CHAPTER-I

INTRODUCTION

Groundnut is the thirteenth most important food crop and third most important oil seed crop of the world. It is commonly called as the king of vegetable oilseeds crops or poor man's nut (also called pea nut, earth nut, monkey nut, goober nut, manila nut, pinder and panda nut). Groundnut is a native of South American leguminous oil seed (Hammons, 1982). It was first found in Brazil or Peru as early as 950 B.C. (Higgins, 1951). According to Weiss (1983), a peanut was probably brought to West Africa from Brazil in the 16th century and then to the African East coast and to India. In India introduced by the Portuguese in 16th century as an oil seed crop for commercial cultivation. Groundnut appeared to have originated in South America *i.e.*, North-West of Brazil and the secondary center of its cultivation is in Africa and then spread to other part of the world (Vavilov, 1951).

The botanical name of groundnut is *Arachis hypogaea Linn;* is derived from two Greek words, *Arachis* meaning a legume and *hypogaea* meaning beneath ground referring to the formation of pod in the soil. It belongs to family *Leguminosae*. The groundnut is slow growing annual plant with central upright stem. The plant grows 30 to 60 cm high and produced angular hairy stem with spreading and erect branches. The spreading varieties have pods scattered along their prostrate branches from base of plant of the erect or bunchy type. It has relatively deep tap root with well-developed lateral root system. The flowers are borne at the axils of the leaves, after fertilization of flowers formation of pegs takes place and then pegs are penetrated below the ground.

Groundnut is a rich source of oil, which supplies about 500 calories 100 g^{-1} which is higher than all vegetable proteins. Groundnut plays an important role in the rural economy of India, which constitute the important component of Indian diet. Kernel contains 48 to 50 % of edible oil, 25 % protein and 20 % of the carbohydrates (Weiss, 1983). It has got nutritional importance due to presence of oleic and linolic acid and proportion of

saturated monoenoic and polyunsaturated fatty acid. The oil cake contain 7-8 % N, 1.50 % P_2O_5 and 1.20 % K_2O hence, it is used as fertilizer. Groundnut and its products are also used as an animal feed (seeds, oil pressings and green and dried haulms) and industrial raw material (oil and deoiled cake). The kernels are also good source of minerals like calcium, phosphorous, iron and vitamins like E, niacin, folacin, riboflavin and thiamine. Groundnut haulms constitute nutritional fodder for livestock. Groundnut haulm contains 8-15 % protein, 1-3 % lipids, 9-17 % minerals and 38-45 % carbohydrates at levels higher than those of cereal fodders. After the harvest the roots left behind in the soil add valuable nutrients to the soil. These multiple uses of groundnut make it excellent crop for domestic markets as well as for foreign trade in several developing and developed countries.

Groundnut is grown on 26.4 million hectares worldwide with a total production of 37.1 million metric tonnes and an average productivity of 1.4 tonnes ha^{-1} over 100 countries worldwide grow groundnut. Developing countries constitute 97 % of the global area and 94 % of the global production of this crop. The production of groundnut is concentrated in Asia and Africa (56 % and 40 % of the global area and 68 % and 25 % of the global production, respectively). The major groundnut producing countries in the world are India, China, Nigeria, Senegal, Sudan, Burma and the United States of America. Out of the total area of 18.9 million hectares and the total production of 17.8 million tonnes in the world, these countries account for about 69 percent of the area and 70 percent of the production (Madhusudhana, 2013).

In India groundnut is cultivated on nearly 4.19 million hectares area with 6.68 million tonnes production and average productivity of 1.59 tonnes ha^{-1} (DGR, Junagadh 2015), while in Maharashtra state it is cultivated on area of 1.96 lakh hectares with productivity of 1163 Kg ha^{-1} and production of 2.28 lakh tonnes during *Kharif* season and 0.71 lakh hectares area and 0.97 lakh tonnes production with 1366 kg ha^{-1} productivity during *Rabi* season 2013-14 (Anonymous, 2014). The major groundnut growing districts

in Maharashtra are Dhule, Satara, Kolhapur, Pune, Nashik, Ahmednagar, Parbhani and Jalgaon.

In *Konkan* region groundnut is grown on 8400 hectares area with productivity of 1130 Kg ha^{-1} during *Kharif*. While groundnut crop is cultivated on more than 5000 ha area with productivity of 1827 Kg ha^{-1} during *Rabi* season (Anonymous, 2016).

Low productivity of groundnut under Indian as well as Maharashtra condition can be attributed to number of factors *viz.*, varies of monsoon, unavailability of irrigation facilities, poor management, heavy weed infestation and lack of improved technologies. Amongst these, weed infestation is one of the key factor. In *konkan* region heavy weed infestation is the main factor which reduces the yield of groundnut in *kharif* season. Weeds are regarded as pest of crop as they compete with the crops plant for nutrients, moisture, light, space, and carbon dioxide etc. The unchecked weed growth in groundnut field restricts the growth and yield potential of groundnut and overall improvement of soil health. In turn, it increases the cost of production and impairs the quality of the produce. If the field left uncontrolled these may reduce the groundnut yields up to 78% (Gnanamurthy and Balasuhbramanian 1998).

Though the physical methods of weed control are very effective, they have certain limitations such as unavailability of labours particularly during critical crop weed competition. Further, if the labours need to be engaged this incurs high cost. The progressive modernization of Indian agriculture involves intensive input use of comprising fertilizer, irrigation and herbicide are more beneficial for get quick control of weeds in short period is gaining importance in recent years. The pre-emergence and post-emergence application of selective herbicides either prevents the germination of weed seeds or inhibits the growth of weed seedling. Thus, to control the weeds by herbicides (pre or post) which are helpful for the entire season, long duration weed control is possible with the use of pre-emergence herbicide which, persist in the soil for about 40-45 days.

In Maharashtra, the groundnut is cultivated in *Konkan* region as rainfed crop during the *kharif* season but, fails to produce the productivity during *kharif* season. The crop yields are low during *kharif* mainly due to heavy weed infestation. Thus, restricts the cultivation during *kharif* season.

Hence, the groundnut crop is cultivated during summer season where irrigation facilities are available.

Indiscriminate use of herbicide not only affects the crop but also human health and environment and hence the 'Integrated Weed Management' has greater scope in *Kharif* groundnut. It is necessary to develop remunerative weed control by combining cultural and chemical methods of weed control. The new integrated method of weed control must be effective with cut adverse effect on crop. It is economical and environmentally safe.

Thus, weed is the biggest problem in groundnut cultivation, Therefore a field experiment entitled, **"Effect of Integrated Weed Management in *Kharif* Groundnut (*Arachis hypogaea* L.)"** is to be conducted at Agronomy Farm, Department of Agronomy, College of Agriculture, Dapoli (M.S.) during the *kharif* season of 2016 with the following objectives.

1. To study the relative performance of chemical and cultural weed control measures for control of weeds in *kharif* groundnut.
2. To study the effect of different weed control measures on growth, yield and quality of *kharif* groundnut.
3. To study the economics of various treatments.

CHAPTER-II

REVIEW OF LITERATURE

In view of the voluminous literature available in relation to the "Effect of integrated weed management in *kharif* groundnut (*Arachis hypogaea* L.)", only selected work is reviewed under the following headings in this chapter.

2.1 Effect of weed management practices on growth, yield attributes, yield and uptake of nutrients by groundnut.

2.1.1 Effect on growth attribute of crop.

2.1.2 Effect on yield and yield attribute of crop.

2.1.3 Effect on quality and nutrient uptake of crop.

2.2 Effect of different weed management practices and uptake of nutrients by weeds.

2.2.1 Effect on weed flora.

2.2.2 Effect on weed density.

2.2.3 Effect on growth of weed, weed control efficiency and weed index.

2.2.4 Effect on nutrient uptake of weeds.

2.3 Economics of different weed management treatments.

2.1 Effect of weed management practices on growth, yield attributes, yield and uptake of nutrients by groundnut.

2.1.1 Effect on growth attribute of crop.

Chandolia *et al.* (2010) conducted field trial on sandy loam soil of Udaipur to study the weed management in groundnut under varying crop geometry. They found that application of Pendimethalin @ 1 kg a.i. ha^{-1} + one hand weeding 30 DAS recorded significantly higher crop dry matter accumulation by 52.11 % at harvest.

Kalhapure *et al.* (2013) conducted field experiment at Rahuri to study the Integrated weed management in groundnut for consecutive two *kharif* season in 2010 and 2011. He reported that, weed-free recorded significantly

taller plants (29.12 cm) followed by Pendimethalin @ 1.5 kg a.i. ha^{-1} + Imazethapyr @ 0.150 kg a.i. ha^{-1} + one hand weeding at 40 DAS (26.49 cm).

Basavaraj *et al.* (2014) reported that, weed competition lowered the leaf area $plant^{-1}$ by 63 %, total dry matter production $plant^{-1}$ by 56 %, number of leaves $plant^{-1}$ by 62 % and consequently lowered the kernel weight $plant^{-1}$ by 70 % and 100 kernel weight by 90 %, as compared to hand weeding. Thus, adoption of suitable weed management through hand weeding or use of herbicides *i.e.* Imazethapyr @ 0.100 kg a.i. ha^{-1} and Pendimethalin @ 0.750 kg a.i. ha^{-1} improved the yield and growth components by 56 to 90 %.

2.1.2 Effect on yield and yield attribute of crop.

A field experiment was conducted by Malligawad *et al.* (2000) on black clayey soil of Dharwad to study the intigrated weed control in *kharif* groundnut. They reported that application of Pendimethalin @ 1 kg a.i. ha^{-1} + cultural practices produced significantly higher pod yield (3585 kg ha^{-1}).

Dutta *et al.* (2005) conducted a field experiment on acid lateritic soils during *kharif* season at West Bengal to study the comparative performance of cultural, chemical and integrated methods of weed control in rainfed groundnut. They found that, hand weeding twice at 20 and 40 DAS showed best result in respect of yield attributes and pod yield (1466 kg ha^{-1}) followed by application of Pendimethalin @ 0.750 kg a.i. ha^{-1} with one hand-weeding at 20 DAS (1436 kg ha^{-1}).

Solanki *et al.* (2005) conducted a field experiment on medium black soil of Junagadh to know the effect of integrated weed management in irrigated groundnut. They observed that, application of Pendimethalin @ 1.0 kg ha^{-1} + two interculturing (30 and 45 DAS) and one hand weeding (35 DAS) produced significantly higher pod yield (2114 kg ha^{-1}).

A field experiment was conducted by Dubey *et al.* (2010) at Jabalpur during *kharif* seasons evaluate the efficacy of Imazethapyr against weeds in groundnut. They reported that, higher Pod yield (1283 kg ha^{-1}), kernel yield (863 kg ha^{-1}) and haulm yield (2122 kg ha^{-1}) observed in application of Imazethapyr @ 0.100 kg a.i. ha^{-1} + chlorimuron 0.024 kg ha^{-1} followed by Imazethapyr @ 0.300 kg a.i. ha^{-1} (1208 kg, 833 kg and 2081 kg ha^{-1}, respectively).

Malunjkar *et al.* (2012) reported that the yield reduction up to 65 per cent was recorded if field kept un-weeded on medium clay loam soil at Jalgaon Maharashtra.

Kalhapure *et al.* (2013) conducted a field experiment at Rahuri to study the integrated weed management in groundnut for consecutive two *kharif* season in 2010 and 2011. He reported that, weed free check recorded heighest number of pods plant^{-1} (22.0), followed by Pendimethalin @ 1.5 kg a.i. ha^{-1} + Imazethyperr @ 0.150 kg a.i. ha^{-1} + one hand weeding at 40 DAS (21.2).

Gunri *et al.* (2014) reported that, among the post-emergence herbicidal treatments pod yield and haulm yield of groundnut was found maximum with application of Quizalofop ethyl @ 0.75 g a.i. ha^{-1} (2409 kg ha^{-1} and 2941 kg ha^{-1}, respectively) which was significantly superior to application of Imazethyper @ 0.50 g a.i. ha^{-1} (2082 kg ha^{-1} and 2546 kg ha^{-1}, respectively) and Imazethyper @ 0.75 g a.i. ha^{-1} (2109 kg ha^{-1} and 2598 kg ha^{-1}, respectively) at 20 DAS respectively but statistically at par with Imazethyper @ 0.100 kg a.i. ha^{-1} at 20 DAS (2211 kg ha^{-1} and 2731 kg ha^{-1}).

Singh *et al.* (2014) studied the efficacy of Quizalofop ethyl at various doses as sponsor sample (SS) over the available market sample (MS) against the complex weed flora in groundnut at Pantnagar during *Kharif* season. The experimental results indicated that higher number of pods plant^{-1} observed in application of Quizalofop ethyl @ 50 g a.i. ha^{-1} (10.7) followed by Quizalofop ethyl @ 37.5 g a.i. ha^{-1} (10.6).

Kalaichelvi *et al.* (2015) conducted a trial at Vaigaidam (TN) to study integrated weed management in groundnut. Result indicated that number of pods plant^{-1} (37) and seed pod yield (1.83 t ha^{-1}) was significantly higher with application of Pendimethalin @ 0.75 kg a.i. ha^{-1} + one hand weeding at 20 DAS.

Dixit *et al.* (2016) conducted a field experiment at research farm of Zonal Agricultural Research Station, Khargone, JNKVV, Jabalpur during 2009 and 2010 and observed that, the dry pod yield was recorded maximum in treatment weed free check (1522 kg ha^{-1}) followed by application of Pendimethalin @ 1.0 kg a.i. ha^{-1} + Imazythypar @ 75 g ha^{-1} 20 DAS (1207 kg ha^{-1}) and minimum in unweeded check (607 kg ha^{-1}).

2.1.3 Effect on quality and nutrient uptake of crop.

Madhu *et al.* (2006) conducted a trial on integrated weed management on nutrient uptake and yield in groundnut and sunflower intercropping system and observed that, all the weed control treatments registered a significant improvement in the uptake of nutrients by groundnut crop as compared to unweeded check. The maximum nutrient uptake was noticed in weed free check (71.49 N, 22.30 P_2O_5 and 78.58 K_2O kg ha^{-1}), closely followed by Pendimethalin 1.0 kg a.i. ha^{-1} + IC at 20 and 40 DAS (70.5 N, 21.92 P_2O_5 and 77.44 K_2O kg ha^{-1}).

An experiment was conducted by Singh and Singh (2009) on loamy sand soil of Ludhiana to study weed management and soil micro-organisms studies in irrigated summer groundnut. Results indicated that the maximum oil content (51.8 %) was obtained in Trifluralin @ 0.75 kg a.i. ha^{-1} + one hand weeding 40 DAS which was at par with Pendimethalin @ 0.75 kg a.i. ha^{-1} + one hand weeding 40 DAS (49.8 %).

An experiment was carrid out by Chandolia *et al.* (2010) on sandy loam soil of Udaipur during *kharif* season on weed management in groundnut under varying crop geometry and they observed that application of Pendimethalin @ 1 kg a.i. ha^{-1} + one hand weeding 30 DAS were the most effective in enhancing nutrient uptake except weed free check.

Basavaraj *et al.* (2014) conducted a field trial at Bengaluru to study influence of weed managent practices on crop growth, nutrient uptake and yield of groundnut under irrigation condition, during *kharif* 2011 and observed that, total uptake of nitrogen, phosphorus and potassium was significantly higher (1.6 to 1.8 times higher) in hand weeding (80.73 N, 15.10 P_2O_5 and 35.40 K_2O kg ha^{-1}) as compared to unweeded control (43.17 N, 8.43 P_2O_5 and 20.27 K_2O kg ha^{-1}), but it was at par with Imazethapyr @ 0.100 kg a.i. ha^{-1} (78.93 N, 14.13 P_2O_5 and 35.17 K_2O kg ha^{-1}).

2.2 Effect of different weed management practices and uptake of nutrients by weeds.

2.2.1 Effect on weed flora.

A field experiment was conducted by Solanki *et al.* (2005) at Junagadh on medium black soil to know the effect of integrated weed management in irrigated groundnut. They reported that, application of

Pendimethalin @ 1.0 kg ha^{-1} + two interculturing (30 and 45 DAS) and one hand weeding (35 DAS) gave lower weed dry matter (723 kg ha^{-1}).

Singh and Singh (2009) conducted a field trial on loamy sand soil of Ludhiana and studied weed management and soil micro-organisms in irrigated summer groundnut. Results indicated that Pendimethalin @ 0.75 kg a.i. ha^{-1} + one hand weeding at 40 DAS was effective in controlling the population of weeds.

Chandolia *et al.* (2010) while working at Udaipur on weed management in groundnut under varying crop geometry reported that, application of Pendimethalin @ 1 kg a.i. ha^{-1} + one hand weeding at 30 DAS were more effective in controlling all the monocot and dicot weeds and dry matter accumulation of weeds was found to be lower at all the stages of crop growth (20, 30 and 40 DAS).

Malunjkar *et al.* (2012) reported that, the application of Pendimethalin @ 1.0 kg a.i. ha^{-1} + Imazethapyr @ 750 ml ha^{-1} at 20 DAS recorded significantly least number of weed (42.7 m^{-2}) and weed dry matter (176.2 g m^{-2}) than application of Pendimethalin @ 1.0 kg a.i. ha^{-1} + one hand weeding 20DAS (45.2 m^{-2} and 176.2 g m^{-2}, respectively) except weed free check (18.9 m^{-2} and 78.0 g m^{-2}, respectively).

Gunri *et al.* (2014) carried out a field trial on alluvial zone of West Bengal to find out the effect of different post emergence herbicide on summer growing groundnut during summer season of 2010 and 2011. They found that the best herbicidal response to weed density (25 m^{-2} at 45 DAS and 60 m^{-2} at 75 DAS) and weed dry matter production (26 g at 45 DAS and 63.1 g at 75 DAS) was recorded from application of Pendimethalin @ 1.0 kg a.i. ha^{-1} along with one hand weeding.

2.2.2 Effect on weed density.

Dutta *et al.* (2005) conducted a field experiment during *kharif* season on acid lateritic soils of West Bengal to study the comparative performance of cultural, chemical and integrated methods of weed control in rainfed groundnut. The results indicated that, among the herbicides treatments, application of Pendimethalin @ 0.75 kg a.i. ha^{-1} + one hand weeding at 20 DAS showed its superiority by recording lower weed density (48.55 m^{-2}) and

weed dry weight (180.1 kg ha^{-1}) as compared with the fluchloralin @ 0.9 kg a.i. ha^{-1} + one hand weeding at 20 DAS weed density (65.65 m^{-2}) and weed dry weight (221.1 kg ha^{-1}).

Das and Samant (2014) conducted a field trial at Odisha during *rabi* season for two consecutive years 2011-12 and 2012-13. They reported that, application of quizalofop ethyl @ 0.050 kg a.i. ha^{-1} with one hand weeding at 25 DAS recorded lowest population of weeds (36.2 m^{-2}).

Gunri *et al.* (2014) carried out a field trial on alluvial zone of West Bengal to find out the effect of different post emergence herbicide on summer growing groundnut during summer season of 2010 and 2011 and observed that, among the post-emergence herbicide treatments, best response was observed from application of Quizalofop ethyl @ 100 g a.i. ha^{-1} at 20 DAS and Imazethyper @ 75 g a.i. ha^{-1} at 20 DAS regarding total weed density (51 m^{-2} and 54 m^{-2} at 45 DAS, respectively) and weed dry matter (89.3 g m^{-2} and 78.3 g m^{-2}, respectively).

Singh *et al.* (2014) studied the efficacy of Quizalofop ethyl at various doses as sponsor sample (SS) over the available market sample (MS) against the complex weed flora in groundnut at Pantnagar during *Kharif* season. The experimental results indicated that application of Quizalofop ethyl @ 50 g a.i. ha^{-1} showed lower grassy weed density (1.0 m^{-2}) and total weed dry weight (7.4 g m^{-2}).

Sheoran *et al.* (2015) conducted a field experiment during the *kharif* seasons of 2009 and 2010 at Ludhiana to determine effective weed management strategy in groundnut. He observed that, application of Pendimethalin @ 0.75 kg a.i. ha^{-1} + Imazethapyr @ 0.05 kg a.i. ha^{-1} (20 DAS) + one hand weeding (45 DAS) recorded highest weed control efficiency (83.7 %) with lowest weed dry weight (74.0 g m^{-2}) and two hand weedings done at three and six weeks after sowing (WAS) was found to be the next superior treatment (82.6 % and 79.3 g m^{-2} respectively).

Kalaichelvi *et al.* (2015) conducted a trial at Vaigaidam (TN) to study integrated weed management in groundnut. They observed that, application of Pendimenthalin @ 0.75 kg a.i. ha^{-1} + one hand weeding 20 DAS was significantly lowered grass, broad-leaved and sedges weed density and

Pendimenthalin @ 0.75 kg a.i. ha^{-1} + Quizalofop ehyl @ 0.25 kg a.i. ha^{-1} was also significantly lowered the grass weed density.

