ethyl (60%) at 20-30DAS	209.07	16.35	329.28
T_9 - Weedy check	204.66	11.35	324.05
T_{10}- Weed free	267.61	19.64	346.45
S.E(m)±	170.09	0.16	249.01
C.D. at 5%	NS	0.48	NS
G.M.	229.53	16.79	335.07

The maximum amount of available nutrient (P) found in Weed free (T_{10}) which were at par with pre-emergence and post emergence application of Pendimethalin @ 1.5 kg ai/ha (PE) + Imazethapyr @ 75 g a.i. ha^{-1} (T_1) and rest of treatments except Weedy check (T_9). The lowest amount of available nutrient was found in Weedy check (T_9).

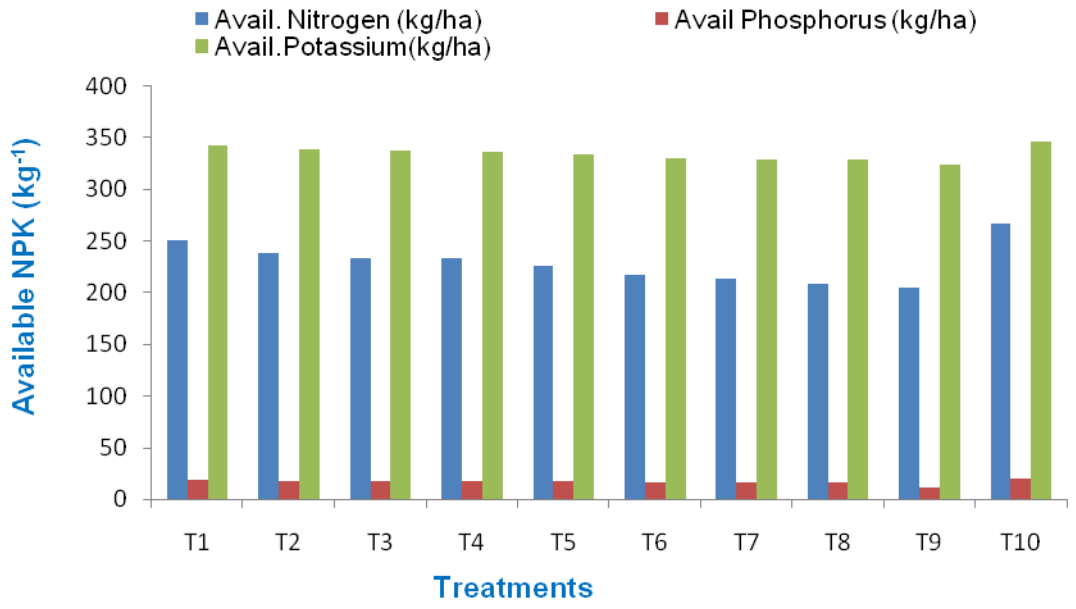


Fig.16. Available N,P and K content in soil at harvest as influenced by various weed control treatments.

