WEED MANAGEMENT IN ASH GOURD

[*Benincasa hispida* (Thunb.) Cogn.]

By

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(2012-11-144)

THESIS

submitted in partial fulfilment of the requirement for the degree of

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DECLARATION

I hereby declare that the thesis entitled **"Weed management in ash gourd [*Benincasa hispida* (Thunb.) Cogn.]"** is a bonafide record of research work done by me during the course of research and the thesis has not previously formed the basis for the award of any degree, diploma, associateship, fellowship or other similar title, of any other university or society.

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We, the undersigned members of the advisory committee of **Ms. Sajeera C. Chathoth (2012-11-144)** a candidate for the degree of **Master of Science in Agriculture**, with major field in Agronomy, agree that the thesis entitled **"Weed management in ash gourd [*Benincasa hispida* (Thunb.) Cogn.]"** may be submitted by **Ms. Sajeera C. Chathoth (2012-11-144),** in partial fulfilment of the requirement for the degree.

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INTRODUCTION

1. INTRODUCTION

Weeds pose a serious threat to crop production and in most cases its management accounts for the major share of the total cost of cultivation. Rao (1983) reported 45 per cent loss of agricultural produce by weeds, 30 per cent by insects, 20 per cent by diseases and five per cent by other pests. The damage due to weeds varies with the crop, type of weeds and severity of weed problem.

Vegetables are highly susceptible to weed competition. Singh *et al.* (1993) estimated a yield loss in vegetables ranging from 6 to 82 per cent. Vegetables are slow growing in the initial stages. Heavy use of FYM, ideal soil condition, comparatively high dose of fertilizer application and frequent irrigation favour the growth of a number of weeds in vegetable fields. Timely removal of weeds is very important to ensure a successful crop. Frequent hoeing and weeding is cumbersome and costly, thereby reducing the net returns from farming.

Cucurbits are important group of vegetable crops grown all round the year and consumed throughout India. An area of 8092 ha in Kerala is cultivated under cucurbitaceous vegetables (GOK, 2013). Most of the cucurbitaceous vegetables require early season weed control to ensure a good quality crop. Unchecked weeds can bring about 43 per cent yield loss in cucumber (Zimdahl, 1980). In addition, the vining habit of these crops makes weed control difficult, once the vines begin to run (Kelley and McDonald, 2008). Generally, an aggressive and healthy crop will out-compete and exclude many weeds for which weed control in early phase of crop growth is important.

Ash gourd is cultivated for its immature as well as mature fruits which are used as a cooked vegetable, in confectionary, and ayurvedic medicines. The famous ayurvedic preparation *Kooshmandarasayana* is made of ash gourd fruits.

It keeps well for a long time storage and is thus ideal for exporting. Inexpensive and versatile, ash gourd is a health promoting vegetable that should definitely be a part of any nutritious diet.

Many technological options are available at present for weed control in crops. However, choice of a method depends on many factors like location, crop, cost, season, labour availability etc. Use of herbicides is an important practice for most crops as it is easier, time and labour saving, and economical as compared to other weed control measures (Rekha *et al.*, 2003). Though chemical control of weed is the cheapest, due to environmental constraints, it cannot be adopted in all situations. However, in large scale cultivation, there is scope for using herbicides as a part of integrated weed management.

Mulching with organic or inorganic material creates a physical barrier that limits weed growth. Organic mulching will help in maintaining soil organic matter and provide food and shelter for earthworms and other desirable soil biota, apart from the weed control. The black plastic film mulch does not allow sunlight to pass through onto the soil. In the absence of sunlight, photosynthesis in weeds located below the black film does not take place. Hence weed growth is completely arrested. The prevalence of high-tech agriculture in vegetable farming also warrants more thrust to research on weed management practices like plastic mulching. Instead of depending on single method of control, integration of different methods like sanitation, mechanical methods, biological means and herbicide use keeps the weeds under check at an economic cost.

Though cucurbitaceous vegetables are widely cultivated in the state, research output on weed management on these crops is scanty. Hence the present study is taken up with the following objectives

1. To compare the efficacy of cultural, physical and chemical methods of weed management and their combinations to arrive at an integrated weed management practice in ash gourd
2. To work out the economics of various weed management practices
3. To assess percentage yield reduction due to weed competition
4. To study the removal of nutrients by the weeds

REVIEW OF LITERATURE

2. REVIEW OF LITERATURE

Various options are available for weed control in vegetables. However, choice of a method or combination of different methods depends on many factors. Environment friendly methods are gaining importance recently due to preference of organic farming in vegetables, especially in small scale cultivation.

A review on weeds of vegetable crops, chemical, cultural and biological methods of weed control and crop-weed competition is given in this chapter.

2. 1 Weed flora of vegetable crops

Almost all types of upland weeds can be found in vegetable fields. However, the weed flora varies with location, crop and season. Rattan *et al.* (1981) reported that 75 per cent of weed flora in okra was shared by *Cyperus rotundus* and *Cynodon dactylon*, which are grouped under world's worst weeds because of their fast spreading and competitive nature. Bhalla and Parmar (1982) reported that *Commelina benghalensis, Setaria glauca, Ageratum conyzoides, Physalis minima, Amaranthus viridis* and *Cyperus rotundus* as the major weeds in the okra field in Madhya Pradesh. In a field experiment under All India Co-ordinated Vegetable Improvement Project, conducted in Kerala the major weeds observed in chilli and okra field were *Cyperus rotundus, Eleusine indica, Brachiaria distachya, Ludwigia parviflora, Cleome viscosa and Ageratum conizoides* (KAU, 1992).