2.2.3 Effect on growth of weed, weed control efficiency and weed index.

Malligawad *et al.* (2000) reported that application of Pendimethalin @ 1 kg a.i. ha^{-1} + intercultivations at 30 and 45 DAS and one hand weeding at 30 DAS gave highest weed control efficiency (94.45 %).

Dutta *et al.* (2005) carried out a field experiment during *kharif* season on acid lateritic soils of West Bengal to study the comparative performance of cultural, chemical and integrated methods of weed control in rainfed groundnut. They observed that, weed control efficiency was higher (85.3 %) with hand-weeding twice at 20 and 40 DAS closely followed by application of Pendimethalin @ 0.75 kg a.i. ha^{-1} + one hand weeding at 20 DAS (83.7 %).

Solanki *et al.* (2005) conducted a field experiment on medium black soil of Junagadh to know the effect of integrated weed management in irrigated groundnut. They observed that, application of Pendimethalin @ 1.0 kg a.i. ha^{-1} + two intercllituring (30 and 45 DAS) and one hand weeding (35 DAS) produced significantly higher weed control efficiency (82 %) and lowest weed index (18 %).

A field experiment was conducted by Dubey *et al.* (2010) at Jabalpur during *kharif* seasons and evaluate the efficacy of Imazethapyr against weeds in groundnut. They reported that, among herbicidal treatments higher weed control efficiency observed in application of Imazethapyr @ 0.100 kg a.i. ha^{-1} + chlorimuron 0.024 kg ha^{-1} (98.6 % 40 DAS and 98.1 % at harvest) followed by Imazethapyr @ 0.300 kg a.i. ha^{-1} (98.3 % 40 DAS and 97.4 % at harvest).

Patel *et al.* (2013) reported that, among different weed control treatments, two hand weeding + two interculture at 20 and 40 DAS recorded significantly lowest weed index (3.1 %) followed by pendimethalin @ 1 kg a.i. ha^{-1} (8.7 %) and highest weed index in weedy check (57.3 %).

Basavaraj *et al.* (2014) carried out an experiment at Bengaluru to study influence of weed managent practices on crop growth, nutrient uptake and yield of groundnut under irrigation condition, during *kharif* 2011. They

observed that, lowest weed index was noticed in Imazethapyr @ 0.100 kg a.i. ha^{-1} 20 DAS (2.16 %) and Pendimethalin @ 0.750 kg a.i. ha^{-1} (4.56 %).

Das and Samant (2014) conducted a field trial was at Odisha during *rabi* season for two consecutive years 2011-12 and 2012-13. They reported that, application of Quizalofop ethyl @ 0.050 kg a.i. ha^{-1} + one hand weeding at 25 DAS recorded higher weed control efficiency (71.0 %).

Malunjkar *et al.* (2012) conducted field experiment during *kharif* season at Jalgaon on evaluation of post emergence herbicides in rainy season groundnut in order to control groundnut associated weeds and result indicated that, application of Pendimethalin @ 1.0 kg a.i. ha^{-1} + Imazethapyr @ 750 ml ha^{-1} at 20 DAS was recorded significantly highest weed control efficiency (74 %) than the application of Pendimethalin @ 1.0 kg a.i. ha^{-1} + one hand weeding (70 %) except weed free check (100 %).

Kalhapure *et al.* (2013) carried out a field experiment at Rahuri and noted that, highest weed control efficiency (91.40 %) and lowest weed index (0.0 %) were observed in weed free check and Pendimethalin @ 1.5 kg a.i. ha^{-1} + Imazethapyr @ 0.150 kg ha^{-1} + one hand weeding at 40 DAS was found next superior treatment after weed free check in respect of weed control efficiency (89.94 %) and weed index (5.13 %).

Patel *et al.* (2013) reported that, among different weed control treatments, two hand weeding + two interculture at 20 and 40 DAS recorded significantly higher weed control efficiency (94.2 %), which was at par with application of Pendimethalin @ 1.0 kg *a.i.* ha^{-1} (90 %). Among herbicidal treatments, pendimethalin @ 1.0 kg a.i. ha^{-1} (90 %) and Quizalofop ethyl @ 200 g ha^{-1} (86.20 %) were at par with each other.

Singh *et al.* (2014) studied the efficacy of Quizalofop ethyl at various doses as sponsor sample (SS) over the available market sample (MS) against the complex weed flora in groundnut at Pantnagar during *Kharif* season. The experimental results indicated that higher weed control efficiency observed in weed free check (100 %) followed by application of Quizalofop ethyl @ 0.050 kg a.i. ha^{-1} (SS) (86 %) and Quizalofop ethyl @ 0.050 kg a.i. ha^{-1} (MS) (83.8 %).

2.2.4 Effect on nutrient uptake of weeds.

Ambulkar *et al.* (1993) conducted an experiment at College of Agriculture, Dapoli, Maharashtra, in *kharif* season and reported that maximum removal of 69.85 Kg N and 13.24 Kg P_2O_5 ha^{-1} by weeds in unweeded control.

Madhu *et al.* (2006) conducted an experiment to study the integrated weed management on nutrient uptake and yield in groundnut and sunflower intercropping system. Results showed that, lowest nutrient uptake by weeds was noticed in weed free check (7.20 N, 5.16 P_2O_5, 2.74 K_2O kg ha^{-1}) and Pendimethalin @ 1.0 kg a.i. ha^{-1} (25.38 N, 9.80 P_2O_5, 9.55 K_2O kg ha^{-1}).

Basavaraj *et al.* (2014) carried out an experiment at Bengaluru to study influence of weed management practices on crop growth, nutrient uptake and yield of groundnut under irrigation condition, during *kharif* 2011. They observed that, the minimum nutrient uptake by weed was noticed in Imazethapyr @ 0.100 kg a.i. ha^{-1} at 20 DAS (13.00 N, 4.44 P_2O_5, 13.50 K_2O kg ha^{-1}) followed by Pendimethalin @ 0.750 kg a.i. ha^{-1}(15.08 N, 5.71 P_2O_5, 14.63 K_2O kg ha^{-1}) and Quizalofop ethyl @ 0.050 kg ha^{-1} at 20 DAS (15.60 N, 6.12 P_2O_5, 15.82 K_2O kg ha^{-1}).

2.3 Economics of different weed management treatments.

A field experiment was conducted by Malligawad *et al.* (2000) at Dharwad on black clayey soil to study the Integrated weed control in *kharif* groundnut. They reported that application of Pendimethalin @ 1 kg a.i. ha^{-1} + cultural practices gave highest gross return (₹ 40342 ha^{-1}), net return (₹ 24212 ha^{-1}) and B: C ratio (2.50).

Dutta *et al.* (2005) conducted a field experiment on acid lateritic soils during *kharif* season at West Bengal, to study the comparative performance of cultural, chemical and integrated methods of weed control in rainfed groundnut and observed that, application of Pendimethalin @ 0.75 kg a.i. ha^{-1} + one hand weeding at 20 DAS which gave highest net return (₹ 16994 ha^{-1}) and B: C ratio (1.45).

Solanki *et al.* (2005) conducted a field experiment on medium black soil of Junagadh to know the effect of integrated weed management in irrigated groundnut. They observed that, weed-free treatment recorded higher gross return (₹ 37824 ha^{-1}) and net return (₹ 24080 ha^{-1}) followed by

Pendimethalin @ 1.0 kg ha^{-1} + interculturing 30 and 45 DAS and hand weeding 35 DAS (₹ 31565 and ₹ 17972 ha^{-1}, respectively).

A field experiment was conducted by Dubey *et al.* (2010) at Jabalpur during *kharif* season and evaluates the efficacy of Imazethapyr against weeds in groundnut. They reported that, among herbicide treatments higher net return (₹ 14096 ha^{-1}) and B: C ratio (1.8) observed in application of Imazethapyr @ 0.100 kg a.i. ha^{-1} + chlorimuron 0.024 kg ha^{-1} followed by Imazethapyr @ 0.200 kg a.i. ha^{-1} (₹ 11745 and 1.6 ha^{-1}, respectively).

Malunjkar *et al.* (2012) carried out experiment at Jalgaon during *kharif* season and observed that, among the different herbicides, application of Pendimethalin @ 1.0 kg a.i. ha^{-1} + Imazethapyr @ 750 ml ha^{-1} at 20 DAS recorded significantly higher gross returns (₹ 49,779 ha^{-1}) and net returns (₹ 28705 ha^{-1}) followed by Pendimethalin @ 1.0 kg a.i. ha^{-1} + one hand weeding (₹ 47549 and ₹ 24920, respectively).

Kalhapure *et al.* (2013) conducted field experiment at Rahuri to study the integrated weed management in groundnut for consecutive two *kharif* season in 2010 and 2011 and they reported that, weed-free check recorded significantly highest gross returns (₹ 1,09,845 ha^{-1}), whereas application of Pendimethalin @ 1.5 kg a.i. ha^{-1} + Imazethapyr @ 0.150 kg a.i. ha^{-1} + one hand weeding at 40 DAS recorded highest net returns (₹ 61,460 ha^{-1}) and B: C ratio (2.42).

Singh *et al.* (2014) studied the efficacy of Quizalofop ethyl at various doses as sponsor sample (SS) over the available market sample (MS) against the complex weed flora in groundnut at Pantnagar during *Kharif* season. The experimental results indicated that higher net return (₹ 36950 ha^{-1}) and B: C ratio (1.03) obtained in weed free check followed by application of Quizalofop-ethyl @ 50 g ha^{-1} (₹ 15550 and 0.46 respectively).

Dixit *et al.* (2016) conducted field trial at Khargone, JNKVV, Jabalpur during 2009 and 2010 and observed that, maximum net return showed in weed free check (₹ 16712 ha^{-1}) followed by Pendimethalin @ 1.0 kg a.i. ha^{-1} + Imazethypar @ 75 g a.i. ha^{-1} at 20 DAS (₹ 16270 ha^{-1}). Maximum B: C ratio was observed in application of Pendimethalin @ 1.0 kg a.i. ha^{-1} + Imazethypar @ 75 g a.i. ha^{-1} at 20 DAS (2.2) followed by application of

Imazethypar @ 75 g a.i. ha^{-1} at 20 DAS (2.1) and Quizalofop ethyl @ 50 g a.i. ha^{-1} at 20 DAS (1.9).

CHAPTER-III

MATERIALS AND METHODS

The present investigation “Effect of integrated weed management in *kharif* groundnut (*Arachis hypogaea* L.)” was conducted at Agronomy Farm, Department of Agronomy, College of Agriculture, Dapoli, Dist. Ratnagiri (M.S.) during *kharif* season of 2016. The materials used and methodology adopted during the investigation are explained in this chapter.

3.1 Experimental site

The experiment was conducted at the Agronomy Farm, Department of Agronomy, College of Agriculture, Dapoli, Dist. Ratnagiri during *kharif* season of 2016. The experiment was laid out in plot number 17 of ‘B’ block. The topography of the experimental plot was uniform. The selection of site was considered on the basis of suitability of the land for cultivation of groundnut.

3.2 Soil of the experimental field

The composite soil sample from 0 to 30 cm soil layer was taken with the help of screw auger before starting of field experiment. Soil thus collected was air dried and preserved properly in aluminium boxes. It was then analysed for various physico-chemical properties of soil by various methods, the details of which presented in Table 1.

The soil of the experimental plot was sandy clay loam in texture, slightly acidic in pH and medium in organic carbon content. It was low in available nitrogen, medium in available phosphorus and available potassium.

3.3 Climate and weather

Agronomy Farm, College of Agriculture, Dapoli, Dist. Ratnagiri is situated in tropical region at $17^{0}19'$ North latitude having elevation of 250 meters above mean sea level. The climate is tropical, warm and humid which is favorable for groundnut crop during *kharif* season.

The annual rainfall during 2016 of Dapoli is 4497.9 mm distributed from the beginning of June to October and the data regarding different weather parameters recorded at the meteorological observatory of Agronomy Farm, College of Agriculture, Dapoli during the period of experimentation are presented in Table 2 and graphically depicted in Fig. 1.

Table 1. Initial physical and chemical properties of soil from the experimental field

Particulars	Composition	Method used
Physical properties:		
Particle size distribution		
Sand (%)	22.8	Bouyoucos hydrometer (Jackson, 1973)
Silt (%)	30.0	
Clay (%)	47.2	
Textural class	Sandy clay loam	Using textural triangle given by ISSS
Chemical properties:		
Soil pH (1:2.5)	5.72	Potentiometric method (Jackson, 1973)
EC (dSm^{-1})	0.62	
Organic carbon (g kg^{-1})	9.7	Walkey and Black wet oxidation method (Black, 1965)
Available N (kg ha^{-1})	270.00	Alkaline permanganate method (Subbaih and Asija, 1956)
Available P_2O_5 (kg ha^{-1})	17.80	Bray's method

		(Bray's and Kurtz, 1945)
Available K_2O (kg ha^{-1})	190.22	Flame photometer (Jackson, 1973)

Table 2. Meteorological observations during the crop growth period during 2016

Period (28.05.2016 to 12.11.2016)	MW	Temprature (^{0}C)		Mean relative humidity (%)		Rain-fall	RD	BSS
		Max.	Min.	Morn.	Even.	(mm)	day	(hrs.)
28.05 - 03.06	22	34.7	25.6	83	59	5.1	1	9.2
04.06 - 10.06	23	34.0	24.8	91	70	40.0	2	3.2
11.06 - 17.06	24	31.4	24.9	91	76	93.5	5	4.7
18.06 - 24.06	25	26.6	23.1	98	93	298.7	7	1.4
25.06 - 01.07	26	27.2	22.6	98	97	792.5	7	0.0
02.07 - 08.07	27	28.5	23.6	94	92	462.6	7	0.2
09.07 - 15.07	28	28.4	23.3	95	89	256.8	7	1.4
16.07 - 22.07	29	27.3	22.4	99	95	403.0	7	0.6
23.07 - 29.07	30	28.8	22.4	98	85	268.0	6	0.7
30.07 - 05.08	31	27.6	22.7	97	94	481.5	7	0.6
06.08 - 12.08	32	27.6	23.6	94	92	182.7	7	0.4
13.08 - 19.08	33	29.3	24.3	91	84	39.0	4	1.8
20.08 - 26.08	34	28.9	23.4	95	87	73.6	6	2.0
27.08 - 02.09	35	28.4	22.6	95	88	138.4	7	1.1
03.09 - 09.09	36	29.4	21.6	94	72	36.9	3	5.3
10.09 - 16.09	37	29.9	22.2	93	82	55.8	2	3.3
17.09 - 23.09	38	27.0	22.5	98	94	582.4	7	1.0
24.09 - 30.09	39	29.1	22.6	96	82	88.1	6	2.4
01.10 - 07.10	40	27.7	21.4	97	83	189.1	2	3.5

08.10 - 14.10	41	30.4	22.3	94	83	10.2	1	5.8
Mean/Total		**29.11**	**23.09**	**94.55**	**84.85**	**4497.9**	**101**	**2.43**

3.4 Cropping history of the experimental plot

The cropping sequences followed for the previous years on the experimental plot before the investigation are presented in Table 3.

Table 3. Cropping history of the experimental plot

Year	Season	
	Kharif	***Rabi***
2012-13	Rice	Fallow
2013-14	Rice	Horse gram
2014-15	Fingermillet	Groundnut
2015-16	Prosomillet	Fallow
2016-17	Groundnut (Experiment)	-

3.5 Experimental details

The field experiment was laid out in Randomized Block Design comprising of ten treatment combinations replicated three times. The layout of experimental plot is depicted in Fig. 2. Symbols used for different treatments, dose of herbicides and their time of application are given in Table 4.

Table 4. Symbols used for different treatments, dose and their time of application

Symbol	Treatment	Dose (g a.i.ha^{-1})	Time of Application
T_1	Pendimethalin	1000	0-2 DAS
T_2	Imazethapyr	750	20 DAS
T_3	Pendimethalin *fb* Imazethapyr	1000 *fb* 750	0-2 *fb* 20 DAS
T_4	Pendimethalin *fb* Quizalofop ethyl	1000 *fb* 750	0-2 *fb* 20 DAS
T_5	Pendimethalin *fb* 1 HW	1000	0-2 *fb* 20 DAS
T_6	Pendimethalin *fb* 1 HW	1000	0-2 *fb* 40 DAS
T_7	Imazethapyr *fb* 1 HW	750	20 *fb* 40 DAS

T_8	Pendimethalin *fb* Imazethapyr *fb* 1 HW	1000 *fb* 750	0-2 *fb* 20 *fb* 40 DAS
T_9	Weed free check.	-	HW at 20,40,60 DAS
T_{10}	Weedy check.	-	-

a) Crop : Groundnut

b) Variety : *Konkan Tapora*

c) Spacing : 30 cm X 15 cm

d) Experimental design : Randomized Block Design

e) No. of replications : Three

f) No. of treatments : Ten

g) Gross plot size : 4.80 m X 3.60 m

h) Net plot size : 4.50 m X 3.00 m

i) Manures and fertilizers : a) F.Y.M- 10 t ha^{-1}

b) R.D.F- 25:50:00 N:P:K kg ha^{-1}

Table 5. Schedule of cultural operations carried out in the experimental plot during *Kharif* 2016

Sr.No.	Field operations followed	Frequency	Date of operation
A)	**Pre-sowing operations**		
	a. Ploughing	1	27/05/2016
	b. Clod crushing	1	02/06/2016
	c. Layout of experimental plot	1	07/06/2016
	d. Bed preparation	1	08/06/2016
B)	**Sowing**		
	a. Seed treatment with Rhizobium	1	11/06/2016
	b. Sowing of groundnut	1	11/06/2016
C)	**Fertilizer and FYM application at the time of sowing**		

	a. FYM application	1	08/06/2016
	b. Fertilizer application at the time of sowing	1	11/06/2016
D)	**Spraying of herbicides**		
	a. Pre-emergence herbicide	1	12/06/2016
	b. post-emergence herbicide 20 DAS	1	01/07/2016
E)	**Inter cultural and weeding operation**		
	a. Gap filling	1	21/06/2016
	b. Hand weeding as per treatment (20, 40,60 DAS)	3	01/07/2016 21/07/2016 11/08/2016
F)	**Plant protection measures**		
	a. Spraying of Cypermethrin	1	07/07/2016
	b. Spraying of M-45	1	04/08/2016
G)	**Harvesting**	1	10/10/2016
	Weed		
	a. Weeds from each treatment were cut with the help of sickle close to ground level	1	10/10/2016
	b. Drying of weeds	1	12/10/2016
	c. Weighing of weeds	1	15/10/2016

3.6 Details of field operations

3.6.1 Preparatory tillage

The experimental site was ploughed with the help of tractor and clod crushing was done by tractor drawn rotavator. The field was levelled with the help of wooden leveller and made ready for the layout.

3.6.2 Layout of Fields

Layout of field was done as per randomized block design. Raised beds were prepared of 20-25 cm height and small bunds were made around each plot along with keeping distance of 1 m between two replications. There were ten plots in each replication and in all there were three replications. Hence, there were 30 plots of 4.80 m x 3.60 m each.

3.6.3 Seed and Sowing

a) Seed

The seed of groundnut variety *Konkan tapora* treated with rhizobium culture @ 250 g per 10 kg of seeds to improve symbiotic nitrogen fixation in soil. The duration of the variety is 115-120 days.

b) Sowing

The sowing of *kharif* groundnut was done at the spacing 30 cm X 15 cm as to maintain the uniform plant population in all the plots. Healthy and well developed unbroken kernels were selected as seed. Sowing was done by dibbling of two seeds per hill manually with seed rate 120 kg ha^{-1} at 2-3 cm depth.

3.6.4 Manures and Fertilizer application

F.Y.M. @ 10 tonns ha^{-1} was uniformly applied at the time of bed preparation. Chemical fertilizers were applied @ nitrogen (25 kg ha^{-1}) and phosphorus (50 kg ha^{-1}) in the form of urea (46 % N) and single super phosphate (16% P_2O_5) respectively as basal dose and mixed into the soil before sowing of seed.

3.6.5 Intercultural and other cultural practices

a) Gap filling

The gap filling was done ten days from sowing to maintain the optimum plant population.

b) Weeding

The hand weeding was done at 20, 40 and 60 DAS.

3.6.6 Application of herbicides

Herbicides were applied as per the treatments. Pendimethalin was applied as a pre emergence (0-2 DAS) and again Imazethapyr and Quizalofop

ethyl were applied as a post emergence (20 DAS), respectively. The details regarding chemistry of herbicides which are used in experiment are as follows:

Table 6. Chemical name, mode of action, trade name and chemical formulae of herbicides.

Sr. No.	Chemical name	Mode of action of Herbicide	Trade name	Chemical formulae
1	Pendimethalin (PE)	It inhibits root and shoot growth and prevent plant cell division and elongation in susceptible species	Pendi guard	$C_{13}H_{19}N_3O_4$
2	Imazethapyr	It inhibits amino acid synthesis (ALS enzyme)	Steek	$C_{15}H_{19}N_3O_3$
3	Quizalofop ethyl	Systemic herbicide, absorbed from the leaf surface, with translocation throughout the plant, moving in both the xylem and phloem, and accumulating in the meristematic tissue	Targa super	$C_{19}H_{17}ClN_2O_4$

3.6.7 Plant protection measures

Plant protection measures were carried out throughout the crop season. Spraying of cypermethrin was done to control the leaf eating caterpillar and Mancozeb to control tikka disease.