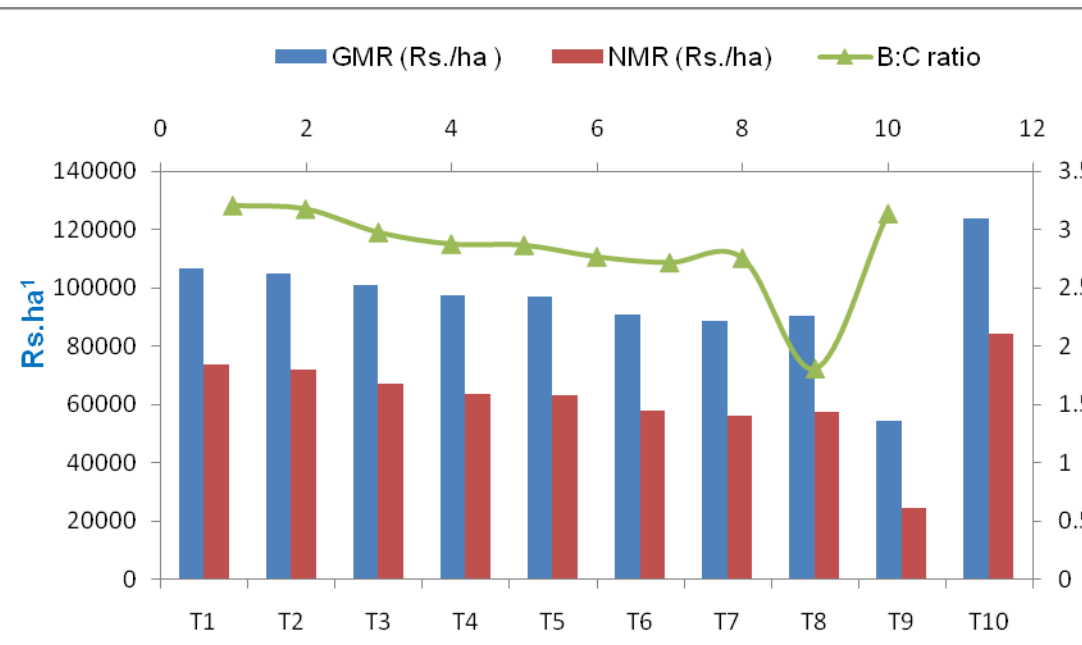


Fig.17. Economics of weed control treatments.

4.8 Economic studies

Data in respect gross monetary returns, net monetary returns and benefit cost ratio are presented in Table 29. and graphically depicted in Fig 17.

Table 29. Economics of weed control treatments

Treatment	Total cost of cultivation (Rs. ha^{-1})	GMR (Rs. ha^{-1})	NMR (Rs.ha^{-1})	B:C ratio
T_1 – Pendimethalin @ 1.5 kg ai/ha (PE) + Imazethapyr @ 75 g ai/ha at 20-30 DAS	33263	106802	73539	3.21
T_2 –Pendimethalin @ 1.5 kg ai/ha(PE) + Quizalofop ethyl @ 50 g ai/ha at 20-30DAS	33000	104845	71845	3.18
T_3 -Pendimethalin @ 1.5 kg ai/ha (PE) + Imazethapyr (50%)+ Quizalofop ethly(50%) at 20-30 DAS	33930	101087	67157	2.98
T_4 - Pendimethalin @1.5kg ai/ha (PE)+ Imazethpyr (60%)+Quizalofop ethyl(40%) at 20-30 DAS	33860	97579	63719	2.88
T_5 - Pendimethalin @ 1.5kg ai/ha (PE) + Imazethapyr (40%) + Quizalofop ethyl (60%) at 20-30DAS	33860	97119	63259	2.87
T_6 – Imazethapyr (50%) + Quizalofop ethyl (50%) at 20-30DAS	32740	90690	57950	2.77
T_7 - Imazethapyr (60%) + Quizalofop ethyl (40%) at 20-30DAS	32670	88837	56167	2.72
T_8 - Imazethpyr(40%) + Quizalofop ethyl (60%) at 20-30DAS	32670	90349	57679	2.76
T_9-Weedy check	29983	54360	24377	1.81
T_{10}-Weed free	39533	123905	84372	3.14
S.E(m)±	-	950.3	950.3	-
C.D. at 5%	-	2823	2823	-
G.M.	33550	95557	62006	2.83

4.8.1 Gross monetary returns

The data in table 29. revealed that gross monetary returns Rs ha^{-1} were affected due to various treatments and average gross monetary returns were (95557 Rs ha$^{-1)}$. Treatment Weed free (T_{10}) recorded maximum gross monetary returns of (123905 Rs ha^{-1}) followed by Pendimethalin @ 1.5 kg ai/ha (PE) + Imazethapyr @ 75 g a.i. ha^{-1} (T_1) (106802 Rs ha^{-1}) , Pendimethalin @1.5 kg ai/ha (PE) + Quizalofop ethyl @

50 g a.i.ha^{-1} (T_2) (104845 Rs ha^{-1}) , Pendimethalin @ 1.5 kg ai/ha (PE) + Imazethapyr (50%) + Quizalofop ethyl (50%) a.i. ha^{-1}(T_3) (101087 Rs ha^{-1}), Pendimethalin @ 1.5 kg ai/ha (PE) + Imazethapyr (60%) + Quizalofop ethyl (40%) (T_4) (97579 Rs ha^{-1}), Pendimethalin @ 1.5 kg ai/ha (PE) + Imazethapyr (40%) + Quizalofop ethyl (60%) (T_5) (97119 Rs ha^{-1}), Imazethapyr (50%) + Quizalofop ethyl (50%) (T_6) (90690 Rs ha^{-1}), Imazethapyr (40%) + Quizalofop ethyl (60%) (T_8) (90349 Rs ha^{-1}), Imazethapyr (60%) + Quizalofop ethyl (40%) (T_7) (88837 Rs ha^{-1}). The lowest gross monetary returns of (54360 Rs ha^{-1}) recorded in weedy check (T_9). Similar results were obtained by Dixit *et al* (2016) and Malunjkar *et al. (*2012).

4.8.2 Net monetary returns

Net monetary return Rs. ha^{-1} was influenced due to various treatments and average net monetary returns was 62006 Rs.ha^{-1}. Treatment Weed free (T_{10}) recorded maximum net monetary return (84372 Rs. ha^{-1}) followed by Pendimethalin @1.5 kg ai/ha (PE) + Imazethapyr @ 75 g a.i. ha^{-1} (T_1) (73539 Rs ha^{-1}) ,Pendimethalin @ 1.5 kg ai/ha (PE) + Quizalofop ethyl @ 50 g a.i.ha^{-1} (T_2) (71845 Rs ha^{-1}) ,Pendimethalin @ 1.5 kg ai/ha (PE) + Imazethapyr (50%) + Quizalofop ethyl (50%) a.i. ha^{-1}(T_3) (67157 Rs ha^{-1}) ,Pendimethalin @1.5 kg ai/ha (PE) + Imazethapyr (60%) + Quizalofop ethyl (40%) (T_4) (63719 Rs ha^{-1}), Pendimethalin @ 1.5 kg ai/ha (PE) + Imazethapyr (40%) + Quizalofop ethyl (60%) (T_5) (63259 Rs ha^{-1}), Imazethapyr (50%) + Quizalofop ethyl (50%)(T_6) (57950 Rs ha^{-1}), Imazethapyr (40%) + Quizalofop ethyl (60%)(T_8), (57679 Rs ha^{-1}), Imazethapyr (60%) + Quizalofop ethyl (40%) (T_7) (56167 Rs ha^{-1}) and The lowest net monetary return (24377 Rs ha$^{-1)}$ recorded in weedy check (T_9). Similar results were obtained by Dixit *et al* (2016) and Malunjkar *et al. (*2012).

4.8.3 Benefit to cost ratio

The data presented in Table 29. showed that treatment Pendimethalin @ 1.5 kg ai/ha (PE) + Imazethapyr @ 75 g a.i. ha^{-1} (T_1) recorded highest benefit cost ratio, i.e.(3.21), followed by treatments Pendimethalin @ 1.5 kg ai/ha (PE) + Quizalofop ethyl @50 g a.i.ha^{-1} (T_2)

(3.18) , Weed free (T_{10}) (3.14), Pendimethalin @1.5kg ai/ha (PE) + Imazethapyr (50%)+ Quizalofop ethyl (50%) a.i. ha^{-1}(T_3) (2.98), Pendimethalin @ 1.5 kg ai/ha (PE) + Imazethapyr (60%) + Quizalofop ethyl (40%) (T_4) (2.88), Pendimethalin @ 1.5 kg ai/ha (PE) + Imazethapyr (40%) + Quizalofop ethyl (60%) (T_5) (2.87), Imazethapyr (50%) + Quizalofop ethyl (50%) (T_6) (2.77), Imazethapyr (40%) + Quizalofop ethyl (60%)(T_8) (2.76) , Imazethapyr (60%) + Quizalofop ethyl (40%) (T_7) (2.72) and lowest benefit cost ratio (1.81) was recorded in treatment Weedy check (T_9) as a result of higher crop weed competition which reduced the groundnut yield. The differences in B:C ratio is due to the cost of herbicides and productivity of the crop Similar results were obtained by Dixit *et al* (2016) and Malunjkar *et al. (*2012).