3.6.8 Harvesting

The experimental plot crop was harvested when the pods matured fully. The plants from border rows of all the four sides were removed to eliminate the border effect. Harvesting was carried out manually by uprooting the plants. Five observation plants were harvested separately for recording the observations. The produce was allowed to sundry for seven days. Dry weight of the pods and haulm were recorded from each plot.

3.7 Biometric observations

In order to assess the effect of different treatments on the growth and development of the experimental crop, periodical observations were recorded. First periodical observation was recorded at 20 DAS and subsequent observations were recorded at every 20 DAS intervals from first observation till the last at harvest. Particulars of important observations recorded in respect of the experimental crop are mentioned in Table 7.

3.7.1 Growth studies of groundnut crop

3.7.1.1 Sampling technique

For recording biometric observations, five representative hills from each net plot were selected randomly. The selected hills were labeled with proper notations and all the biometric observations were recorded from these plants.

3.7.1.2 Plant population

Numbers of plants in the net plot of different treatments were counted at 20 DAS and at harvest.

3.7.1.3 Plant height (cm)

Plant height of main stem was measured from the base of the plant *i.e.* from the ground level up to the collar of the fully opened leaf of the plant.

Table 7: Details of biometric and other observations recorded from the treatments

Sr. No.	Particular	Days after Sowing
A)	**Pre-harvest studies**	
1.	Plant population	At 20 DAS and at harvest
2.	Plant height (cm)	20, 40, 60, 80, 100 DAS and at harvest
3.	Number of functional leaves per hill	20, 40, 60, 80, 100 DAS and at harvest
4.	Plant spread (cm)	20, 40, 60, 80, 100 DAS and at harvest

5.	Number of branches per hill	20, 40, 60, 80, 100 DAS and at harvest
6.	Dry matter per hill (g)	20, 40, 60, 80, 100 DAS and at harvest
B)	**Post-harvest studies**	
1.	Number of pods per hill	At harvest
2.	Number of developed pods per hill	At harvest
3.	Weight of mature pods per hill	At harvest
4.	100 Kernel weight (g)	At harvest
5.	Dry pod yield (q ha^{-1})	At harvest
6.	Kernel yield (q ha^{-1})	At harvest
7.	Haulm yield (q ha^{-1})	At harvest
8.	Shelling percentage (%)	At harvest
C)	**Weed studies**	
	a. No of grasses, sedges and broad leaves weed	20, 40, 60, 80, 100 DAS and at harvest
	b. Dry weight of grasses, sedges and broad leaves weeds (g)	At harvest
	c. Weed control efficiency (%)	At harvest
	d. Weed index (%)	At harvest
D)	**Chemical studies**	
	I) Soil analysis	

	For available Nitrogen, Phosphorous and potassium (kg ha^{-1})	Before sowing and after harvesting
	II) Uptake studies of crop	
	i) Nitrogen uptake (kg ha^{-1})	At harvest
	ii) Phosphorous uptake (kg ha^{-1})	At harvest
	iii) Potassium uptake (kg ha^{-1})	At harvest
	III) Uptake studies of weed	
	i) Nitrogen uptake (kg ha^{-1})	At harvest
	ii) Phosphorous uptake (kg ha^{-1})	At harvest
	iii) Potassium uptake (kg ha^{-1})	At harvest
E)	**Quality studies**	
	i) Protein content in kernel	At harvest
	ii) Oil content in kernel	At harvest

3.7.1.4 Number of functional leaves

Numbers of functional leaves borne on the five hills were counted periodically in order to get the idea of growth and vigour of the plants in various treatments. The data obtained from five hills were divided by number of hills to get number of leaves per hill.

3.7.1.5 Spread of plant (cm)

The spread of plant for five selected hills were measured and average spread was work out.

3.7.1.6 Number of branches per hill

Number of branches on the five hills was counted periodically in order to get the idea of growth and vigour of the plants in various treatments. The

data obtained from five hills were divided by number of hills to get number of branches per hill.

3.7.1.7 Dry weight per hill (g)

For dry matter studies one representative plant was sampled randomly from each plot. After uprooting, sampled hill was washed with clean water to remove all soil particles. The roots were removed from the collar. This plants was chopped into small pieces and preserved in brown paper bag labeled suitably and air dried first and then put in thermostatically controlled oven at the temperature of 60^0C. The drying was done till getting constant weight.

3.7.2 Post harvest studies

3.7.2.1 Total number of pods per hill

The number of pod (developed and undeveloped) were counted at harvest from the five observational hills and average was worked out.

3.7.2.2 Number of developed pods per hill

From the five observational hills developed pods were counted and average was worked out.

3.7.2.3 Weight of developed pods per hill (g)

Total weight of developed pods from five observational hills were taken and average was worked out.

3.7.2.4 Weight of 100 kernels (g)

One hundred kernels were counted randomly from five observational hills and also net plots and their weight was recorded.

3.7.2.5 Dry pod yield

Pod yield for each plant was obtained from the net plots and converted to per ha dry pod yield.

3.7.2.6 Haulm yield (q ha^{-1})

Haulm, after separation of pods, plot wise aerial parts were sun dried for seven days. Dry weight of this produce was taken as haulm yield. Yield of haulm per net plot was recorded and expressed on hectare basis.

3.7.2.7 Kernel yield (q ha^{-1})

Kernel yield (q ha^{-1}) for each plot was obtained based on shelling percentage and dry pod yield (q ha^{-1}).

$$\text{Kernel yield (q ha}^{-1}\text{)} = \frac{\text{Shelling percentage x Dry pod yield (q ha}^{-1}\text{)}}{100} \times 100$$

3.7.2.8 Shelling percentage

A treatment wise sample of 500 g of pods was shelled and weight of kernels was recorded and shelling percentage was calculated by formula.

$$\text{Shelling percentage (\%)} = \frac{\text{Weight of kernels (g)}}{\text{Weight of pods (g)}} \times 100$$

3.8 Weed studies

Intensity of weeds occurring in the net plot was calculated by quantitative methods. For this purpose, a quadrant having an area of 1 m^2 was arranged randomly in a net plot. Such three spots were identified in each net plot. By taking average from the three spots weeds m^{-2} were recorded. The weeds observed in the quadrant were grouped as grassy, sedges and broad leaved weeds.

3.8.1 Weed count

The weed count was done by species wise that is grasses, sedges and BLWs were counted within the 1 m^2 quadrant. First weed count was taken at 20 DAS. The second, third, fourth, fifth and sixth weed count was taken at 40, 60, 80, 100 DAS and at harvest, respectively.

3.8.2 Dry matter of weeds

The weeds were cut close to ground at the time of harvest of crop and were grouped as grasses, sedges and broad leaved weeds and then kept for sun drying up to four days. Then all the weeds from each net plot were collected and their weights were recorded. These were kept in oven for drying. The dry weight was recorded after obtaining constant weight.

3.8.3 Weed control efficiency (%)

The weed control efficiency was calculated as the percentage reduction in density and growth of weeds in case of the treatments under study compared to the control treatment.

$$\text{Weed control efficiency (\%)} = \frac{W_0 - W_t}{W_0} \times 100$$

Where,

W_0 = Total dry weight of weeds from unweeded plot.

W_t = Total dry weight of weeds from treated plot.

3.8.4 Weed index (%)

The weed index was calculated as the percentage increase in yield of crop in case of the treatments under study compared to the weed free treatment.

$$\text{Weed index (\%)} = \frac{Y_{HW} - Y_t}{Y_{HW}} \times 100$$

Where,

Y_{HW} = Average yield of crop in wed-free plot.

Y_t = Average yield of crop in plot under other weed control treatment.

3.9 Chemical studies

3.9.1 Soil analysis

The soil analysis was carried out for available N, P_2O_5 and K_2O and before initiating the experiment and after harvest of the crop by following the methods mentioned in Table 8.

3.9.2 Plant analysis

The sampled plants from each net plot were harvested and used for chemical analysis of kernel and haulm. The dried samples were grind to fine powder and kept in properly labelled bags. Similarly, weed samples were also

prepared and kept in same manner and used for estimation of total N, P_2O_5, and K_2O content by the methods mentioned in Table 8.

Table 8: Methods used for soil and plant analysis

I) Soil analysis			
Sr.No.	**Properties**	**Method**	**Reference**
1.	Texture and textural class of initial soil sample.	Bouycos hydrometer method	Piper (1956)
2.	Soil reaction (pH)	Potentiometric (1:2.5)	Jackson (1973)
3.	Electrical conductivity	Potentiometric (1:2.5)	Jackson (1973)
4.	Organic carbon	Walkley and Black wet oxidation method	Black (1965)
5.	Available Nitrogen	Alkaline permanganate method	Subbaiah and Asija (1956)
6.	Available Phosphorus	Bray's No. 1(0.025 N HCl + 0.03 N NH_4 F Fextraction)	Black (1965)
7.	Available Potassium	Flame photometry (Neutral normal ammonium acetate)	Jackson (1973)
II) Plant, Kernel and Weed analysis			
1.	Total nitrogen	Micro-Kjeldhal method	Tandon (1993)
2.	Total phosphorus	Ammonium molybdovanadate method	Tandon (1993)
3.	Total potassium	Flame photometry	Tandon (1993)
4.	Oil	Soxhlet apparatus	Mehra (1955)
5.	Protein	Determination of available N x Factor (6.25)	A.O.A.C. (1975)

3.9.3 Uptake of nutrients by the crop and weeds

The uptake of nitrogen, phosphorous and potassium (kg ha^{-1}) was worked out by multiplying the percentage of these nutrients in kernel, haulm and weeds with the corresponding yields and dry weight of the respective constituent.

3.10 Quality studies in groundnut

3.10.1 Oil content in kernel

Oil content in groundnut kernel was estimated as described by Mehra (1955) by using Soxhlet apparatus, and per cent oil content was multiplied by kernel yield to get total oil yield (q ha^{-1}).

3.10.2 Protein content (%) in kernel

The protein content in kernel of groundnut was calculated by multiplying the nitrogen percentage with factor 6.25 (A.O.A.C., 1975).

3.11 Statistical analysis and interpretation of data

Experimental data was analysed statistically by applying technique of analysis of variance as applicable in randomized block design. The significance of the treatment difference was tested by variance ratio test (f value), critical difference (C.D.) at 5 per cent level of probability was worked out for comparison and statistical interpretation of the significance was done on the basis of treatment means (Panse and Sukhatme, 1967).

3.12 Economics of the treatments

On the basis of the results obtained from the field experiment the economics was worked out. The gross income per ha was calculated on the basis of cost of dry pod yield and haulm yield from the respective treatments. The prevailing market price for dry pod and haulm were considered. The cost of cultivation of crop under individual treatment was worked out by taking into accounts the cost of all inputs.

CHAPTER-IV
EXPERIMENTAL FINDINGS

Results of the experiment entitled "Effect of Integrated weed management in *kharif* groundnut (*Arachis hypogaea* L.)" are presented in this chapter under the suitable sub headings. These are as follows:

4.1 Plant population studies
4.2 Crop growth studies
4.3 Studies on yield contributing characters
4.4 Yield studies
4.5 Weed studies
4.6 Quality and nutrient uptake by groundnut
4.7 Nutrient uptake by weeds
4.8 Soil studies
4.9 Economics of the treatments

Table 9. Experimental treatments, herbicides doses and their time of application

Symbol	Treatments	Dose (g a.i. ha^{-1})	Time of application
T_1	Pendimethalin (PE)	1000	2 DAS
T_2	Imazethapyr (PoE)	750	20 DAS
T_3	Pendimethalin (PE) *fb* Imazethapyr (PoE)	1000 *fb* 750	2 *fb* 20 DAS
T_4	Pendimethalin (PE) *fb* Quizalofop ethyl (PoE)	1000 *fb* 750	2 *fb* 20 DAS
T_5	Pendimethalin (PE) *fb* 1 HW	1000	2 *fb* 20 DAS
T_6	Pendimethalin (PE) *fb* 1 HW	1000	2 *fb* 40 DAS
T_7	Imazethapyr (PoE) *fb* 1 HW	750	20 *fb* 40 DAS
T_8	Pendimethalin (PE) *fb* Imazethapyr (PoE) *fb* 1 HW	1000 *fb*750	2 fb 20 *fb* 40 DAS
T_9	Weed free check	-	HW at 20, 40, 60 DAS
T_{10}	Weedy check	-	-

4.1 Plant population studies

The data pertaining to mean number of plants per net plot of groundnut as observed under various treatments at 20 DAS and at harvest are presented in Table 10 and graphically shown in Fig. 3.

Perusal of the data showed that the differences in mean number of plant population per net plot in all the treatments were non-significant at 20 DAS as well as at harvest. Therefore, variation in the yield of groundnut under different treatments was not due to the plant population but it was due to treatment effect only.

Table 10. Mean plant population of groundnut per net plot as influenced by the different treatments

Sr. No.	Treatment	Plant population	
		20 DAS	At harvest
T_1	Pendimethalin (PE)	297.67	291.00
T_2	Imazethapyr (PoE)	297.67	292.33
T_3	Pendimethalin (PE) *fb* Imazethapyr (PoE)	297.33	293.33
T_4	Pendimethalin (PE) *fb* Quizalofop ethyl (PoE)	297.67	293.00
T_5	Pendimethalin (PE) *fb* HW at 20 DAS	297.33	293.67
T_6	Pendimethalin (PE) *fb* HW at 40 DAS	297.67	294.00
T_7	Imazethapyr (PoE) *fb* HW at 40 DAS	298.00	294.00
T_8	Pendimethalin (PE) *fb* Imazethapyr (PoE) *fb* HW at 40 DAS	297.67	294.33
T_9	Weed free check	297.67	294.67
T_{10}	Weedy check	297.33	290.00
	S.E.+	0.46	2.92
	C.D. at 5%	N.S.	N.S.
	General mean	**297.60**	**293.03**

4.2 Crop growth studies

The result obtained from different treatments on growth and development parameters *viz.,* plant height (cm), number of functional leaves, plant spread (cm), number of branches and dry matter accumulation (g) at periodical interval are presented here.

4.2.1 Plant height (cm)

Data related to the plant height as influenced periodically by various treatments are presented in Table 11 and graphically depicted in Fig. 4. In general plant height was increased as per the advancement in age of the crop. The mean height of the groundnut recorded at harvest was 66.31cm.

It is seen from data, that the plant height was influenced significantly due to different weed control treatments except at 20 and 40 DAS. At 20 and 40 DAS effect of different weed control treatments on plant height was non significant.

The treatment weed free check i.e. hand weeding at 20, 40 and 60 DAS recorded significantly higher plant height during 60, 80, 100 DAS and at harvest as compared to rest of the treatments except T_8 and T_7 *i.e.* Pendimethalin (PE) *fb* Imazethapyr (PoE) *fb* HW at 40 DAS and Imazethapyr (PoE) *fb* HW at 40 DAS which were at par with each other.

However, among the different weed control measures tried, application of Pendimethalin (PE) *fb* Imazethapyr (PoE) *fb* HW at 40 DAS (T_8) recorded significantly taller plant height during all growth stages of observations except at 20 and 40 DAS as compared to treatments T_3, T_4, T_2, T_1 and T_{10} and remained same bar with rest of the treatments. Where, treatment T_{10} *i.e.* weedy check recorded significantly lower plant height of groundnut than rest of the treatments.

Table 11. Mean plant height (cm) of groundnut as influenced periodically by different treatments

Sr. No.	Treatment	Plant height (cm)					
		20 DAS	**40 DAS**	**60 DAS**	**80 DAS**	**100 DAS**	**At harvest**
T_1	Pendimethalin (PE)	9.81	21.30	36.93	48.70	58.17	60.48
T_2	Imazethapyr (PoE)	9.22	21.33	37.00	50.10	60.27	61.25
T_3	Pendimethalin (PE) *fb* Imazethapyr (PoE)	9.47	21.60	38.27	52.23	63.67	66.37
T_4	Pendimethalin (PE) *fb* Quizalofop ethyl (PoE)	9.43	21.43	37.93	51.13	62.77	64.87
T_5	Pendimethalin (PE) *fb* HW at 20 DAS	9.10	23.11	39.53	53.43	65.00	68.33
T_6	Pendimethalin (PE) *fb* HW at 40 DAS	9.38	23.41	40.13	54.13	65.97	69.20
T_7	Imazethapyr (PoE) *fb* HW at 40 DAS	9.50	23.93	40.87	55.47	67.13	71.50
T_8	Pendimethalin (PE) *fb* Imazethapyr (PoE) *fb* HW at 40 DAS	9.48	24.34	42.23	56.77	68.70	72.27
T_9	Weed free check	9.73	24.83	43.67	58.27	69.93	73.30
T_{10}	Weedy check	8.70	20.33	33.47	45.17	54.18	55.53
	S.E (m)±	0.43	1.27	1.12	1.31	1.32	1.36
	C.D. at 5%	N.S.	N.S.	3.34	3.91	3.93	4.05
	General mean	**9.42**	**22.56**	**39.00**	**52.54**	**63.58**	**66.31**

4.2.2 Number of leaves per hill

Data regarding the mean number of functional leaves per hill as influenced periodically by different weed control measures are presented in Table 12 and graphically depicted in Fig. 5. The mean number of functional leaves per hill of the groundnut recorded at harvest was 93.24.

Data revealed that, the mean number of functional leaves per hill increased with increasing the age of the plant up to 100 DAS and there after number of functional leaves per hill decreased due to shedding of leaves. The highest mean number of functional leaves per hill of the groundnut recorded at 100 DAS was 112.19.

The effects of different treatments on mean number of leaves per hill was significant in all the growth stages except at 20 DAS. At 20 DAS the effect of different treatments on mean number of leaves per hill was non significant.

However, three hand weeding at 20, 40 and 60 DAS (weed free check) recorded significantly higher number of leaves per hill as compared to rest of the treatments except T_8 and T_7 *i.e.* Pendimethalin (PE) *fb* Imazethapyr (PoE) *fb* HW at 40 DAS and Imazethapyr (PoE) *fb* HW at 40 DAS were at par with each other but found significantly superior over rest of the treatments.

Among the different weed control measures treatment T_8 *i.e.* Pendimethalin (PE) *fb* Imazethapyr (PoE) *fb* HW at 40 DAS recorded significantly higher number of leaves over rest of the weed control measures except treatments T_7, T_6 and T_5 *i.e.* Imazethapyr (PoE) *fb* HW at 40 DAS, Pendimethalin (PE) *fb* HW at 40 DAS and Pendimethalin (PE) *fb* HW at 20 DAS. Where, treatment T_{10} *i.e.* weedy check recorded significantly lowest mean number of functional leaves per hill than rest of the treatments.

Table 12. Mean number of functional leaves per hill of groundnut as influenced periodically by different treatments

Sr. No.	Treatment	No. of functional leaves per hill					
		20 DAS	**40 DAS**	**60 DAS**	**80 DAS**	**100 DAS**	**At harvest**
T_1	Pendimethalin (PE)	9.25	21.58	48.29	74.60	87.36	83.59
T_2	Imazethapyr (PoE)	8.29	23.50	50.39	76.54	94.27	89.28
T_3	Pendimethalin (PE) *fb* Imazethapyr (PoE)	8.80	25.07	54.00	80.38	100.08	93.53
T_4	Pendimethalin (PE) *fb* Quizalofop ethyl (PoE)	8.24	24.53	52.06	79.54	98.60	92.44
T_5	Pendimethalin (PE) *fb* HW at 20 DAS	8.34	25.97	54.74	82.05	105.19	94.52
T_6	Pendimethalin (PE) *fb* HW at 40 DAS	9.08	26.70	56.29	83.16	106.41	96.90
T_7	Imazethapyr (PoE) *fb* HW at 40 DAS	9.24	27.10	57.23	84.60	108.13	98.56
T_8	Pendimethalin (PE) *fb* Imazethapyr (PoE) *fb* HW at 40 DAS	9.21	28.30	59.12	87.23	110.75	100.09
T_9	Weed free check	9.20	29.31	61.01	89.83	112.19	103.98
T_{10}	Weedy check	8.23	19.61	44.90	68.54	83.40	79.50
	S.E (m)±	0.42	0.86	1.53	1.80	1.88	1.89
	C.D. at 5%	N.S.	2.55	4.54	5.36	5.58	5.61
	General mean	**8.79**	**25.17**	**53.80**	**80.65**	**100.64**	**93.24**

4.2.3 Plant spread (cm)

Data pertaining to the mean spread of the plant (cm) as influenced periodically by different treatments are summarized in Table 13 and graphically depicted in Fig. 6.