CHAPTER V

SUMMARY AND CONCLUSION

5.1 Summary

The present investigation “Studies on tank mix application of post-emergence herbicides for efficient weed control in Groundnut (*Arachis hypogaea* L.)” was carried out at the field Oilseed Research Unit, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola. During *kharif* 2016. In the present investigation chemical weed management practices i.e. herbicides viz; Pendimethalin, Imazethapyr and Quizalofop ethyl were used alone and in combination i.e. Pendimethalin @1.5 kg ai/ha (PE) + Imazethapyr @ 75 g a.i. ha^{-1} (T_1) ,Pendimethalin @1.5 kg ai/ha (PE) + Quizalofop ethyl @ 50 g a.i.ha^{-1} (T_2),Pendimethalin @1.5 kg ai/ha (PE) + Imazethapyr (50%)+ Quizalofop ethyl (50%) a.i. ha^{-1}(T_3) ,Pendimethalin @ 1.5 kg ai/ha (PE) + Imazethapyr (60%)+Quizalofop ethyl (40%) (T_4),Pendimethalin @ 1.5 kg ai/ha (PE) + Imazethapyr (40%) +Quizalofop ethyl (60%) (T_5), Imazethapyr (50%) + Quizalofop ethyl (50%)(T_6), Imazethapyr (60%) + Quizalofop ethyl (40%) (T_7) ,Imazethapyr (40%) + Quizalofop ethyl (60%)(T_8) , with Weedy check (T_9) and Weed free (T_{10}) were studied.

The important research findings are summarized here –

1. Pendimethalin @ 1.5 kg a.i. ha^{-1} PE at 20 DAS, use in treatment (T_1,T_2,T_3,T_4,T_5) recorded lowest monocot and dicot weeds, total weed count and weed dry weight at early stages of crop growth. Subsequently the total weed count and weed dry weight were lower in T_1 (Pendimethalin @ 1.5 kg ai/ha (PE) + Imazethapyr @ 75 g a.i. ha^{-1}). The treatment T_9 (Weed check) showed highest monocot and dicot weeds infestation and weed dry weight.
2. Maximum weed control efficiency at 20 DAS was obtained with treatment Pendimethalin @ 1.5 kg a.i. ha^{-1} PE use in treatment (T_1,T_2,T_3,T_4,T_5) . At 40 DAS up to at harvest higher weed control

efficiency was observed in treatment Pendimethalin @ 1.5 kg ai/ha (PE) + Imazethapyr @ 75 g a.i. ha^{-1} (T_1).

3. Lowest weed index was recorded in treatment Pendimethalin @ 1.5 kg ai/ha (PE) + Imazethapyr @ 75 g a.i. ha^{-1} (T_1) and highest weed index was obtained with treatment Weedy check.
4. Plant height of groundnut crop was improved at 20 DAS was obtained with treatment Pendimethalin @ 1.5 kg a.i. ha^{-1} PE use in treatment (T_1, T_2, T_3, T_4, T_5). At 40 DAS up to at harvest with Pendimethalin @ 1.5 kg ai/ha (PE) + Imazethapyr @ 75 g a.i. ha^{-1}, while treatment Weedy check recorded minimum plant height.
5. Number of root nodule $plant^{-1}$ was observed in treatment Pendimethalin @ 1.5 kg a.i. ha^{-1} PE at 20 DAS use in treatment (T_1,T_2,T_3,T_4,T_5). At 40 DAS up to at harvest, treatment Pendimethalin @1.5 kg ai/ha (PE) + Imazethapyr @ 75 g a.i. ha^{-1} recorded maximum number of root nodule $plant^{-1}$. while treatment Weedy check recorded minimum root nodule $plant^{-1}$.
6. Plant dry matter initially (20 DAS) was higher in Pendimethalin @ 1.5 kg a.i. ha^{-1} PE in treatment (T_1,T_2,T_3,T_4,T_5) later growth stages treatment Pendimethalin @1.5kg ai/ha(PE) + Imazethapy r@ 75 g a.i. ha^{-1} recorded highest dry matter. Lowest plant dry matter was recorded in Weedy check.
7. Number of developed pod $plant^{-1}$ was observed maximum in treatment Pendimethalin @1.5kg ai/ha (PE) + Imazethapyr @ 75 g a.i. ha^{-1}. Lowest developed pod $plant^{-1}$ was recorded in Weedy check.
8. Yield attributes i.e 100 kernels weight was significantly higher in Pendimethalin @1.5kg ai/ha (PE) + Imazethapyr @ 75 g a.i. ha^{-1} . The lower 100 kernels weight was recorded in Weedy check.
9. Different weed management practices significantly improve the pod yield and haulm yield. Weed free treatment registered highest pod yield (2492 kg ha^{-1}) followed by treatment Pendimethalin @ 1.5kg ai/ha (PE)