Mean plant spread was significantly influenced due to different weed control treatments under study at all the growth stages except at 20 and 40 DAS. Treatment weed free check (T_9) *i.e.* hand weeding at 20, 40 and 60 DAS recorded maximum plant spread during all growth stages except 20 and 40 DAS and which was at par with treatments T_8 and T_7 *i.e.* Pendimethalin (PE) *fb* Imazethapyr (PoE) *fb* HW at 40 DAS and Imazethapyr (PoE) *fb* HW at 40 DAS.

Application of Pendimethalin (PE) *fb* Imazethapyr (PoE) *fb* HW at 40 DAS (T_8) remained at par with treatments T_7, T_6 and T_5 *i.e.* Imazethapyr (PoE) *fb* HW at 40 DAS, Pendimethalin (PE) *fb* HW at 40 DAS and Pendimethalin (PE) *fb* HW at 20 DAS and significantly superior over rest of the treatments. Whereas treatment T_{10} *i.e.* weedy check recorded significantly lowest plant spread than rest of the treatments.

4.2.4 Number of branches per hill

Data regarding the mean number of branches per hill as influenced periodically by different weed control measures are presented in Table 14 and graphically depicted in Fig.7. It is clear from the data that the number of branches per hill went on increasing with increase in age of the crop and they were maximum at harvest.

It is seen from data, at 20 and 40 DAS the number of branches per hill was not differed statistically due to various treatments under study. While, at 60, 80, 100 DAS and harvest the mean number of branches were significantly higher in treatment weed free check (T_9) as compared to rest of the treatments except T_8 and T_7 *i.e.* Pendimethalin (PE) *fb* Imazethapyr (PoE) *fb* HW at 40 DAS and Imazethapyr (PoE) *fb* HW at 40 DAS which was at par with treatment T_9.

Table 13. Mean plant spread (cm) of groundnut as influenced periodically by different treatments

Sr. No.	Treatment	Plant Spread (cm)					
		20 DAS	**40 DAS**	**60 DAS**	**80 DAS**	**100 DAS**	**At harvest**
T_1	Pendimethalin (PE)	12.10	23.03	31.18	38.05	45.15	47.20
T_2	Imazethapyr (PoE)	11.07	23.17	31.53	38.05	45.98	48.92
T_3	Pendimethalin (PE) *fb* Imazethapyr (PoE)	11.83	23.37	33.13	40.77	48.47	51.07
T_4	Pendimethalin (PE) *fb* Quizalofop ethyl (PoE)	11.80	23.25	32.47	39.84	47.81	49.80
T_5	Pendimethalin (PE) *fb* HW at 20 DAS	11.13	23.68	33.65	41.39	49.73	53.40
T_6	Pendimethalin (PE) *fb* HW at 40 DAS	11.87	24.01	34.28	41.98	50.77	54.10
T_7	Imazethapyr (PoE) *fb* HW at 40 DAS	11.97	24.37	34.97	42.46	51.97	55.57
T_8	Pendimethalin (PE) *fb* Imazethapyr (PoE) *fb* HW at 40 DAS	11.93	24.71	35.62	44.39	53.14	56.62
T_9	Weed free check	12.08	25.02	36.92	45.41	54.56	57.56
T_{10}	Weedy check	11.07	22.18	27.83	36.27	43.30	44.26
	S.E (m)±	0.56	0.94	0.69	1.09	1.22	1.13
	C.D. at 5%	N.S.	N.S.	2.04	3.23	3.62	3.37
	General mean	**11.66**	**23.68**	**33.16**	**40.86**	**48.71**	**51.85**

Table 14. Mean number of branches per hill of groundnut as influenced periodically by different treatments

Sr. No.	Treatment	Number of branches per hill					
		20 DAS	**40 DAS**	**60 DAS**	**80 DAS**	**100 DAS**	**At harvest**
T_1	Pendimethalin (PE)	3.25	5.14	6.70	7.00	7.66	7.90
T_2	Imazethapyr (PoE)	3.10	5.22	7.23	7.43	8.07	8.43
T_3	Pendimethalin (PE) *fb* Imazethapyr (PoE)	3.07	5.43	7.50	7.90	8.74	8.83
T_4	Pendimethalin (PE) *fb* Quizalofop ethyl (PoE)	3.23	5.37	7.35	7.74	8.30	8.58
T_5	Pendimethalin (PE) *fb* HW at 20 DAS	3.07	5.53	7.88	8.25	8.97	9.19
T_6	Pendimethalin (PE) *fb* HW at 40 DAS	3.23	5.89	8.00	8.50	9.22	9.48
T_7	Imazethapyr (PoE) *fb* HW at 40 DAS	3.22	6.05	8.33	8.97	9.53	9.97
T_8	Pendimethalin (PE) *fb* Imazethapyr (PoE) *fb* HW at 40 DAS	3.17	6.41	8.63	9.00	9.94	10.10
T_9	Weed free check	3.15	6.61	9.02	9.30	10.27	10.53
T_{10}	Weedy check	3.10	5.04	5.68	5.90	6.18	6.62
	S.E (m)±	0.19	0.40	0.26	0.26	0.34	0.34
	C.D. at 5%	N.S.	N.S.	0.77	0.78	1.01	1.02
	General mean	**3.16**	**5.67**	**7.63**	**8.00**	**8.69**	**8.96**

Among different weed control measures tried application of Pendimethalin (PE) *fb* Imazethapyr (PoE) *fb* HW at 40 DAS (T8) was found same bar with Imazethapyr (PoE) *fb* HW at 40 DAS (T_7), Pendimethalin (PE) *fb* HW at 40 DAS (T_6) and Pendimethalin (PE) *fb* HW at 20 DAS (T_5) and significantly superior over rest of the weed control measures. Whereas treatment T_{10} *i.e.* weedy check recorded significantly lowest number of branches than rest of the treatments.

4.2.5 Dry matter accumulation per hill (g)

Data pertaining to periodical dry matter accumulation per hill as influenced by various treatments are presented in Table 15 and graphically depicted in Fig. 8. In general, the dry matter production per hill increased with increase in age of the crop and it was maximum at harvest *i.e.* 18.19 g.

The mean plant dry matter accumulation per hill was significantly influenced by the different weed control measures at all the growth stages of observations except at 20 and 40 DAS. The treatment weed free check (hand weeding at 20, 40 and 60 DAS) remained at par with treatment T_8 and T_7 *i.e.* Pendimethalin (PE) *fb* Imazethapyr (PoE) *fb* HW at 40 DAS and application of Imazethapyr (PoE) *fb* HW at 40 DAS and significantly superior over rest of the treatments.

However, among different weed control measures treatment T_8 *i.e.* Pendimethalin (PE) *fb* Imazethapyr (PoE) *fb* HW at 40 DAS recorded significantly higher dry matter accumulation as compared to treatments T_3, T_4, T_2, T_1 and T_{10} and remained same bar with rest of the treatments T_7, T_6 and T_5. Where, T_{10} *i.e.* weedy check recorded lower dry matter accumulation than rest of the treatments.

Table 15. Mean dry matter accumulation per hill (g) of groundnut as influenced periodically by the different treatments

Sr. No.	Treatment	Dry matter per hill (g)					
		20 DAS	**40 DAS**	**60 DAS**	**80 DAS**	**100 DAS**	**At harvest**
T_1	Pendimethalin (PE)	1.11	3.27	5.76	11.02	15.49	16.14
T_2	Imazethapyr (PoE)	1.12	3.30	6.33	11.49	16.07	16.97
T_3	Pendimethalin (PE) *fb* Imazethapyr (PoE)	1.32	3.34	7.05	12.81	17.08	17.76
T_4	Pendimethalin (PE) *fb* Quizalofop ethyl (PoE)	1.23	3.31	6.85	12.47	16.80	17.33
T_5	Pendimethalin (PE) *fb* HW at 20 DAS	1.22	3.41	7.25	13.25	17.89	18.85
T_6	Pendimethalin (PE) *fb* HW at 40 DAS	1.34	3.59	7.66	13.66	18.34	19.25
T_7	Imazethapyr (PoE) *fb* HW at 40 DAS	1.30	3.71	7.90	14.01	18.73	19.63
T_8	Pendimethalin (PE) *fb* Imazethapyr (PoE) *fb* HW at 40 DAS	1.27	3.89	8.32	14.43	19.25	20.10
T_9	Weed free check	1.34	4.23	9.00	14.95	20.17	21.11
T_{10}	Weedy check	1.21	3.06	4.96	9.51	13.92	14.71
	S.E (m)±	0.06	0.30	0.38	0.41	0.53	057
	C.D. at 5%	N.S.	N.S.	1.13	1.22	1.57	1.69
	General mean	**1.25**	**3.51**	**7.11**	**12.76**	**17.37**	**18.19**

4.3 Studies on yield attributing characters

Data pertaining to the yield attributing characters of groundnut *i.e.* total number of pods per hill, number of developed pods per hill, weight of developed pods per hill (g), 100 kernel weight (g) and shelling percentage (%) as influenced by different treatments are presented in Table 16.

4.3.1 Total number of pods per hill

The data regarding total number of pods per hill as influenced by different treatments are presented in Table 16 and graphically depicted in Fig. 9.

It was observed that the weed free check (T_9) *i.e.* hand weeding at 20, 40 and 60 DAS recorded significantly higher total number of pods per hill as compared to rest of the treatments except T_8 and T_7 *i.e.* Pendimethalin (PE) *fb* Imazethapyr (PoE) *fb* HW at 40 DAS and Imazethapyr (PoE) *fb* HW at 40 DAS.

Among different weed control measures, treatment T_8 *i.e.* Pendimethalin (PE) *fb* Imazethapyr (PoE) *fb* HW at 40 DAS recorded significantly higher total number of pods per hill as compared to treatments *i.e.* T_3, T_4, T_2, T_1 and T_{10} and remained same bar with rest of the treatments T_7, T_6 and T_5 *i.e.* Imazethapyr (PoE) *fb* HW at 40 DAS, Pendimethalin (PE) *fb* HW at 40 DAS and Pendimethalin (PE) *fb* HW at 20 DAS. The lowest total number of pods per hill was observed in the treatment T_{10} *i.e.* weedy check than rest of the treatments.

4.3.2 Number of developed pods per hill

The data pertaining to number of developed pods per hill are presented in Table 16 and graphically depicted in Fig.9.

It is revealed from the data that, the number of developed pods per hill was influenced significantly due to different treatments. The

significantly higher number of developed pod was recorded in treatment weed free check (T_9) *i.e.* hand weeding at 20, 40 and 60 DAS and it was remained same bar with T_8 and T_7 *i.e.* Pendimethalin (PE) *fb* Imazethapyr (PoE) *fb* HW at 40 DAS and Imazethapyr (PoE) *fb* HW at 40 DAS.

Among the different weed control measures, treatment T_8 *i.e.* Pendimethalin (PE) *fb* Imazethapyr (PoE) *fb* HW at 40 DAS significantly superior as compared to rest of the treatments *i.e.* T_3, T_4, T_2, T_1 and T_{10} and remained same bar with rest of the treatments *i.e.* T_7, T_6 and T_5.

4.3.3 Weight of developed pods per hill (g)

Data presented in Table 16 and graphically depicted in Fig. 9 indicated that different treatments significantly influenced the weight of developed pods per hill (g). The overall mean weight of developed pods per hill was 24.25 g.

It is observed that significantly higher weight of developed pods per hill was recorded in treatment weed free check (T_9) *i.e.* hand weeding at 20, 40 and 60 DAS compared to rest of the treatments except treatment T_8 and T_7 *i.e.* Pendimethalin (PE) *fb* Imazethapyr (PoE) *fb* HW at 40 DAS and Imazethapyr (PoE) *fb* HW at 40 DAS.

However, treatment T_8 *i.e.* Pendimethalin (PE) *fb* Imazethapyr (PoE) *fb* HW at 40 DAS significantly superior as compared to remaining weed control treatments *i.e.* T_3, T_4, T_2, T_1 and T_{10} and remained same bar with rest of the treatments *i.e.* T_7, T_6 and T_5 *i.e.* Imazethapyr (PoE) *fb* HW at 40 DAS, Pendimethalin (PE) *fb* HW at 40 DAS and Pendimethalin (PE) *fb* HW at 20 DAS. The lowest weight of developed pods per hill was observed in the treatment T_{10} *i.e.* weedy check than rest of the treatments.

Table 16. Total number of pods per hill, number of developed pods per hill, weight of developed pods per hill (g), 100 kernel weight (g) and shelling per cent (%) of groundnut as influenced by the different treatments

Sr. No.	Treatment	Total number of pods per hill	Number of developed pods per hill	Weight of developed pods per hill (g)	100 kernel weight (g)	Shelling per cent (%)
T_1	Pendimethalin (PE)	23.80	17.30	19.56	56.33	66.88
T_2	Imazethapyr (PoE)	25.68	19.13	21.39	57.03	67.50
T_3	Pendimethalin (PE) *fb* Imazethapyr (PoE)	29.07	22.00	24.26	58.01	68.11
T_4	Pendimethalin (PE) *fb* Quizalofop ethyl (PoE)	28.67	21.60	23.86	57.35	67.93
T_5	Pendimethalin (PE) *fb* HW at 20 DAS	29.83	22.99	25.34	59.06	68.84
T_6	Pendimethalin (PE) *fb* HW at 40 DAS	30.47	23.68	26.09	59.86	68.90
T_7	Imazethapyr (PoE) *fb* HW at 40 DAS	31.43	24.97	27.23	60.54	69.07
T_8	Pendimethalin (PE) *fb* Imazethapyr (PoE) *fb* HW at 40 DAS	32.87	26.20	28.46	61.00	69.10
T_9	Weed free check	33.93	27.03	29.40	61.92	69.55
T_{10}	Weedy check	20.97	14.65	16.91	55.34	65.61
	S.E (m)±	1.08	1.09	1.07	0.68	0.90
	C.D. at 5%	3.20	3.24	3.19	2.02	N.S.
	General mean	**28.67**	**21.96**	**24.25**	**58.64**	**68.15**

4.3.4 100 kernel weight (g)

The relevant data on mean weight of 100 kernels (g) as influenced by different treatments are presented in Table 16 and graphically shown in Fig.10. The mean 100 kernel weight was 58.64 g.

Data presented in Table 16 revealed that significantly maximum 100 kernel weight was recorded in treatment weed free check (T_9) *i.e.* hand weeding at 20, 40 and 60 DAS as compared to rest of the treatments and it was remained same bar with T_8 and T_7 *i.e.* Pendimethalin (PE) *fb* Imazethapyr (PoE) *fb* HW at 40 DAS and Imazethapyr (PoE) *fb* HW at 40 DAS which were at par with each other.

Among different weed control measures tried application of Pendimethalin (PE) *fb* Imazethapyr (PoE) *fb* HW at 40 DAS (T_8) recorded significantly highest 100 kernel weight as compared to rest of the treatments except T_7 *i.e.* Imazethapyr (PoE) *fb* HW at 40 DAS, T_6 *i.e.* Pendimethalin (PE) *fb* HW at 40 DAS and T_5 *i.e.* Pendimethalin (PE) *fb* HW at 20 DAS remained same bar with treatment T_8. The lowest 100 kernel weight was observed in the treatment T_{10} *i.e.* weedy check than rest of the treatments.

4.3.5 Shelling per cent

Data presented in Table 16 and graphically shown in Fig. 10 denoted that, the shelling percentage did not differed statistically due to different treatments under study. The mean shelling per cent was 68.15.

It is observed from data that, treatment weed free check (T_9) *i.e.* hand weeding at 20, 40 and 60 DAS (69.55 %) recorded numerically maximum shelling percentage over rest of the treatments followed by treatments T_8 (69.10 %) and T_7 (69.07 %) *i.e.* Pendimethalin (PE) *fb* Imazethapyr (PoE) *fb* HW at 40 DAS and Imazethapyr (PoE) *fb* HW at 40 DAS. The lowest shelling percentage was observed in the treatment T_{10} *i.e.* weedy check (65.61 %) than rest of the treatments.

4.4 Yield studies

The data pertaining to the yield *viz.*, dry pod yield (q ha^{-1}), kernel yield (q ha^{-1}) and haulm yield (q ha^{-1}) of groundnut as influenced by various treatments are presented in Table 17.

4.4.1 Dry pod yield (q ha^{-1})

Data pertaining to the dry pod yield (q ha^{-1}) of groundnut as influenced by various treatments under study are presented in Table 17 and graphically shown in Fig.11.

Scrutiny of data presented in Table 17 stipulated that the higher dry pod yield was recorded in treatment weed free check (T_9) *i.e.* hand weeding at 20, 40 and 60 DAS which was significantly superior over rest of the treatments except treatment T_8 *i.e.* Pendimethalin (PE) *fb* Imazethapyr (PoE) *fb* HW at 40 DAS and T_7 *i.e* Imazethapyr (PoE) *fb* HW at 40 DAS were at par with treatment T_9.

However, treatment T_8 recorded significantly higher dry pod yield among different weed control measures as compared to the treatments T_3, T_4, T_2, T_1 and T_{10} and remained same bar with rest of the treatments T_7, T_6 and T_5 *i.e.* Imazethapyr (PoE) *fb* HW at 40 DAS, Pendimethalin (PE) *fb* HW at 40 DAS and Pendimethalin (PE) *fb* HW at 20 DAS.

4.4.2 Kernel yield (q ha^{-1})

The data regarding the kernel yield (q ha^{-1}) of groundnut as influenced by different treatments are presented in Table 17 and graphically depicted in Fig. 11.

Hand weeding at 20, 40 and 60 DAS (weed free check) recorded significantly highest kernel yield as compared to rest of the

treatments except treatments T_8 *i.e.* Pendimethalin (PE) *fb* Imazethapyr (PoE) *fb* HW at 40 DAS and T_7 *i.e.* Imazethapyr (PoE) *fb* HW at 40 DAS which were at par with treatment T_9.

However, treatment T_8 *i.e.* Pendimethalin (PE) *fb* Imazethapyr (PoE) *fb* HW at 40 DAS significantly superior over treatments *i.e.* T_3, T_4, T_2, T_1 and T_{10} and remained same bar with treatments T_7, T_6 and T_5. The lower kernel yield was recorded in weedy check (T_{10}) than rest of the treatments.

4.4.3 Haulm yield (q ha^{-1})

Data pertaining to the haulm yield (q ha^{-1}) of groundnut as influenced by various treatments are presented in Table 17 and graphically depicted in Fig. 11.

The haulm yield was influenced significantly due to various weed control measures. Treatment weed free check (T_9) i.e. hand weeding at 20, 40 and 60 DAS recorded maximum haulm yield which was significantly superior over rest of the treatments except treatment T_8 *i.e.* Pendimethalin (PE) *fb* Imazethapyr (PoE) *fb* HW at 40 DAS and T_7 *i.e.* Imazethapyr (PoE) *fb* HW at 40 DAS was at par with each treatment T_9.

However, treatment T_8 *i.e.* Pendimethalin (PE) *fb* Imazethapyr (PoE) *fb* HW at 40 DAS was significantly superior as compared to treatments *i.e.* T_3, T_4, T_2, T_1 and T_{10} and was remained same bar with treatments T_7 *i.e.* Imazethapyr (PoE) *fb* HW at 40 DAS, T_6 *i.e.* Pendimethalin (PE) *fb* HW at 40 DAS and T_5 *i.e.* Pendimethalin (PE) *fb* HW at 20 DAS. The lower haulm yield was recorded in treatment T_{10} *i.e.* weedy check than rest of the treatments.

Table 17. Dry pod yield (q ha^{-1}), kernel yield (q ha^{-1}) and haulm yield (q ha^{-1}) of groundnut as influenced by the different treatments

Sr. No.	Treatment	Dry pod yield (q ha^{-1})	kernel yield (q ha^{-1})	haulm yield (q ha^{-1})
T_1	Pendimethalin (PE)	16.03	10.72	29.59
T_2	Imazethapyr (PoE)	17.15	11.59	30.80
T_3	Pendimethalin (PE) *fb* Imazethapyr (PoE)	20.01	13.63	33.87
T_4	Pendimethalin (PE) *fb* Quizalofop ethyl (PoE)	19.58	13.31	32.95
T_5	Pendimethalin (PE) *fb* HW at 20 DAS	21.34	14.69	35.26
T_6	Pendimethalin (PE) *fb* HW at 40 DAS	22.03	15.16	36.25
T_7	Imazethapyr (PoE) *fb* HW at 40 DAS	22.78	15.72	37.36
T_8	Pendimethalin (PE) *fb* Imazethapyr (PoE) *fb* HW at 40 DAS	23.47	16.22	38.56
T_9	Weed free check	24.76	17.21	40.32
T_{10}	Weedy check	11.47	7.54	23.45
	S.E (m)±	0.80	0.55	1.13
	C.D. at 5%	2.37	1.62	3.35
	General mean	**19.86**	**13.58**	**33.84**

4.5 Weed studies

4.5.1 Dominant weeds observed in groundnut

In the experimental crop, following predominant grassy, sedges and broad leaved weed species were observed (Table 18).

Table 18. Dominant weeds observed in groundnut

Sr. No.	Botanical name	Family	Local name
A)	**Grassy weeds**		
1	*Ischaemum globosa*	Poaceae	Dhur
2	*Digitaria sanguinalis*	Poaceae	Jungle rice
3	*Echinochloa colona*	Poaceae	Pakhad
B)	**Sedge weeds**		
1	*Cyperus iria*	Cyperaceae	Lavala
2	*Cyperus difformis*	Cyperaceae	Lavala
C)	**Broad leaved weeds**		
1	*Ludwigia octovalvis*	Onagraceae	Kadu chinch
2	*Mimosa pudica*	Leguminaceae	Lajaloo
3	*Physalis minima*	Solanaceae	Kapalphodi
4	*Alternanthera sessilis*	Amaranthaceae	Reshim kata

4.5.2 Weed population m^{-2}

Weed population was recorded at 20, 40, 60, 80, 100 DAS and at harvest. In general, all the weed control measures recorded significantly less weed population than weedy check (T_{10}).

4.5.2.1 Number of grassy weeds m^{-2}

Data pertaining to the mean number of grassy weeds in groundnut as affected by various treatments are presented in Table 19 and graphically depicted in Fig.12.

Table 19. Mean number of grassy weeds m^{-2} as influenced periodically by different treatments

Sr. No.	Treatment	Number of weeds m^{-2}					
		20 DAS	**40 DAS**	**60 DAS**	**80 DAS**	**100 DAS**	**At harvest**
T_1	Pendimethalin (PE)	9.42* (3.15)**	13.90 (3.80)	22.11 (4.75)	24.29 (4.98)	26.47 (5.19)	27.51 (5.29)
T_2	Imazethapyr (PoE)	10.49 (3.32)	13.41 (3.73)	20.48 (4.58)	22.98 (4.84)	25.66 (5.11)	26.72 (5.22)
T_3	Pendimethalin (PE) *fb* Imazethapyr (PoE)	9.36 (3.14)	12.74 (3.64)	15.36 (3.98)	19.88 (4.51)	22.13 (4.76)	22.35 (4.78)
T_4	Pendimethalin (PE) *fb* Quizalofop ethyl (PoE)	9.48 (3.16)	13.07 (3.68)	17.21 (4.21)	21.05 (4.64)	23.50 (4.90)	24.84 (5.03)
T_5	Pendimethalin (PE) *fb* HW at 20 DAS	10.24 (3.24)	12.09 (3.55)	14.17 (3.83)	18.24 (4.33)	21.02 (4.64)	22.61 (4.81)
T_6	Pendimethalin (PE) *fb* HW at 40 DAS	9.17 (3.11)	11.18 (3.42)	13.67 (3.76)	16.51 (4.12)	19.16 (4.43)	19.65 (4.49)
T_7	Imazethapyr (PoE) *fb* HW at 40 DAS	9.84 (3.22)	10.53 (3.32)	11.57 (3.47)	13.71 (3.76)	15.83 (4.04)	16.87 (4.17)
T_8	Pendimethalin (PE) *fb* Imazethapyr (PoE) *fb* HW at 40 DAS	8.96 (3.08)	9.43 (3.15)	9.91 (3.22)	11.53 (3.46)	13.72 (3.77)	14.82 (3.91)
T_9	Weed free check	5.89 (2.52)	6.41 (2.63)	6.76 (2.69)	7.57 (2.83)	8.79 (3.03)	9.45 (3.15)
T_{10}	Weedy check	11.47 (3.46)	33.08 (5.79)	43.80 (6.65)	49.97 (7.10)	53.04 (7.32)	55.33 (7.47)
	S.E (m)±	(0.04)	(0.06)	(0.09)	(0.10)	(0.09)	(0.09)
	C.D. at 5%	(0.13)	(0.18)	(0.26)	(0.31)	(0.28)	(0.26)
	General mean	**(3.12)**	**(3.67)**	**(4.12)**	**(4.46)**	**(4.72)**	**(4.83)**

* Original value, ( )** Figures in parentheses are square root transformation of original value

At all growth stages, weed free check (T_9) *i.e.* hand weeding at 20, 40 and 60 DAS recorded significantly less population of grassy weeds over rest of the treatments under study.

Among weed control treatments under study, treatment T_8 *i.e.* Pendimethalin (PE) *fb* Imazethapyr (PoE) *fb* HW at 40 DAS recorded significantly less grassy weed population during 40, 60, 80, 100 DAS and at harvest over rest of the weed control treatments except T_7 *i.e.* Imazethapyr (PoE) *fb* HW at 40 DAS which was at par with treatment T_8. At 20 DAS, treatment T_8 *i.e.* Pendimethalin (PE) *fb* Imazethapyr (PoE) *fb* HW at 40 DAS recorded significantly less grassy weed population over rest of the weed control treatments except T_6 *i.e.* Pendimethalin (PE) *fb* HW at 40 DAS, T_4 *i.e.* Pendimethalin (PE) *fb* Quizalofop ethyl (PoE), T_3 *i.e.* Pendimethalin (PE) *fb* Imazethapyr (PoE) and T_1 *i.e.* Pendimethalin (PE) which was at par with treatment T_8.

However, during 40, 60, 80, 100 DAS and at harvest treatment T_9 *i.e.* hand weeding at 20, 40 and 60 DAS recorded significantly less population of grassy weeds over rest of the treatments under study. Treatment T_8 *i.e.* Pendimethalin (PE) *fb* Imazethapyr (PoE) *fb* HW at 40 DAS and T_7 *i.e.* Imazethapyr (PoE) *fb* HW at 40 DAS and during 20 DAS were at par with each other. Where, weedy check (T_{10}) recorded more population of grassy weeds at all growth stages of groundnut than rest of the treatments under study.

4.5.2.2 Number of sedges m^{-2}

Data pertaining to the mean number of sedges in groundnut as affected by various treatments at 20, 40, 60, 80, 100 DAS and at harvest are presented in Table 20 and graphically depicted in Fig. 13.

Weed free check (T_9) i.e. hand weeding at 20, 40 and 60 DAS recorded the less weed population of sedges at all the growth stages than rest of the treatments. Among different weed control measures, treatment T_8 *i.e.* Pendimethalin (PE) *fb* Imazethapyr (PoE) *fb* HW at 40

DAS recorded the less weed population of sedges than rest of the treatments at all growth stages. The treatment T_8 *i.e.* Pendimethalin (PE) *fb* Imazethapyr (PoE) *fb* HW at 40 DAS was at par with T_7 *i.e.* Imazethapyr (PoE) *fb* HW at 40 DAS, T_6 *i.e.* Pendimethalin (PE) *fb* HW at 40 DAS and T_5 *i.e.* Pendimethalin (PE) *fb* HW at 20 DAS during 40, 60, 80, 100 DAS and at harvest in respect of weed population of sedges. While at 20 DAS treatment T_8 *i.e.* Pendimethalin (PE) *fb* Imazethapyr (PoE) *fb* HW at 40 DAS was at par with rest of weed control treatments under study except treatment T_7 *i.e.* Imazethapyr (PoE) *fb* HW at 40 DAS and T_2 *i.e.* Imazethapyr (PoE) in respect of weed population of sedges. While weedy check (T_{10}) recorded the maximum population of sedges than rest of the treatments.

4.5.2.3 Number of broad leaved weeds m^{-2}

Data regarding to the mean number of broad leaved weeds in groundnut as influenced by various treatments at 20, 40, 60, 80, 100 DAS and at harvest are presented in Table 21 and graphically depicted in Fig.14.

At all growth stages weed free check (T_9) *i.e.* hand weeding at 20, 40 and 60 DAS recorded significantly lowest population of BLWs over rest of the treatments.

At 20 DAS, treatment T_9 *i.e.* hand weeding at 20, 40 and 60 DAS was at par with T_8 *i.e.* Pendimethalin (PE) *fb* Imazethapyr (PoE) *fb* HW at 40 DAS, T_6 *i.e.* Pendimethalin (PE) *fb* HW at 40 DAS and T_5 *i.e.* Pendimethalin (PE) *fb* HW at 20 DAS.

Among different weed control treatments tried in experiment, treatment T_8 *i.e.* Pendimethalin (PE) *fb* Imazethapyr (PoE) *fb* HW at 40 DAS recorded less population of BLWs than rest of the weed control treatments under study. However, treatment T_8 Pendimethalin (PE) *fb* Imazethapyr (PoE) *fb* HW at 40 DAS was at par with treatment T_7 *i.e.* Imazethapyr (PoE) *fb* HW at 40 DAS during 80, 100 DAS and at harvest. While it was also at par with treatment T_6 *i.e.* Pendimethalin

Table 20. Mean number of sedges weeds m^{-2} as influenced periodically by different treatments

Sr. No.	Treatment	Number of weeds m^{-2}					
		20 DAS	**40 DAS**	**60 DAS**	**80 DAS**	**100 DAS**	**At harvest**
T_1	Pendimethalin (PE)	1.42* (1.38)**	2.58 (1.76)	4.08 (2.14)	5.00 (2.34)	5.67 (2.47)	6.00 (2.54)
T_2	Imazethapyr (PoE)	4.00 (2.12)	2.33 (1.67)	3.00 (1.86)	3.75 (2.06)	4.25 (2.18)	4.67 (2.27)
T_3	Pendimethalin (PE) *fb* Imazethapyr (PoE)	1.42 (1.38)	2.00 (1.58)	2.42 (1.71)	3.42 (1.97)	3.67 (2.04)	4.17 (2.15)
T_4	Pendimethalin (PE) *fb* Quizalofop ethyl (PoE)	1.42 (1.38)	2.17 (1.63)	2.67 (1.78)	3.67 (2.04)	3.92 (2.10)	4.33 (2.20)
T_5	Pendimethalin (PE) *fb* HW at 20 DAS	1.42 (1.38)	1.67 (1.47)	2.17 (1.63)	2.92 (1.84)	3.33 (1.95)	3.75 (2.06)
T_6	Pendimethalin (PE) *fb* HW at 40 DAS	1.33 (1.35)	1.58 (1.44)	2.00 (1.58)	2.75 (1.79)	3.25 (1.93)	3.42 (1.98)
T_7	Imazethapyr (PoE) *fb* HW at 40 DAS	3.92 (2.10)	1.50 (1.41)	1.75 (1.50)	2.42 (1.70)	2.75 (1.80)	3.25 (1.93)
T_8	Pendimethalin (PE) *fb* Imazethapyr (PoE) *fb* HW at 40 DAS	1.33 (1.35)	1.42 (1.38)	1.67 (1.47)	2.00 (1.58)	2.67 (1.77)	3.00 (1.87)
T_9	Weed free check	0.92 (1.18)	1.00 (1.22)	1.33 (1.35)	1.67 (1.47)	2.00 (1.58)	2.33 (1.68)
T_{10}	Weedy check	8.83 (3.05)	9.42 (3.15)	10.17 (3.27)	10.75 (3.35)	11.50 (3.46)	11.92 (3.52)
	S.E (m)±	(0.07)	(0.06)	(0.08)	(0.09)	(0.08)	(0.09)
	C.D. at 5%	(0.19)	(0.19)	(0.22)	(0.28)	(0.24)	(0.27)
	General mean	**(1.67)**	**(1.67)**	**(1.83)**	**(2.02)**	**(2.13)**	**(2.22)**

* Original value, ( )** Figures in parentheses are square root transformation of original value

Table 21. Mean number of broad leaves weeds m^{-2} as influenced periodically by different treatments

Sr. No.	Treatment	Number of weeds m^{-2}					
		20 DAS	**40 DAS**	**60 DAS**	**80 DAS**	**100 DAS**	**At harvest**
T_1	Pendimethalin (PE)	7.67* (2.86)**	15.13 (3.95)	21.19 (4.66)	26.31 (5.18)	29.56 (5.48)	31.88 (5.69)
T_2	Imazethapyr (PoE)	8.58 (3.01)	13.82 (3.78)	19.32 (4.45)	24.13 (4.96)	27.57 (5.30)	29.96 (5.52)
T_3	Pendimethalin (PE) *fb* Imazethapyr (PoE)	7.61 (2.85)	12.22 (3.57)	16.11 (4.07)	21.43 (4.68)	22.45 (4.79)	24.38 (4.98)
T_4	Pendimethalin (PE) *fb* Quizalofop ethyl (PoE)	7.69 (2.86)	13.03 (3.68)	17.28 (4.22)	22.17 (4.76)	24.64 (5.01)	26.17 (5.16)
T_5	Pendimethalin (PE) *fb* HW at 20 DAS	7.58 (2.84)	11.30 (3.43)	14.08 (3.82)	19.01 (4.42)	20.47 (4.58)	22.15 (4.76)
T_6	Pendimethalin (PE) *fb* HW at 40 DAS	7.51 (2.83)	10.23 (3.27)	13.29 (3.71)	17.63 (4.26)	18.67 (4.37)	19.62 (4.48)
T_7	Imazethapyr (PoE) *fb* HW at 40 DAS	8.12 (2.93)	9.49 (3.16)	12.54 (3.61)	14.56 (3.88)	15.46 (3.99)	17.88 (4.28)
T_8	Pendimethalin (PE) *fb* Imazethapyr (PoE) *fb* HW at 40 DAS	7.04 (2.75)	9.38 (3.14)	11.72 (3.49)	12.88 (3.66)	13.78 (3.78)	15.39 (3.98)
T_9	Weed free check	6.62 (2.67)	7.85 (2.89)	8.31 (2.96)	9.83 (3.21)	9.53 (3.16)	11.27 (3.43)
T_{10}	Weedy check	10.04 (3.25)	21.70 (4.71)	31.14 (5.62)	38.84 (6.27)	43.91 (6.66)	48.69 (7.01)
	S.E (m)±	(0.06)	(0.06)	(0.08)	(0.08)	(0.10)	(0.10)
	C.D. at 5%	(0.17)	(0.19)	(0.23)	(0.24)	(0.31)	(0.31)
	General mean	**(2.88)**	**(3.56)**	**(4.06)**	**(4.53)**	**(4.71)**	**(4.93)**

* Original value, ( )** Figures in parentheses are square root transformation of original value

(PE) *fb* HW at 40 DAS during 40 and 60 DAS. At 20 DAS treatment T_8 *i.e.* Pendimethalin (PE) *fb* Imazethapyr (PoE) *fb* HW at 40 DAS was at par with rest of the weed control treatments under study except treatment T_7 *i.e.* Imazethapyr (PoE) *fb* HW at 40 DAS and T_2 *i.e.* Imazethapyr (PoE) in respect of weed population of BLWs. The treatment weedy check (T_{10}) recorded more population of broad leaved weeds than rest of the treatments under study.

4.5.3 Dry weight of grasses, sedges and broad leaved weeds at harvest (g m^{-2})

Data pertaining to the mean dry weight of grasses, sedges and broad leaved weeds in groundnut as influenced by various treatments at harvest are presented in Table 22 and graphically depicted in Fig.15. All the weed control measures recorded significantly less dry weight of weeds than treatment (T_{10}) *i.e.* weedy check.

It is evident from the data that at harvest weed free check (T_9) *i.e.* hand weeding at 20, 40 and 60 DAS recorded significantly lower dry weight of grasses, sedges and broad leaved weeds than remaining treatments at harvest.

Treatment T_8 *i.e.* Pendimethalin (PE) *fb* Imazethapyr (PoE) *fb* HW at 40 DAS recorded significantly less dry weight of grasses, sedges and BLWs than rest of the weed control treatments under study except treatment T_7 i.e. Imazethapyr (PoE) *fb* HW at 40 DAS in case of dry weight of grasses, sedges and BLWs while treatment T_6 *i.e.* Pendimethalin (PE) *fb* HW at 40 DAS and T_5 *i.e.* Pendimethalin (PE) *fb* HW at 20 DAS in respect of dry weight of sedges. The treatment T_7 i.e. Imazethapyr (PoE) *fb* HW at 40 DAS in case of dry weight of grasses, sedges and BLWs. While, treatment T_6 *i.e.* Pendimethalin (PE) *fb* HW at 40 DAS and T_5 *i.e.* Pendimethalin (PE) *fb* HW at 20 DAS in case of grasses and sedges was at par with treatment T_8. The treatment weedy check (T_{10}) recorded more weight of grasses, sedges and BLWs than rest of the treatments under study.

Table 22. Mean dry weight of grasses, sedges and broad leaved weeds (g m^{-2}) at harvest as influenced by different treatments

	Treatment	Dry matter production of weeds at harvest (g)		
		Grasses	**Sedges**	**BLW**
T_1	Pendimethalin (PE)	22.24* (4.76)**	3.75 (2.06)	40.45 (6.40)
T_2	Imazethapyr (PoE)	18.69 (4.38)	3.50 (2.00)	38.00 (6.20)
T_3	Pendimethalin (PE) *fb* Imazethapyr (PoE)	16.53 (4.13)	3.30 (1.95)	27.72 (5.31)
T_4	Pendimethalin (PE) *fb* Quizalofop ethyl (PoE)	17.13 (4.20)	3.41 (1.98)	33.80 (5.85)
T_5	Pendimethalin (PE) *fb* HW at 20 DAS	15.87 (4.04)	3.21 (1.92)	21.07 (4.64)
T_6	Pendimethalin (PE) *fb* HW at 40 DAS	15.73 (4.03)	3.15 (1.91)	16.13 (4.07)
T_7	Imazethapyr (PoE) *fb* HW at 40 DAS	14.27 (3.84)	2.89 (1.83)	13.53 (3.75)
T_8	Pendimethalin (PE) *fb* Imazethapyr (PoE) *fb* HW at 40 DAS	12.33 (3.58)	2.63 (1.77)	11.36 (3.44)
T_9	Weed free check	8.40 (2.98)	1.75 (1.50)	6.33 (2.55)
T_{10}	Weedy check	74.35 (8.65)	4.85 (2.31)	93.35 (9.69)
	S.E (m)±	(0.10)	(0.06)	(0.19)
	C.D. at 5%	(0.31)	(0.17)	(0.56)
	General Mean	**(4.46)**	**(1.92)**	**(5.19)**

* Original value, ( )** Figures in parentheses are square root transformation of original value

4.5.4 Total dry weight of weeds (q ha^{-1}), weed control efficiency (%) and weed index (%) at harvest

The data pertaining to the total dry weight of weeds, weed control efficiency (%) and weed index (%) at harvest as affected by various weed control measures are presented in Table 23.

4.5.4.1 Total dry weight of weeds at harvest (q ha^{-1})

Data presented in Table 23 and graphically shown in Fig. 16 clearly indicate that, the weed free check (T_9) i.e. hand weeding at 20, 40 and 60 DAS recorded significantly the lower total dry weight of weeds at harvest than rest of the treatments under study.

Among weed control treatments pendimethalin *fb* Imazethapyr *fb* HW at 40 DAS (T_8) was recorded low dry weight of weed than rest of weed control treatments except treatment T_7 *i.e.* Imazethapyr (PoE) *fb* HW at 40 DAS which was at par with treatment T_8. Whereas, treatment T_{10} *i.e.* weedy check recorded higher total dry weight of weeds at harvest than rest of the treatments.

4.5.5.2 Weed control efficiency (%) at harvest

From the data presented in Table 23 and graphically shown in Fig. 17 it is seen that, the numerically highest weed control efficiency was recorded under weed free check (T_9) i.e. hand weeding at 20, 40 and 60 DAS than remaining treatments followed by pendimethalin *fb* Imazethapyr *fb* HW at 40 DAS (T_8), Imazethapyr *fb* HW at 40 DAS (T_7) and Pendimethalin *fb* HW at 40 DAS (T_6) in the descending order. Whereas, treatment T_{10} *i.e.* weedy check recorded lowest weed control efficiency at harvest than rest of the treatments.

Table 23. Total dry weight of weeds (q ha^{-1}), weed control efficiency (%) and weed index (%) at harvest

	Treatments	Dry weight of weeds (q ha^{-1})	Weed control efficiency (%)	Weed index (%)
T_1	Pendimethalin (PE)	6.64	61.49	35.24
T_2	Imazethapyr (PoE)	6.02	65.11	30.71
T_3	Pendimethalin (PE) *fb* Imazethapyr (PoE)	4.76	72.44	19.19
T_4	Pendimethalin (PE) *fb* Quizalofop ethyl (PoE)	5.43	68.50	20.92
T_5	Pendimethalin (PE) *fb* HW at 20 DAS	4.01	76.74	15.34
T_6	Pendimethalin (PE) *fb* HW at 40 DAS	3.50	79.71	12.37
T_7	Imazethapyr (PoE) *fb* HW at 40 DAS	3.07	82.21	8.00
T_8	Pendimethalin (PE) *fb* Imazethapyr (PoE) *fb* HW at 40 DAS	2.63	84.74	4.40
T_9	Weed free check	1.65	90.44	0.00
T_{10}	Weedy check	17.25	---	53.68
	S.E (m)±	0.18	---	---
	C.D. at 5%	0.52	---	---
	General mean	**5.50**	---	---

4.5.5.3 Weed index (%) at harvest

From the data presented in Table 23 and graphically shown in Fig. 17 it is seen that, the numerically lowest weed index was recorded under pendimethalin *fb* Imazethapyr fb HW at 40 DAS (T_8) followed by treatments T_7 *i.e.* Imazethapyr (PoE) *fb* HW at 40 DAS and T_6 *i.e.* Pendimethalin (PE) *fb* HW at 40 DAS. Where, treatment T_{10} *i.e.* weedy check recorded highest weed index percentage at harvest than rest of the treatments.