+ Imazethapyr @ 75 g a.i. ha^{-1}(2135 kg ha^{-1}). Weedy check treatment recorded lowest pod yield i.e. (1072 kg ha^{-1}). Similar trend was observed in respect of haulm yield and biological yield.

10. Treatment Pendimethalin @ 1.5 kg ai/ha (PE) + Imazethapyr @ 75 g a.i. ha^{-1}recorded highest B:C ratio (3.21), while minimum B:C ratio (1.81) was observed in Weedy check.
11. Uptake of NPK in pod, haulm and total uptake by groundnut was significantly more with Weed free treatment followed Pendimethalin @ 1.5 kg ai/ha (PE) + Imazethapyr @ 75 g a.i. ha^{-1}. The lowest value of NPK uptake was recorded in Weedy check.
12. NPK uptake by weeds was significantly less in Weed free condition followed by Pendimethalin @ 1.5 kg ai/ha (PE) + Imazethapyr @ 75 g a.i. ha^{-1}. The highest value of NPK uptake by weed was recorded in Weedy check.

Conclusions

On the basis of the result obtained from present investigation following conclusion are emerged.

1. In groundnut for effective weed management, application of pre-emergence and post emergence herbicide Pendimethalin @1.5kg ai/ha(PE) + Imazethapyr @ 75 g a.i. ha^{-1} registered reduction in weed population, weed dry matter, higher weed control efficiency and recorded lowest weed index than rest of the herbicidal treatment.
2. Maximum growth parameters, yield attributes and yield were found in Pendimethalin @ 1.5 kg ai/ha (PE) + Imazethapyr @ 75 g a.i. ha^{-1} recorded followed by Pendimethalin @1.5 kg ai/ha (PE) + Quizalofop ethyl @ 50 g a.i.ha^{-1} (T_2) .
3. Among the pre and post herbicide treatment Pendimethalin @ 1.5 kg ai/ha (PE) + Imazethapyr @ 75 g a.i. ha^{-1} recorded maximum GMR (Rs. 106802 ha^{-1}), NMR (Rs. 73539 ha^{-1}) and B: C ratio (3.21) followed by Pendimethalin @1.5 kg ai/ha (PE) + Quizalofop ethyl @ 50 g a.i.ha^{-1}

(T_2) . Lowest GMR (Rs. 54360 ha^{-1}), NMR (Rs. 24377 ha^{-1}) and B:C ratio (1.81) recorded in Weedy check.

The additional amount of income obtain from weed free treatment appeared to immaterial. When compared to cost of weeding incurred to maintain weed free condition which result in the lowest value of B:c ratio (3.14).

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

CHAPTER VI

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Place : Akola **Signature of Student**

Date : / /2017 **(Pawar Sunil Bhimrao)**

APPENDIX

Fertilizer Cost –

Urea	- Rs 7/Kg
SSP	- Rs 7.4/Kg

Herbicide cost-

Pendimethalin	- Rs. 460/Lit
Quizalofop ethyl	- Rs. 1475/Lit
Imazethapyr	- Rs. 2000/Lit

Insecticide cost-

Quinolphos	- Rs. 600/Lit
Profex super	- Rs. 800/Lit

Seed cost- - Rs. 120/Kg

Labour charges-

Male	- Rs. 120/Day
Female	- Rs. 120/Day
Machinery	- Rs. 300/H
Bullock labour	- Rs. 400/Day

Yield-

Groundnut	- Rs. 4300/q
Haulm	- Rs. 500/q