4.6 Quality and nutrient uptake by groundnut

4.6.1 Quality parameters of groundnut

Oil and protein content in groundnut were considered as the quality parameters. The data pertaining to the oil (%), oil yield (q ha^{-1}) and protein content (%) as influenced by various treatments are presented in Table 24.

4.6.1.1 Oil content (%) in kernel

The data regarding oil content (per cent) in kernel of groundnut as influenced by different treatments are presented in Table 24 and graphically depicted in Fig. 18.

The data revealed that oil content in groundnut was not influenced up to the significant extent due to the different treatments. However, numerically higher oil content (47.74 %) was recorded in treatment T_9 *i.e.* hand weeding at 20, 40 and 60 DAS.

4.6.1.2 Oil yield (q ha^{-1})

Data pertaining to oil yield (q ha^{-1}) of groundnut as influenced by different treatment are presented in Table 24 and graphically depicted in Fig. 19.

Table 24. Oil content (%), oil yield (q ha^{-1}) and protein content (%) in kernel of groundnut as influenced by different treatments

	Treatments	Oil content (%)	Oil yield (q ha^{-1})	Protein content (%)
T_1	Pendimethalin (PE)	46.14	4.95	24.38
T_2	Imazethapyr (PoE)	46.19	5.35	24.75
T_3	Pendimethalin (PE) *fb* Imazethapyr (PoE)	46.88	6.38	27.19
T_4	Pendimethalin (PE) *fb* Quizalofop ethyl (PoE)	46.78	6.23	25.06
T_5	Pendimethalin (PE) *fb* HW at 20 DAS	47.03	6.91	26.94
T_6	Pendimethalin (PE) *fb* HW at 40 DAS	47.12	7.15	27.69
T_7	Imazethapyr (PoE) *fb* HW at 40 DAS	47.32	7.44	28.31
T_8	Pendimethalin (PE) *fb* Imazethapyr (PoE) *fb* HW at 40 DAS	47.64	7.73	28.88
T_9	Weed free check	47.74	8.22	29.06
T_{10}	Weedy check	46.12	3.48	23.63
	S.E (m) ±	0.50	0.27	1.32
	C. D. at 5 %	N.S.	0.80	N.S.
	General mean	**46.90**	**6.38**	**26.59**

Treatment weed free check (T_9) *i.e.* hand weeding at 20, 40 and 60 DAS recorded significantly superior oil yield over rest of the treatments under study except treatment T_8 *i.e.* Pendimethalin (PE) *fb* Imazethapyr (PoE) *fb* HW at 40 DAS and T_7 *i.e.* Imazethapyr (PoE) *fb* HW at 40 DAS was at par with treatment T_8.

Application of Pendimethalin (PE) *fb* Imazethapyr (PoE) *fb* HW at 40 DAS (T_8) recorded more oil yield as compared to the rest of the treatments and remained at par with treatments T_7 and T_6

4.6.1.3 Protein content (%)

The data regarding protein content (%) in kernel of groundnut as influenced by different treatments are presented in Table 24 and graphically depicted in Fig. 18.

It is observed that the different treatments did not affect the protein per cent. However, numerically higher protein per cent (29.06%) was observed in treatment weed free check (T_9).

4.6.2. Nutrient content in groundnut

4.6.2.1. Nitrogen content in kernel and haulm of groundnut

Data regarding nitrogen content in kernel and haulm as influenced by different treatments at harvest are presented in Table 25.

The data revealed that nitrogen content in kernel was not influenced up to significant extent due to different weed control measures. However, weed free check *i.e.* Hand weeding at 20, 40 and 60 DAS recorded numerically higher value of nitrogen content in kernel. Graphically depicted in Fig. 20.

Further data pertaining to nitrogen content in haulm revealed that different treatments failed to exert any significant effect. However,

weed free check T_9 (Hand weeding at 20, 40 and 60 DAS) recorded numerically higher value of nitrogen content in haulm. Graphically depicted in Fig. 21.

4.6.2.2 Phosphorus content (%) in kernel and haulm

Data pertaining to the effect of different treatments on phosphorus content in kernel and haulm are presented in Table 25.

Data revealed that phosphorus content in kernel was not influenced up to significant extent due to different weed control measures. However, the higher phosphorus content was recorded in treatment T9 i.e. Hand weeding at 20, 40 and 60 DAS (0.331). Graphically depicted in Fig. 20.

Similarly, difference in phosphorus content in haulm under various treatments did not reach the level of significance. However, the higher phosphorus content was recorded in treatment weed free check *i.e.* T_9 (0.145). Graphically depicted in Fig. 21.

4.6.2.3 Potassium content (%) in kernel and haulm

Data pertaining to the potassium content in kernel and haulm of groundnut as influenced by different treatments are presented in Table 25.

Potassium content (%) in kernel was found to be non-significant in all treatments. The maximum and minimum potassium content was recorded in treatment T_9 i.e. Hand weeding at 20, 40 and 60 DAS (1.94) and T_{10} (1.69), respectively. Graphically depicted in Fig. 20.

Data pertaining to Potassium content (%) in haulm was found non-significant in all weed control measures. The maximum and minimum potassium content was recorded in treatment T_9 (0.859) and T_{10} (0.831), respectively. Graphically depicted in Fig. 21.

Table 25. Mean nitrogen content (%), phosphorus content (%) and potassium content (%) in kernel and haulm of groundnut as influenced by different treatments

	Treatments	Mean nitrogen content (%)		Mean phosphorus content (%)		Mean potassium content (%)	
		Kernel	Haulm	Kernel	Haulm	Kernel	Haulm
T_1	Pendimethalin (PE)	3.90	1.39	0.306	0.115	1.76	0.836
T_2	Imazethapyr (PoE)	3.96	1.40	0.308	0.119	1.77	0.841
T_3	Pendimethalin (PE) *fb* Imazethapyr (PoE)	4.35	1.42	0.313	0.126	1.81	0.843
T_4	Pendimethalin (PE) *fb* Quizalofop ethyl (PoE)	4.01	1.41	0.311	0.123	1.78	0.841
T_5	Pendimethalin (PE) *fb* HW at 20 DAS	4.31	1.47	0.314	0.130	1.85	0.844
T_6	Pendimethalin (PE) *fb* HW at 40 DAS	4.43	1.50	0.317	0.132	1.86	0.847
T_7	Imazethapyr (PoE) *fb* HW at 40 DAS	4.53	1.54	0.319	0.134	1.88	0.849
T_8	Pendimethalin (PE) *fb* Imazethapyr (PoE) *fb* HW at 40 DAS	4.62	1.56	0.323	0.137	1.91	0.850
T_9	Weed free check	4.65	1.58	0.331	0.145	1.94	0.859
T_{10}	Weedy check	3.78	1.36	0.299	0.105	1.69	0.831
	S.E (m)±	0.21	0.07	0.01	0.01	0.05	0.01
	C.D. at 5%	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
	General mean	**4.25**	**1.46**	**0.314**	**0.127**	**1.82**	**0.844**

4.6.3. Nutrient uptake by groundnut

4.6.3.1. Nitrogen uptake (kg ha^{-1}) in kernel and haulm

The data regarding nitrogen uptake by kernel and haulm as influenced by different treatments at harvest are presented in Table 26 and graphically depicted in Fig.22.

Weed free check (T_9) i.e. Hand weeding at 20, 40 and 60 DAS recorded significantly higher nitrogen uptake by kernel over rest of the treatments except treatment (T_8) *i.e.* Pendimethalin (PE) *fb* Imazethapyr (PoE) *fb* HW at 40 DAS which was at par with each other. However, among the different weed control measures tried, application of Pendimethalin (PE) *fb* Imazethapyr (PoE) *fb* HW at 40 DAS (T_8) recorded significantly higher nitrogen uptake by kernel as compared to the treatments *i.e.* T_5, T_4, T_3, T_2 and T_1 and remained same bar with treatments T_7 and T_6. The lowest nitrogen uptake by kernel was recorded in treatment (T_{10}) *i.e.* weedy check.

Significantly highest nitrogen uptake by haulm was observed in the treatment weed free check (T_9) over rest of the treatments except treatment T_8 and T_7 *i.e.* Pendimethalin (PE) *fb* Imazethapyr (PoE) *fb* HW at 40 DAS and Imazethapyr (PoE) *fb* HW at 40 DAS which was at par with each other. While, treatment T_8 *i.e.* Pendimethalin (PE) *fb* Imazethapyr (PoE) *fb* HW at 40 DAS recorded significantly higher nitrogen uptake by haulm as compared to remaining weed control treatments *i.e.* T_4, T_3, T_2 and T_1 and remained same bar with the treatments T_7, T_6 and T_5. The lowest nitrogen uptake by haulm was recorded in treatment (T_{10}) *i.e.* weedy check.

4.6.3.2 Total nitrogen uptake (kg ha^{-1}) by groundnut

Data pertaining to the total uptake of nitrogen by groundnut as influenced by different treatments are presented in Table 26 and graphically depicted in Fig.22.

Table 26. Nitrogen uptake (kg ha^{-1}) in kernel, haulm and total uptake of nitrogen (kg ha^{-1}) by the groundnut as influenced by different treatments

	Treatments	Nitrogen uptake (kg ha^{-1})		Total nitrogen uptake (kg ha^{-1})
		Kernel	Haulm	
T_1	Pendimethalin (PE)	41.79	41.16	82.96
T_2	Imazethapyr (PoE)	45.89	43.13	89.02
T_3	Pendimethalin (PE) *fb* Imazethapyr (PoE)	59.30	48.09	107.39
T_4	Pendimethalin (PE) *fb* Quizalofop ethyl (PoE)	53.37	46.46	99.84
T_5	Pendimethalin (PE) *fb* HW at 20 DAS	63.37	51.84	115.22
T_6	Pendimethalin (PE) *fb* HW at 40 DAS	67.18	54.37	121.55
T_7	Imazethapyr (PoE) *fb* HW at 40 DAS	71.22	57.53	128.75
T_8	Pendimethalin (PE) *fb* Imazethapyr (PoE) *fb* HW at 40 DAS	74.93	60.14	135.08
T_9	Weed free check	80.15	64.08	144.22
T_{10}	Weedy check	27.75	31.57	59.32
	S.E (m)±	2.72	3.11	4.19
	C.D. at 5%	8.08	9.23	12.46
	General mean	**58.49**	**49.84**	**108.33**

Hand weeding at 20, 40 and 60 DAS (Weed free check) recorded significantly higher total nitrogen uptake by groundnut over rest of the treatments except application of Pendimethalin (PE) *fb* Imazethapyr (PoE) *fb* HW at 40 DAS (T_8) which was at par with each other. However, among the different weed control measures tried, treatment (T_8) *i.e.* Pendimethalin (PE) *fb* Imazethapyr (PoE) *fb* HW at 40 DAS recorded significantly higher total nitrogen uptake by groundnut as compared to treatments T_5, T_4, T_3, T_2 and T_1 and remained same bar with the treatment T_7. The lowest nitrogen uptake by groundnut was recorded in treatment (T_{10}) i.e. weedy check.

4.6.3.3 Phosphorus uptake (kg ha^{-1}) by kernel and haulm

Data pertaining to the phosphorus uptake by kernel and haulm of groundnut as influenced by different treatments are presented in Table 27 and graphically depicted in Fig.23.

Three hand weeding at 20, 40 and 60 DAS (weed free check) recorded significantly higher phosphorus uptake by kernel compared to rest of the treatments except T_8 *i.e.* Pendimethalin (PE) *fb* Imazethapyr (PoE) *fb* HW at 40 DAS which was at par with each other. Among the different weed control measures treatment T_8 *i.e.* Pendimethalin (PE) *fb* Imazethapyr (PoE) *fb* HW at 40 DAS recorded significantly higher phosphorus uptake by kernel over rest of the treatments under study except treatments T_7 and T_6 *i.e.* Imazethapyr (PoE) *fb* HW at 40 DAS and Pendimethalin (PE) *fb* HW at 40 DAS which were at par with T_8. Where, treatment T_{10} *i.e.* weedy check recorded significantly lowest phosphorus uptake by kernel than rest of the treatments.

The data further revealed that hand weeding at 20, 40 and 60 DAS (weed free check) recorded significantly higher phosphorus uptake by haulm compared to rest of the treatments under study except T_8 *i.e.* Pendimethalin (PE) *fb* Imazethapyr (PoE) *fb* HW at 40 DAS which was at par with each other. Among the different weed control measures T_8 *i.e.* Pendimethalin (PE) *fb* Imazethapyr (PoE) *fb*

HW at 40 DAS recorded numerically higher value of phosphorus uptake by haulm over remaining treatments under study except treatments T_7 *i.e.* Imazethapyr (PoE) *fb* HW at 40 DAS, T_6 *i.e.* Pendimethalin (PE) *fb* HW at 40 DAS and T_5 *i.e.* Pendimethalin (PE) *fb* HW at 20 DAS which were at par with each other.

4.6.3.4 Total phosphorus uptake (kg ha^{-1}) by groundnut

Data regarding the total uptake of phosphorus by groundnut as influenced by different treatments are presented Table 27.

Data on total phosphorous uptake by groundnut crop influenced by different treatments are graphically illustrated in Fig.23. Hand weeding at 20, 40 and 60 DAS (T_9) recorded significantly highest total phosphorus uptake by groundnut over rest of the treatments under study except treatment (T_8) which was at par with each other. Among different weed control measures tried application of Pendimethalin (PE) *fb* Imazethapyr (PoE) *fb* HW at 40 DAS (T_8) was found significantly superior over rest of the treatments under study and it was remained same bar with Imazethapyr (PoE) *fb* HW at 40 DAS (T_7) and Pendimethalin (PE) *fb* HW at 40 DAS (T_6). Where, treatment (T_{10}) i.e. weedy check recorded significantly lowest total phosphorus uptake by groundnut than rest of the treatments.

4.6.3.5 Potassium uptake (kg ha^{-1}) by kernel and haulm

Data pertaining to the potassium uptake by kernel and haulm of groundnut as influenced by different treatments is presented in Table 28 and graphically depicted in Fig.24.

Treatment weed free check (T_9) resulted in to significantly higher potassium uptake by kernel over rest of the treatments under study except T_8 *i.e.* Pendimethalin (PE) *fb* Imazethapyr (PoE) *fb* HW at 40 DAS which was at par with each other. Among the different weed control measures treatment (T_8) *i.e.* Pendimethalin (PE) *fb* Imazethapyr (PoE) *fb* HW at 40 DAS recorded higher value of potassium uptake by

kernel as compared to rest of the treatments *i.e.* T_5, T_4, T_3, T_2 and T_1 and remained same bar with the treatments T_7 and T_6. Treatment T_{10} *i.e.* weedy check recorded significantly lowest potassium uptake by kernel than rest of the treatments.

Significantly highest potassium uptake by haulm was recorded under treatment (T_9) *i.e.* hand weeding at 20, 40 and 60 DAS over rest of the treatments but treatment (T_8) *i.e.* Pendimethalin (PE) *fb* Imazethapyr (PoE) *fb* HW at 40 DAS were at par with each other. However, among different weed control measures treatment T_8 *i.e.* Pendimethalin (PE) *fb* Imazethapyr (PoE) *fb* HW at 40 DAS recorded significantly highest potassium uptake by haulm as compared to rest of the treatments under study *i.e.* T_5, T_4, T_3, T_2 and T_1 and remained same bar with rest of the treatments *i.e.* T_7 and T_6. Treatment T_{10} *i.e.* weedy check recorded significantly lowest potassium uptake by haulm than rest of the treatments.

4.6.3.6 Total potassium uptake (kg ha^{-1}) by groundnut

Data pertaining to the total uptake of potassium by groundnut as influenced by different treatments are presented in Table 28 and graphically depicted in Fig. 24.

Appraisal of data presented in Table 28 denoted that hand weeding at 20, 40 and 60 DAS (T_9) recorded significantly superior total uptake of potassium by groundnut over remaining treatments under study except treatment T_8 which were at par with each other. Application of Pendimethalin (PE) *fb* Imazethapyr (PoE) *fb* HW at 40 DAS (T_8) remained at par with treatments T_7 *i.e.* Imazethapyr (PoE) *fb* HW at 40 DAS and T_6 *i.e.* Pendimethalin (PE) *fb* HW at 40 DAS and significantly superior over rest of the treatments under study in respect of weed control treatments. Where, treatment (T_{10}) i.e. weedy check recorded significantly lowest total potassium uptake by groundnut than rest of the treatments.

Table 27. Phosphorus uptake (kg ha^{-1}) in kernel, haulm and total uptake of phosphorus (kg ha^{-1}) by the groundnut as influenced by different treatments

	Treatments	phosphorus uptake(kg ha^{-1})		Total phosphorus uptake (kg ha^{-1})
		Kernel	Haulm	
T_1	Pendimethalin (PE)	3.28	3.41	6.69
T_2	Imazethapyr (PoE)	3.57	3.67	7.24
T_3	Pendimethalin (PE) *fb* Imazethapyr (PoE)	4.26	4.24	8.50
T_4	Pendimethalin (PE) *fb* Quizalofop ethyl (PoE)	4.14	4.05	8.19
T_5	Pendimethalin (PE) *fb* HW at 20 DAS	4.61	4.57	9.18
T_6	Pendimethalin (PE) *fb* HW at 40 DAS	4.81	4.79	9.60
T_7	Imazethapyr (PoE) *fb* HW at 40 DAS	5.01	5.01	10.02
T_8	Pendimethalin (PE) *fb* Imazethapyr (PoE) *fb* HW at 40 DAS	5.24	5.25	10.49
T_9	Weed free check	5.71	5.82	11.53
T_{10}	Weedy check	2.24	2.46	4.70
	S.E (m)±	0.19	0.26	0.36
	C.D. at 5%	0.55	0.78	1.07
	General mean	**4.29**	**4.33**	**8.61**

Table 28. Potassium uptake (kg ha^{-1}) in kernel, haulm and total uptake of potassium (kg ha^{-1}) by the groundnut as influenced by different treatments

	Treatments	potassium uptake (kg ha^{-1})		Total potassium uptake (kg ha^{-1})
		Kernel	Haulm	
T_1	Pendimethalin (PE)	18.83	24.72	43.55
T_2	Imazethapyr (PoE)	20.41	25.90	46.31
T_3	Pendimethalin (PE) *fb* Imazethapyr (PoE)	24.62	28.53	53.15
T_4	Pendimethalin (PE) *fb* Quizalofop ethyl (PoE)	23.58	27.73	51.31
T_5	Pendimethalin (PE) *fb* HW at 20 DAS	27.18	29.76	56.93
T_6	Pendimethalin (PE) *fb* HW at 40 DAS	28.20	30.71	58.91
T_7	Imazethapyr (PoE) *fb* HW at 40 DAS	29.49	31.71	61.20
T_8	Pendimethalin (PE) *fb* Imazethapyr (PoE) *fb* HW at 40 DAS	30.91	32.77	63.69
T_9	Weed free check	33.30	34.64	67.95
T_{10}	Weedy check	12.75	19.52	39.21
	S.E (m)±	0.97	0.96	2.05
	C.D. at 5%	2.89	2.87	6.10
	General mean	**24.93**	**28.60**	**54.22**

4.7 Nutrient uptake by weeds

Data regarding total uptake of nitrogen, phosphorous and potassium (kg ha^{-1}) by the weeds as influenced by different weed managements treatments are presented in Table 29 and graphically shown in Fig. 25.

4.7.1 Total uptake of nitrogen (kg ha^{-1}) by weeds

Data regarding total uptake of nitrogen by weeds i.e. grassy, sedges and broad leaf weeds are presented in Table 29. It is observed that total nitrogen uptake by the weeds was significantly higher in weedy check (T_{10}) compared to all the other treatments.

Total nitrogen uptake by the weeds was significantly less under the weed free check (T_9) *i.e.* hand weeding at 20, 40 and 60 DAS than rest of the treatments. Among the different weed control measures, treatment T_8 *i.e.* Pendimethalin (PE) *fb* Imazethapyr (PoE) *fb* HW at 40 DAS recorded significantly less total nitrogen uptake by weeds as compare to rest of the treatments *i.e.* T_6, T_5, T_4, T_3, T_2 and T_1 and remained same bar with treatment T_7.

4.7.2 Total uptake of phosphorous (kg ha^{-1}) by weeds

It is evident from the data presented in Table 29 that, the total phosphorous uptake in weeds was significantly higher in treatment (T_{10}) *i.e.* weedy check compared to all the other treatments.

However, hand weeding at 20, 40 and 60 DAS *i.e.* Weed free check (T_9) recorded significantly less total phosphorous uptake by weeds than rest of the treatments. Among the different weed control measures, treatment T_8 *i.e.* Pendimethalin (PE) *fb* Imazethapyr (PoE) *fb* HW at 40 DAS recorded significantly less total phosphorous uptake by weeds as compare to rest of the treatments *i.e.* T_6, T_5, T_4, T_3, T_2 and T_1 and remained same bar with treatment T_7.

Table 29. Total uptake of nitrogen, phosphorus and potassium (kg ha^{-1}) by weeds as influenced by the different weed control treatments

	Treatment	Total N uptake (kg ha^{-1})	Total P uptake (kg ha^{-1})	Total K uptake (kg ha^{-1})
T_1	Pendimethalin (PE)	11.61	2.24	7.54
T_2	Imazethapyr (PoE)	10.33	1.97	6.78
T_3	Pendimethalin (PE) *fb* Imazethapyr (PoE)	7.54	1.51	5.30
T_4	Pendimethalin (PE) *fb* Quizalofop ethyl (PoE)	8.98	1.75	6.10
T_5	Pendimethalin (PE) *fb* HW at 20 DAS	6.21	1.25	4.45
T_6	Pendimethalin (PE) *fb* HW at 40 DAS	5.21	1.07	3.80
T_7	Imazethapyr (PoE) *fb* HW at 40 DAS	4.40	0.92	3.11
T_8	Pendimethalin (PE) *fb* Imazethapyr (PoE) *fb* HW at 40 DAS	3.59	0.77	2.61
T_9	Weed free check	1.61	0.47	1.46
T_{10}	Weedy check	32.56	5.44	22.14
	S.E (m)±	0.41	0.08	0.20
	C.D. at 5%	1.20	0.25	0.59
	General mean	**9.20**	**1.74**	**6.33**

4.7.3 Total uptake of potassium (kg ha^{-1}) by weeds.

It was observed from the data presented in Table 29 that, the weedy check (T_{10}) recorded maximum uptake of potassium by weeds and was significantly higher as compared to all treatments.

However, significantly lowest uptake of potassium by weeds recorded under treatment (T_9) *i.e.* hand weeding at 20, 40 and 60 DAS than rest of the treatments. Among the different weed control measures, treatment T_8 *i.e.* Pendimethalin (PE) *fb* Imazethapyr (PoE) *fb* HW at 40 DAS recorded significantly less total potassium uptake by weeds as compare to rest of the treatments *i.e.* T_6, T_5, T_4, T_3, T_2 and T_1 and remained same bar with treatment T_7.

4.8 Nutrient status of soil after harvest of groundnut

The effect of different treatments on available nitrogen, phosphorus and potassium status (kg ha^{-1}) of soil after harvest of groundnut are presented in Table 30 and graphically shown in Fig.26.

It is observed from data that, available nitrogen in the soil after harvest of groundnut was significantly higher in weed free check (T_9) *i.e.* hand weeding at 20, 40 and 60 DAS treatment than all the remaining treatments under study except treatment T_8 *i.e.* Pendimethalin (PE) *fb* Imazethapyr (PoE) *fb* HW at 40 DAS was at par with treatment T_9. The treatment (T_{10}) *i.e.* weedy check recorded significantly the lowest available nitrogen in the soil than rest of the treatments after harvest of the crop.

From the data presented in Table 30, it is observed that significantly highest available phosphorus in soil was found under weed free check (T_9) over rest of the treatments under study except treatment T_8 *i.e.* Pendimethalin (PE) *fb* Imazethapyr (PoE) *fb* HW at 40 DAS was at par with treatment T_9. Treatment (T_{10}) *i.e.* weedy check recorded significantly lower available phosphorus in the soil after harvest than the remaining treatments.

Table 30. Mean available nitrogen, phosphorus and potassium content (kg ha^{-1}) in soil after harvest of groundnut as influenced by different treatments

	Treatment	Available N (kg ha^{-1})	Available P (kg ha^{-1})	Available K (kg ha^{-1})
T_1	Pendimethalin (PE)	252.70	10.70	187.80
T_2	Imazethapyr (POE)	252.90	10.50	188.60
T_3	Pendimethalin (PE) *fb* Imazethapyr (POE)	256.37	12.20	194.10
T_4	Pendimethalin (PE) *fb* Quizalofop ethyl (POE)	254.20	11.69	192.20
T_5	Pendimethalin (PE) *fb* HW at 20 DAS	260.07	13.10	197.00
T_6	Pendimethalin (PE) *fb* HW at 40 DAS	265.63	15.00	200.90
T_7	Imazethapyr (POE) *fb* HW at 40 DAS	270.83	16.21	205.60
T_8	Pendimethalin (PE) *fb* Imazethapyr (PoE) *fb* HW at 40 DAS	273.10	17.20	208.10
T_9	Weed free check	275.33	18.10	212.80
T_{10}	Weedy check	248.10	8.40	181.30
	S.E (m)±	0.83	0.34	1.00
	C.D. at 5%	2.47	1.02	2.96
	General mean	**260.92**	**13.31**	**196.84**

Available potassium in the soil after harvest of groundnut was significantly higher under treatment (T_9) *i.e.* hand weeding at 20, 40 and 60 DAS than rest of the treatments under study. Among different weed control measures, significantly higher available potassium in the soil after harvest of groundnut was observed in treatments T_8 and T_7 which were at par with each other. Treatment (T_{10}) *i.e.* weedy check recorded significantly lower available potassium in the soil after harvest than the remaining treatments.

4.9 Economics of the treatments

Economics of the different weed control measures are presented in Table 31 and graphically shown in fig.27.

Data regarding the economics of the treatments indicated that the net profit as well as B:C ratio was higher under Pendimethalin *fb* Imazethapyr *fb* HW at 40 DAS (T_8) (₹ 75992.30 and 1.62, respectively) as compared to the other treatments. It was followed by Imazethapyr *fb* HW at 40 DAS (T_7) (₹ 71777.15 and 1.60, respectively), weed free check (T_9) (₹ 71153.26 and 1.52, respectively), Pendimethalin *fb* HW at 40 DAS (T_6) (₹ 63348.85 and 1.52, respectively) and Pendimethalin *fb* HW at 20 DAS (T_5) (₹ 61593.60 and 1.48, respectively). While, negative return and less than one B:C ratio was recorded in weedy check (T_{10}) (₹ -824.72 and 0.99, respectively).

Table 31. Total cost, gross income, net income and B:C ratio of groundnut as influenced by different treatments

	Treatments	Total cost (₹ ha^{-1})	Gross income (₹ ha^{-1})	Net income (₹ha^{-1})	B:C Ratio
T_1	Pendimethalin (PE)	107574.15	135637.50	28063.35	1.26
T_2	Imazethapyr (POE)	108962.53	144900.00	35937.47	1.33
T_3	Pendimethalin (PE) *fb* Imazethapyr (POE)	113864.28	168547.50	54683.22	1.48
T_4	Pendimethalin (PE) *fb* Quizalofop ethyl (POE)	113261.94	164877.50	51615.56	1.46
T_5	Pendimethalin (PE) *fb* HW at 20 DAS	120992.40	179535.00	58542.60	1.48
T_6	Pendimethalin (PE) *fb* HW at 40 DAS	121953.65	185302.50	63348.85	1.52
T_7	Imazethapyr (POE) *fb* HW at 40 DAS	119802.85	191580.00	71777.15	1.60
T_8	Pendimethalin (PE) *fb* Imazethapyr (PoE) *fb* HW at 40 DAS	123007.70	199000.00	75992.30	1.62
T_9	Weed free check	137006.74	208160.00	71153.26	1.52
T_{10}	Weedy check	98447.22	97622.50	-824.72	0.99

CHAPTER-V
DISCUSSION

In this chapter, an attempt has been made to discuss the important causes and effects emerging out of the results of investigation, entitled "Effect of Integrated weed management in *kharif* groundnut (*Arachis hypogaea* L.)" carried out during year 2016, *kharif* season at the Agronomy Farm, Department of Agronomy, College of Agriculture, Dapoli. The entire discussion has been divided into following sub-heads.

5.1 Soil, weather and crop growth

5.2 Effect of different weed management practices

5.3 Economics of different treatments

5.1 Soil, weather and crop growth

Before going into discussion of the present investigation, it is important to discuss the weather conditions to which the crop was exposed and the soil conditions on which it was grown.

The initial soil analysis from experimental plot revealed that, the soil was sandy clay loam in texture, slightly acidic in pH and medium in organic carbon content. It was low in available nitrogen, medium in available phosphorus and available potassium (Table 1). The soil was leveled, well drained and uniform in depth.

The meteorological data presented in Table 2 showed that, the weather conditions were favourable for the groundnut crop during *kharif* season of 2016. Rainfall received during the crop growth period was 4497.9 mm, which received in 101 rainy days. The average maximum and minimum temperatures were in the range of 26.6 ^{0}C to 34.7 ^{0}C and 21.4 ^{0}C to 25.6 ^{0}C, respectively. The mean relative humidity during crop period ranged from 83 to 99 % in the morning and 59 to 97 % in the evening, respectively. The relative humidity was quite high because of rainy season and it was quite congenial for the crop growth. The sunshine hours were between 0.0 to 9.2 hours day^{-1}.

In general, the climate was favourable for growth and development of groundnut without an incidence of any major pests or diseases during crop growth period. Thus, the observed differences in growth were mainly due to treatment effects. Similarly, weed growth was also normal in the field. During the initial stages of crop growth, grassy weeds were prominently seen and in the later stage sedges and broad leaf weeds were prominently observed in the crop. The important weeds observed in the experimental plot are given in Table 18.

5.2 Effect of different weed management practices

5.2.1 Plant population

The plant population groundnut per net plot counted at 20 DAS and at harvest did not differ significantly due to different treatments. This indicated that, the plant population was uniform in groundnut crop throughout its life cycle. Therefore, the variation observed in different growth, yield attributes and yield of groundnut in present investigation were entirely due to the imposition of different treatments only (Table 10).

5.2.2 Growth parameters

It is evident from the data presented in previous chapter (Table 11 to 15) that a marked effect of different treatments was observed on growth characters of groundnut throughout the crop growth period. The plant height, number of functional leaves, mean plant spread, number of branches and dry matter accumulation per hill were not-significantly influenced at 20 and 40 DAS due to different treatments. It might be due to non competition between the crop and weeds.

In general all growth parameters *viz.* plant height, number of functional leaves, mean plant spread, number of branches and dry matter accumulation per hill increased with increase in age of groundnut crop. The treatment weed free check *i.e.* Hand weeding at 20, 40 and 60 DAS significantly superior regarding to all growth

parameters during all the growth stages of observation as compared to rest of the treatments except T_8 and T_7 (Table 11 to 15). However, among the different weed control measures, treatment (T_8) which was at par with treatments T_7, T_6 and T_5 significantly superior during all growth stages of observations except at 20 and 40 DAS. It might be due to minimizing the competition of weeds with main crop for resources *viz*. space, light, nutrients and moisture with adaption of effective weed control methods to better weed control at right time reduced inter row competition to crop. Similar results were reported by Singh and Giri (2001), Kalhapure *et al*. (2013) and Basavaraj *et al*. (2014).

Weedy check (T_{10}) recorded significantly the lowest dry matter accumulation per plant over all the weed control treatments because the availability of resources *viz*., nutrient, space and sunshine for groundnut crop was very much restricted due to high weed competition under weedy check. Therefore, the growth of groundnut in respect of plant height, number of leaves, plant spread, number of branches and dry matter accumulation was significantly less under weedy check than the other weed control treatments. These findings are on similar lines with the findings of Kalhapure *et al*. (2013).

5.2.3 Yield attributes

The dry pod yield of groundnut per unit area is contributed by yield attributes *viz*., total number of pods per hill, number of developed pods per hill, weight of developed pods per hill, 100-kernel weight and shelling percentage influenced by different treatments are presented in Table 16. The shelling percentage was found to be non-significant due to influence of different treatments in experimentation.

The result revealed that treatment weed free check (T_9) remained at par with T_8 and T_7 *i.e*. Pendimethalin (PE) *fb* Imazethapyr (PoE) *fb* HW at 40 DAS and Imazethapyr (PoE) *fb* HW at 40 DAS regarding total number of pods per hill, number of developed pods per hill and weight of developed pods per hill significantly improved the yield attributes

(Table 16) over rest of the treatments under study. In case 100-kernel weight highest weight recorded by treatment weed free check (T_9) which were at par with treatments T_8 and T_7 but found significantly superior over rest of the treatments. Weed free environment facilitate better growth and development of plants, flowering, peg initiation, pod formation and development and ultimately increase in yield attributes. These findings are close conformity with Kalhapure *et al.* (2013). Similar findings were reported by Patel *et al.* (2013) and Dixit *et al.* (2016).

Weedy check (T_{10}) recorded the lowest values of yield attributing characters. This was due to severe weed competition exerted by grasses, sedges and broad leaved weeds for space, light, moisture and nutrients throughout the growth period. A similar result was reported by Madhu *et al.* (2005) and Dixit *et al.* (2016).

5.2.4 Dry pod yield, kernel yield and haulm yield (q ha^{-1})

Data pertaining to the dry pod yield, kernel yield and haulm yield (q ha^{-1}) influenced by various treatments are presented in Table 17 indicate that, the weed free check (T_9) *i.e.* hand weeding at 20, 40 and 60 DAS produced significantly highest dry pod yield, kernel yield and haulm yield over rest of the treatments except treatments T_8 and T_7 which were at par with each other. The increase in dry pod yield, kernel yield and haulm yield could be attributed to increase in growth characters like plant height, number of functional leaves per hill, number of branches per hill and dry matter accumulation per hill due to proper integration of weed management practices, The better plant growth and improved yield attributes finally led to higher dry pod, kernel and haulm yield. Dutta *et al.* (2005), Kalhapure *et al.* (2013), Yadaav *et al.* (2014) also reported similar results.

All the weed control measures were significantly superior over the weedy check (T_{10}). This was due to high weed density and biomass. Similar results were reported by Basavaraj *et al.* (2014) and Dixit *et al.* (2016).

5.2.5 Weed studies

The most dominant weed species found in the experimental field (Table 18) throughout the crop growth in groundnut were; *Ischaemum globosa, Digitaria sanguinalis, Echinochloa colona* among grasses: *Cyperus iria, Cyperus difformis* among sedges and *Ludwigia octovalvis, Mimosa pudica, Physalis minima* and *Alternanthera sessilis* among broad leaved weeds.

5.2.5.1 Effect on weed density

It was observed from the weed count recorded periodically from the different treatments that, the three kinds of weeds *viz.*, grasses, sedges and broad leaved weeds significantly less under weed free check (T_9) *i.e.* hand weeding at 20, 40 and 60 DAS during all growth stages (Table 19, 20 and 21).

Among different weed control measures, at 20 DAS, weed free check (T_9) recorded significantly lowest population of grassy weeds than rest of the treatments followed by treatments T_8, T_7, T_6, T_4, T_3 and T_1 were at par with each other found significantly superior over rest of the treatments. At 40, 60, 80, 100 DAS and at harvest treatments T_8 and T_7 also recorded less grassy weeds than rest of the treatments except treatment weed free check (T_9).

At 20 DAS among different weed control measures, Pendimethalin (PE) *fb* Imazethapyr (PoE) *fb* HW at 40 DAS (T_8) recorded the lowest weed population of sedges than rest of the treatments *i.e.* T_7 and T_{10} and it was remained same bar with rest of the treatments. At 40, 60, 80, 100 DAS and harvest treatment T_8 *i.e.* Pendimethalin (PE) *fb* Imazethapyr (PoE) *fb* HW at 40 DAS recorded the lowest weed population of sedges than rest of the treatments and it was remained same bar with the treatments *i.e.* T_7, T_6 and T_5.

Significantly less BLWs observed in treatment T_9 *i.e.* hand weeding at 20, 40 and 60 DAS than rest of the treatments it was remained same bar with treatments T_8, T_6 and T_5 at 20 DAS. Among

different weed control treatments tried in experiment, at 20 DAS treatment T_8 *i.e.* Pendimethalin (PE) *fb* Imazethapyr (PoE) *fb* HW at 40 DAS was at par with rest of weed control treatments under study except treatment T_7 and T_2 in respect of weed population of BLWs. However, treatment T_8 Pendimethalin (PE) *fb* Imazethapyr (PoE) *fb* HW at 40 DAS was at par with treatment T_7 *i.e.* Imazethapyr (PoE) *fb* HW at 40 DAS during 80, 100 DAS and at harvest. While it was also at par treatment T_6 during 40 and 60 DAS.

Pre-emergence application prevents emergence of monocot and grassy weeds by inhibiting root and shoot growth, while imazethapyr sacetolactate synthase (ALS) or acetohydroxy acid synthase (AHAS) in broad leaf weeds which causes distruction of these weeds at 3 to 4 leaf stage. All grassey, sedges and BLWs emerged during later stage were effectively controlled manually by performing hand weeding at 40 DAS hence there was a better weed control at right time to reduced weed growth. The simillar results recorded by the Kalhapure *et al.* (2013) and Satyakumari *et al.* (2015).

However, weedy check (T_{10}) recorded significantly the higher population of grassy, sedges and broad leaved weeds than rest of the treatments. This was due to the unrestricted weed growth under the above referred treatment *i.e.* weedy check (T_{10}). Similar, findings were reported by Madhu *et al.* (2006), Singh and Singh (2009), Das and Samant (2014) and Kalaichelvi *et al.* (2015).

5.2.5.2 Effect on weed growth, weed control efficiency and weed index

It is observed that, the weed free check (T_9) significantly reduced total dry weight of weeds and exhibited highest weed control efficiency (90.44 %) at harvest compared to rest of the treatments (Table 23). It was followed by Pendimethalin (PE) *fb* Imazethapyr (PoE) *fb* HW at 40 DAS (T_8) and Imazethapyr (PoE) *fb* HW at 40 DAS (T_7) which were registered lower dry weight and higher weed control

efficiency which was found to be significantly superior over rest of the treatments except treatment T_9. Pre-emergence application of pendimathalin checked the annual grassy and certain broad-leaf weeds by inhibiting their root and shoot growth while post-emergence application of imazethapyr inhibited growth of mostly broad-leaf weeds at 3–4 leaf stage. Escaped or re-emerged weeds were taken care by hand weeding done at 40 DAS, thereby providing weed free environment for longer period of crop growth tilting the crop-weed competition in favour of crop. The similar results recorded by the Kalhapure *et al*. (2013).

Pendimethalin (PE) *fb* Imazethapyr (PoE) *fb* HW at 40 DAS (T_8) recorded significantly lowest weed index than rest of the treatments followed by Imazethapyr (PoE) *fb* HW at 40 DAS (T_7). Highest weed index was observed in treatment (T_{10}) *i.e*. weedy check. Similar, findings were reported by Patel *et al*. (2013) and Basavaraj *et al*. (2014).

However, weedy check (T_{10}) recorded significantly the highest weed growth compared to rest of weed control treatments at all growth stages of groundnut. This was due to the unrestricted weed growth in the groundnut crop right from germination. These results are in close conformity with Kalhapure *et al*. (2013) and Satyakumari *et al*. (2015).

5.2.6 Nutrient uptake and quality

N, P and K content in kernel and haulm of groundnut were observed to be non-significant. However, numerically higher N, P and K content in kernel and haulm was recorded in treatment T_9 *i.e*. weed free check followed by treatment T_8 *i.e*. Pendimethalin (PE) *fb* Imazethapyr (PoE) *fb* HW at 40 DAS found superior over rest of the treatments (Table 25).

The data presented in Table 26, 27 and 28 revealed that, the weed free check (T_9) recorded significantly higher N, P and K uptake in

kernel and haulm of groundnut over rest of the treatments followed by Pendimethalin (PE) *fb* Imazethapyr (PoE) *fb* HW at 40 DAS (T_8). In general, increased uptake of these nutrients by groundnut was due to increase in kernel and haulm yields and N, P and K content of kernel and haulm under treatments T_9, and T_8. Weedy check (T_{10}) recorded significantly minimum uptake of the major nutrients *i.e.* N, P and K than the other weed control treatments. This was due to the more weed growth under the weedy check. These results are similar to those reported by Madhu *et al.* (2006) and Basavaraj *et al.* (2014)

Total uptake of nitrogen, phosphorous and potassium (Kg ha^{-1}) by the weeds as influenced by different weed management treatments presented in Table 29 revealed that, the weed free check (T_9) recorded significantly less total uptake of N, P and K than rest of the treatments followed by Pendimethalin (PE) *fb* Imazethapyr (PoE) *fb* HW at 40 DAS (T_8) and found to be significantly superior over rest of the treatments. Total N, P and K uptake in weeds was significantly higher in weedy check (T_{10}) compared to all the other treatments this was due to higher population and biomass of weeds in this treatment. Similar results were also reported by Madhu *et al.* (2006) and Basavaraj *et al.* (2014).

Oil and Protein content of groundnut were observed to be non-significant. However, numerically higher oil and protein content (per cent) in kernel was recorded in treatment T_9 *i.e.* weed free check followed by treatment T_8 found superior over rest of the treatments.

The treatment weed free check (T_9) recorded significantly superior oil yield q ha^{-1} over rest of the treatments and which was at par with treatments T_8 and T_7 *i.e.* Pendimethalin (PE) *fb* Imazethapyr (PoE) *fb* HW at 40 DAS and Imazethapyr (PoE) *fb* HW at 40 DAS. The effective weed control owing to these treatments led to higher oil yield compare to weedy check. These results are similar to reported by Satyakumari *et al.* (2015).

5.2.7 Available nutrient in soil after harvest of crop

The available N, P and K in soil after harvest of groundnut were significantly affected by different weed management practices (Table 30). The highest available N, P and K in the soil after harvesting of groundnut was recorded under weed free check (T_9) which remained statistically at par with application of Pendimethalin (PE) *fb* Imazethapyr (PoE) *fb* HW at 40 DAS (T_8). The significantly lowest N, P and K in soil were found under weedy check (T_{10}).

5.3 Economics of different treatments

Economics of the different weed control measures is presented in Table 31 indicated that net profit as well as B: C ratio was higher under Pendimethalin (PE) *fb* Imazethapyr (PoE) *fb* HW at 40 DAS (T_8) as compared to the other treatments. This treatment found effective in reducing the weeds and improving the yield. It was followed by Imazethapyr (POE) *fb* HW at 40 DAS (T_7) and weed free check (T_9).

It was concluded that, the cost of cultivation of weed free check treatment was the highest due to maximum variable cost, which was not affordable by the poor farmers and scarcity and high cost of labours during peak period is also questionable. This cost was reduced in treatment application of pre-emergence and post-emrgergence herbicide with hand weeding proved practically more convenient and economically best feasible integrated weed management practice for groundnut. Similar results were also reported by Sasikala *et. al.* (2004) and Rao *et. al.* (2011), Kalhapure *et al*. (2013) and Satyakumari *et al*. (2015).

CHAPTER-VI
SUMMARY AND CONCLUSION

Field experiment was conducted during *kharif,* 2016 at Agronomy Farm, College of Agriculture, Dapoli (M.S.) to study the "Effect of integrated weed management in *kharif* groundnut (*Arachis hypogaea* L.)".

The experiment was laid out in randomized block design with ten treatments and three replications. The groundnut was sown on 11th June 2016. The variety *Kankan tapora* was used for sowing. Seeds were sown by dibbling method. The gross and net plot sizes were 4.80 m x 3.60 m and 4.50 m x 3.00 m, respectively.

Observations on growth characters of groundnut and weeds were recorded periodically, while the observations on yield attributing characters and yield of groundnut were recorded at harvest. The qualitative parameter like Oil and protein content was recorded at harvest. Chemical analysis of kernel and haulm of groundnut as well as weeds were carried out at harvest to determine the nutrient uptake (kg ha^{-1}) by groundnut and weeds.

The analysis of the initial soil sample indicated that, the soil of the experimental plot was sandy clay loam in texture, slightly acidic in pH and medium in organic carbon content. It was low in available nitrogen, medium in available phosphorus and available potassium (Table 1) and final soil fertility status was studied at harvest (Table 30). The soil was levelled, well drained and uniform in depth. Thus, the soil was suitable for growing groundnut in *kharif* season.

In general, the season was favorable for the growth of groundnut without incidence of any major pests or diseases during the crop growth period. The important findings emerged out from this investigation are summarized below-

1. Plant population count at 20 DAS and at harvest was not significantly influenced due to different treatments.

2. Weed free check (T_9) recorded significantly taller plants than other treatments at all growth stages of groundnut which was at par with treatment T_8 and T_7 *i.e.* Pendimethalin (PE) *fb* Imazethapyr (PoE) *fb* HW at 40 DAS and Imazethapyr (PoE) *fb* HW at 40 DAS except at 20 and 40 DAS.

3. Except 20 DAS weed free check (T_9) recorded significantly higher number of functional leaves than rest of the treatments at 40, 60, 80, 100 DAS and at harvest which was at par with Pendimethalin (PE) *fb* Imazethapyr (PoE) *fb* HW at 40 DAS (T_8) and Imazethapyr (PoE) *fb* HW at 40 DAS (T_7).

4. The mean plant spread was not significantly influenced due to various treatments at 20 and 40 DAS. Whereas, weed free check (T_9) recorded significantly the higher plant spread than rest of the treatments at 40, 60, 80, 100 DAS and at harvest which was at par with Pendimethalin (PE) *fb* Imazethapyr (PoE) *fb* HW at 40 DAS (T_8) and Imazethapyr (PoE) *fb* HW at 40 DAS (T_7).

5. Number of branches of groundnut was not differ significantly due to various treatments at 20 and 40 DAS. Significantly higher number of branches of groundnut recorded in treatment T_9 *i.e.* weed free check which was at par with treatments T_8 and T_7 at 60, 80, 100 DAS and at harvest but found significantly superior over rest of the treatments.

6. The mean plant dry matter accumulation per hill was significantly influenced by the different weed control measures at all the growth stages of observations except at 20 and 40 DAS. Weed free check (T_9) recorded significantly higher dry matter production than rest of the treatments at 60, 80, 100 DAS and at harvest remained at par with treatments T_8 and T_7.

7. In case of various yield attributing characters under study *viz.*, total number pods per hill, number of developed pods per hill, weight of developed pods per hill, 100 kernel weight and shelling

percentage. the treatment weed free check (T_9) *i.e.* hand weeding at 20 and 40 DAS recorded significantly highest yield attributing characters which was at par with treatments T_8 and T_7 *i.e.* Pendimethalin (PE) *fb* Imazethapyr (PoE) *fb* HW at 40 DAS and Imazethapyr (PoE) *fb* HW at 40 DAS found significantly superior over rest of the treatments. The shelling percentage was not significantly influenced due to various treatments under study.

8. Dry pod yield (q ha^{-1}) of groundnut was found higher in treatment T_9 *i.e.* weed free check over rest of the treatments which was at par with treatments T_8 and T_7 *i.e.* Pendimethalin (PE) *fb* Imazethapyr (PoE) *fb* HW at 40 DAS and Imazethapyr (PoE) *fb* HW at 40 DAS. Kernel yield (q ha^{-1}) of groundnut was recorded significantly highest in treatment weed free check (T_9) over rest of the treatments and remain same bar with treatments T_8 and T_7. Haulm yield (q ha^{-1}) of groundnut was found highest in treatment (T_9) *i.e.* weed free check which was at par with treatments T_8 and T_7 but found significantly superior over rest of the treatments.

9. Grasses were significantly least under weed free check (T_9) at 20 DAS followed by treatments T_8, T_7, T_6 and T_5 were at par with each other and found significantly superior over rest of the treatments. However, at 40, 60, 80, 100 DAS and at harvest treatment T_9 recorded significantly lowest population of grasses followed by treatment T_8 and T_7 which was at par with each other and found significantly superior over rest of the treatments. At 20 DAS treatment T_9 recorded significantly lowest population of Sedges which was at par with treatments T_8 and T_6 found significantly superior over rest of the treatments. At 40, 60, 80, 100 DAS and at harvest sedges were less under Weed free check (T_9) than rest of the treatments which was at par with treatments T_8 and T_7. However, BLWs were significantly less under weed free check (T_9) followed by treatments (T_8) and (T_7) which were at par with each other at 80, 100 DAS and at harvest.

However, at 20 DAS treatment T_9 recorded less BLWs which were at par with treatments T_8, T_6 and T_5 and found significantly superior over rest of the treatments. At 40 and 60 DAS weed free check (T_9) recorded less BLWs followed by treatments T_8, T_7 and T_6 which were at par with each other and found significantly superior over rest of the treatments.

10. Weed free check (T_9) recorded significantly lower dry weight of grasses and BLWs at harvest as compared to rest of the treatments followed by Pendimethalin (PE) *fb* Imazethapyr (PoE) *fb* HW at 40 DAS (T_8) and Imazethapyr (PoE) *fb* HW at 40 DAS (T_7) which were at par with each other. Lower dry weight of sedges were recorded in treatment weed free check (T_9) followed by treatments T_8, T_7 and T_6 which were at par with each other and found significantly superior over rest of the treatments. Weedy check (T_{10}) recorded the highest dry weight of all types of weeds than the remaining treatments.
11. The total dry weight of weeds at harvest was also significantly least under weed free check (T_9), whereas it was highest under weedy check (T_{10}).
12. The highest weed control efficiency (90.44 %) was recorded under treatment T_9 *i.e.* weed free check followed by Pendimethalin (PE) *fb* Imazethapyr (PoE) *fb* HW at 40 DAS (84.74 %), Imazethapyr (PoE) *fb* HW at 40 DAS (82.21 %) and Pendimethalin (PE) *fb* HW at 40 DAS (79.71 %).
13. The lowest weed index (4.40 %) was recorded under Pendimethalin (PE) *fb* Imazethapyr (PoE) *fb* HW at 40 DAS (T_8) followed by Imazethapyr (PoE) *fb* HW at 40 DAS (T_7) (8 %) and Pendimethalin (PE) *fb* HW at 40 DAS (12.37 %).
14. Oil and Protein content of groundnut were observed to be non-significant. However, numerically higher oil and protein content (%) in kernel was recorded in treatment T_9 followed by treatment

T_8 found superior over rest of the treatments. The treatment weed free check (T_9) recorded significantly highest oil yield over rest of the treatments and which was at par with treatments T_8 and T_7 *i.e.* Pendimethalin (PE) *fb* Imazethapyr (PoE) *fb* HW at 40 DAS and Imazethapyr (PoE) *fb* HW at 40 DAS.

15. The major nutrient content in kernel and haulm of groundnut was not influenced significantly due to the different weed control measures. However, weed free check (T_9) recorded numerically higher N, P and K content in kernel and haulm of groundnut.

16. Chemical studies showed that, the total nitrogen uptake by groundnut was significantly higher in weed free check (T_9) which was at par with Pendimethalin (PE) *fb* Imazethapyr (PoE) *fb* HW at 40 DAS (T_8). Weedy check (T_{10}) recorded significantly lower uptake of nitrogen by groundnut than the remaining treatments.

17. Total phosphorous uptake by groundnut was significantly higher under weed free check (T_9) which was at par with Pendimethalin (PE) *fb* Imazethapyr (PoE) *fb* HW at 40 DAS (T_8) and found significantly superior over rest of the treatments. While weedy check (T_{10}) recorded the lowest uptake of phosphorous.

18. Among the different weed control measures, potassium uptake by groundnut was significantly higher under weed free check (T_9) than rest of the treatments, which was at par with treatment T_8 *i.e.* Pendimethalin (PE) *fb* Imazethapyr (PoE) *fb* HW at 40 DAS.

19. Total nitrogen uptake by the weeds was significantly less under the weed free check (T_9) than rest of the treatments followed by treatments T_8 and T_7 and significantly superior over rest of the treatments and total uptake of nitrogen by the weed was significantly higher under treatment weedy check (T_{10}).

20. Total phosphorous uptake in weeds was significantly higher in weedy check (T_{10}) compared to all the other treatments. Weed free check (T_9) reduced the phosphorous uptake by weeds and found

to be significantly superior over the remaining treatments followed by treatments T_8 and T_7 *i.e.* Pendimethalin (PE) *fb* Imazethapyr (PoE) *fb* HW at 40 DAS and Imazethapyr (PoE) *fb* HW at 40 DAS.

21. Significantly higher potassium uptake by the weeds was observed in weedy check (T_{10}) and significantly less under the weed free check (T_9) than rest of the treatments followed by Pendimethalin (PE) *fb* Imazethapyr (PoE) *fb* HW at 40 DAS (T_8) and Imazethapyr (PoE) *fb* HW at 40 DAS (T_7) and found significantly superior over remaining treatments.

22. The significantly highest available nitrogen, phosphorus and potassium in the soil after harvest of groundnut was recorded under weed free check (T_9) over rest of the treatments, while treatment weedy check (T_{10}) recorded significantly lowest N, P and K content in soil.

23. Weed control measures and weedy check did not influence the soil available nitrogen, phosphorus and potassium significantly measured after harvest of groundnut.

24. Net profit as well as B: C ratio was higher under Pendimethalin (PE) *fb* Imazethapyr (PoE) *fb* HW at 40 DAS (T_8) as compared to the other treatments. It was followed by Imazethapyr (POE) *fb* HW at 40 DAS (T_7) and weed free check (T_9). While, lowest net return and less B: C ratio was recorded in weedy check (T_{10}).

CONCLUSION

From the experiment entitled “Effect of integrated weed management in *kharif* groundnut (*Arachis hypogaea* L.)” it can be concluded that,

- Weed free check followed by Pendimethalin (PE) *fb* Imazethapyr (PoE) *fb* HW at 40 DAS results in highest weed control efficiency.
- Maximum growth, yield and quality parameters of groundnut have been obtained in weed free check followed by Pendimethalin (PE) *fb* Imazethapyr (PoE) *fb* HW at 40 DAS compared to other treatments of weed management.
- For obtaining highest net returns and B: C ratio, Pendimethalin (PE) *fb* Imazethapyr (PoE) *fb* HW at 40 DAS has proved better weed management method for *kharif* Groundnut under *konkan* condition.

However, conclusion drawn is based on one year result; trial needs to be repeated for one more year.

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COLLEGE OF AGRICULTURE, DAPOLI.
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Dapoli – 415 712, Dist. Ratnagiri (Maharashtra)

Title of Thesis	:	Effect of integrated weed management in *kharif* groundnut (*Arachis hypogaea* L.)
Name of the student	:	**Mr. Toradmal Sujit Sukhadev**
Registration No.	:	2395
Name of Research Guide	:	**Dr. S. B. Gangawane** Officer Incharge, Agriculture research station, Palghar, Dist. Palghar.
Year of award of degree	:	2017

THESIS ABSTRACT

The present investigation entitled "Effect of Integrated weed management in *kharif* groundnut (*Arachis hypogaea* L.)" was conducted at Agronomy Farm, Department of Agronomy, College of Agriculture, Dapoli, Dist. Ratnagiri (M.S.) during *kharif* season of 2016.

The trial was laid out in a randomized block design. There were ten treatments which were replicated thrice. The treatments mainly comprised of Pendimethalin PE (T_1), Imazethapyr PoE (T_2), Pendimethalin PE *fb* Imazethapyr PoE (T_3), Pendimethalin PE *fb* Quizalofop ethyl PoE (T_4), Pendimethalin PE *fb* HW at 20 DAS (T_5), Pendimethalin PE *fb* HW at 40 DAS (T_6), Imazethapyr PoE *fb* HW at 40 DAS (T_7), Pendimethalin PE *fb* Imazethapyr PoE *fb* HW at 40 DAS (T_8), Weed free check (T_9) and Weedy check (T_{10}).

The gross plot size was 4.80 m x 3.60 m and net plot size was 4.50 m x 3.00 m, respectively. The soil of the experimental plot was sandy clay loam in texture, slightly acidic in pH and medium in organic carbon content. It was low in available nitrogen, medium in available phosphorus and potassium. The sowing was done in the experimental plot on 7th June 2016 by dibbling method at a distance 30 cm X 15 cm. The other recommended packages of practices were

followed time to time and periodical growth observations were recorded.

The results revealed that, treatments weed free check, Pendimethalin PE *fb* Imazethapyr PoE *fb* HW at 40 DAS and Imazethapyr PoE *fb* HW at 40 DAS produced higher growth and yield attributes as compared to rest of the treatments under study. Treatment weed free check recorded highest dry pod (24.76 q ha^{-1}), kernel (17.21 q ha^{-1}) and haulm (40.32 q ha^{-1}) yield. Similarly, these treatments recorded significantly least weed population of grassy, sedges and broad leaves weeds which was found superior over rest of the treatments and effectively controlled weed density and growth. Nutrient uptake by weeds was significantly less under weed free check followed by Pendimethalin PE *fb* Imazethapyr PoE *fb* HW at 40 DAS and Imazethapyr PoE *fb* HW at 40 DAS while, it was maximum in Weedy check.

The nutrient uptake and oil yield in groundnut crop was significantly higher under treatment Weed free check followed by Pendimethalin PE *fb* Imazethapyr PoE *fb* HW at 40 DAS and Imazethapyr PoE *fb* HW at 40 DAS. However, nutrient, oil and protein content were found statastically identical. This particular combination *i.e.* Pendimethalin PE *fb* Imazethapyr PoE *fb* HW at 40 DAS showed great promise in respect of enhancing highest net return (₹ 71,992 ha^{-1}) and B: C ratio (1.62).

On the basis of results obtained during study, it can be concluded that the herbicides combination with one hand weeding gives better results as compare to pre and post-emergence combination or use of herbicide alone. The treatment Pendimethalin PE *fb* Imazethapyr PoE *fb* HW at 40 DAS was the most effective and economical treatment followed by Imazethapyr PoE *fb* HW at 40 DAS and Weed free check to control weeds effectively in groundnut during *kharif* season and to obtain higher productivity and profit.

APPENDIX – I

Cost of input for calculating economics of treatments.

1.	**Labour** a) Male	₹ Day^{-1}	180/-
	b) Female	₹ Day^{-1}	180/-
2.	**Field preparation**		
	A) Ploughing	Hrs^{-1}	350/-
	B) Harrowing	Hrs^{-1}	300/-
3.	**Seed**	₹ Kg^{-1}	120/-
4.	**Herbicides**		
	Pendimethalin	Lit^{-1}	490/-
	Imazethapyr	Lit^{-1}	470/-
	Quizalofop ethyl	Lit^{-1}	481/-
5.	**Farm yard Manure**	₹ Kg^{-1}	4/-
6.	**Fertilizers**		
	B) Urea	₹ Kg^{-1}	7/-
	C) S. S. P.	₹ Kg^{-1}	8/-
7.	**Seed treatment**		
	a) Rhizobium	₹ Kg^{-1}	150/-
8.	**Plant protection**		
	A) Cypermethrin	₹ Lit^{1}	570/-
	B) Mancozeb	₹ Kg^{-1}	245/-
9.	**Price of produce**		
	a) Dry pod	₹ q^{-1}	8000/-
	b) Haulm	₹ q^{-1}	250/-

APPENDIX II

Abbreviations Used

@	: At the rate of
a.i.	: Active ingredient
%	: Per cent
:	: As to
-	: to
$^{-1}$	: Per
/	: Per
=	: Is equal to
^{0}	: Degree
₹	: Rupees
B:C	: Bright Sun Shine
BSS	: Benefit Cost Ratio
^{0}C	: Degree Celsius
C.D. 5%	: Critical difference at 5 % level of significance
cm	: Centimeter (s)
DAS	: Days After Sowing
day^{-1}	: per day
Dist	: District
Dr.	: Doctor
DMA	: Dry Matter Accumulation
Even.	: Evening
et al.	: And others
etc.	: Excettra
fb	: Followed by
Fig.	: Figure
F.Y.M	: Farm yard manure
i.e.	: That is
g	: Gram
g^{-1}	: per gram
ha	: Hectare
ha^{-1}	: per hectare
hill^{-1}	: per hill
hrs.	: hours

HW	: Hand weeding
J	: Journal
K	: Potassium
K_2O	: Potassium oxide
Kg	: Kilogram (s)
Kg^{-1}	: Kilograms per hectare
Lit.	: Liter (s)
M	: Meter
M^2	: Square meter
M.S.	: Maharashtra state
Max.	: Maximum
Min.	: Minimum
Morn.	: Morning
Met.	: Meteorological
MW	: Meteorological week
mm	: millimeter
N	: Nitrogen
No.	: Number (s)
N.S.	: Non significant
P	: Phosphorus
P_2O_5	: Phosphorus pentoxide
PE	: Pre-emergence
PoE	: Post-emergence
q	: Quintal (s)
₹	: Rupees
RD	: Rainy Days
RDF	: Recommended dose of fertilizer
RH	: Relative humidity
S.E.	: Standard Error
Sr. No	: Serial number
Sig.	: Significant
S.Em.	: Standard Error of mean
Sq. m.	: Square meter
T	: Tonnes
TN	: Tamilnadu
viz.	: Namely
W.C.E.	: Weed Control Efficiency
Wt.	: Weight

EFFECT OF INTEGRATED WEED MANAGEMENT IN *KHARIF* GROUNDNUT (*Arachis hypogaea* L.)

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A thesis submitted to the

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in partial fulfillment of the requirements for the degree of

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This is to certify that the thesis entitled **"Effect of integrated weed management in *kharif* groundnut (*Arachis hypogaea* L.)"** submitted to the Faculty of Agriculture, Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli, Dist. Ratnagiri, Maharashtra state in partial fulfilment of the requirements for the degree of **MASTER OF SCIENCE (AGRICULTURE)** in **AGRONOMY**, embodies the results of the piece of *bona-fide* research carried out by **Mr. TORADMAL SUJIT SUKHADEV** under my guidance and supervision. No part of this thesis has been submitted for any other degree or diploma. All the assistance and help received during the course of investigation and the sources of literature have been duly acknowledged by him.

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Date : **/ /2017**

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