Saimbhi *et al.* (1994) observed the dominance of *Cyperus rotundus, Eleusine aegypticum, Chenopodium album, Tribulus terrestris, Trianthema portulacastrum, Celosia argentia and Portulaca spp.* in the vegetable fields at Jalandhar. In Kerala, *Cynodon dactylon* and *Cyperus rotundus* were the predominant perennial weeds whereas *Cyperus iria, Digitaria ciliaris,*

Dactyloctenium aegyptium, Eleucine indica and *Ludwigia parviflora* were the major annual weeds. (Sainudheen, 2000). According to Gopalakrishnan (2007), perennial weeds like *Cynodon dactylon, Cyperus rotundus* and *Panicum repens* were serious problem in many vegetable fields.

According to Syriac and Geetha (2007), the major weed flora in vegetables field in Kerala included *Eleusine indica, Digitaria sanguinalis, Paspalum* sp., *Eragrostis* sp. among grassy weeds; *Ageratum conyzoides, Leucas aspera, Ludwigia perennis, Commelina benghalensis, Cleome viscosa, Phyllanthus niruri and Vernonia cinerea* among broad-leaved weeds and *Cyperus rotundus, C. iria* and *Kyllinga monocephala* among sedges .

Yadav (2001) observed *Amaranthus viridis, Trianthema portulacastrum, Digitaria ciliaris* and *Dactyloctenium aegyptium* as the most problematic weeds in a capsicum field at Jalandhar. Sharma and Patel (2011) reported that *Eleusine indica* was the most dominant weed, while *Digitaria sanguinialis* was second in order followed by *Dactyloctenium aegyptium, Phyllanthus niruri, Boerhaavia repanda, Digera arvensis, Cypreus iria and C. rotundus* in okra field of Gujarat. *Echinochloa colona, Cynodon dactylon and Brachiaria racemosa* were the major grass weeds in capsicum field at Raipur (Choudhary *et al.*, 2012).

2. 2 Methods of weed control

2. 2. 1 Use of pre emergence herbicides

Fabro and Robles (1982) studied the response of mung bean and soyabean to oxyflourfen at different rates and times of application. They found that the herbicide was best applied at four days before or after planting. Shoot growth recovered faster at 0.25 and 0.50 kg a.i./ha at four days after planting. Nandal, (1986) observed that, fluchloralin at 1.25 kg/ha, oxadaizon at 1.25 kg/ha and pendimethalin at 3.00 kg/ha were effective in improving crop yield through

control of weeds in brinjal. Henderson (1996) found that the oxyfluorfen sprayed before transplanting was the best herbicide option in cabbage, due to the least cost, greatest yields, most effective weed control. Singh *et al.* (1992) reported that highest yield was observed that when pendimethalin (1.0 kg/ha) plus oxyfluorfen (0.15 kg/ha) were applied as pre-emergence, it increased 77.6 and 41.4 per cent fruit yield over the weedy check and hand weeding twice, respectively in bell pepper. Kumar and Thakral (1993) observed that pre-emergence application of pendimethalin @ 1.25 kg/ha resulted in minimum weed dry weight which was significantly lower than oxyfluorfen @ 0.25 kg/ha with or without hoeing or hand weeding twice, in chilli. Leela (1993) suggested pendimethalin for short duration crops like bean, peas and amaranthus because she observed good weed control up to 30 days only. She suggested pendimethalin followed by hand weeding for long duration vegetable crops. In field trials conducted in sandy loam soil of Jodhpur during 1991-92, the effects of pre-plant incorporated fluchloralin at 1.0 kg/ha, pendimethalin at 1.0 kg/ha, oxyfluorfen at 0.1- 0.3 kg/ha and metolachlor at 0.5-1.0 kg/ha for weed control in *Capsicum annuum* were evaluated. All weed control treatments decreased weed dry weight and increased fruit yield. Oxyfluorfen at 0.3 kg/ha resulted in the greatest crop yields (Singh *et al.* 1993). Bellinder *et al.* (1993) evaluated oxyfluorfen (0.28, 0.42, 0.56 and 0.84 kg/ha) under clear polythene film for weed control, crop injury, and effects on yield in transplanted musk melon, cucumber and summer squash. Numerous narrow leaved and broad leaved weeds were effectively suppressed by 0.42 kg/ha of oxyfluorfen.

Saimbhi *et al.* (1994) observed that pendimethalin @ 0.5 kg/ha resulted in maximum weed control efficiency in okra in field trials at Jabalpur and Jalandhar. They also reported that pendimethalin 0.75 kg/ha followed by hand weeding at 35 days after sowing was the best method for weed control in okra. Frost and Hingston (2004) opined that most effective herbicides were pendimethalin, clomazone and oxydiargyl, which gave best result when applied pre - crop transplanting. Nandal *et al.* (2007) found out that oxadiazon at 1.0 kg/ha and

oxadiazon at 0.75 + pendimethalin 0.75 kg/ha were the most effective in terms of weed control and yield in cabbage.

According to Gopalakrisnan (2007), pre-emergence application of oxyflourfen @ 0.25 kg/ha or pendimethalin @ 1.0 kg/ha or fluchloralin @ 1.5 kg/ha or alachlor @ 2.0 kg/ha followed by hand weeding at 30 to 45 days after planting was economical in crops like chilli, brinjal, tomato, okra etc. A field experiment was conducted during the summer season at Regional Agricultural Research Station, Kumarakom to evaluate pre-emergence herbicides and soil solarization for weed management in brinjal. The pre-emergence herbicides alachlor (2.0 and 2.5 kg/ha), oxadiazon (0.5 and 0.75 kg/ha) and pendimethalin (2.0 kg/ha) and hand weeding twice treatments recorded fruit yields comparable to that of soil solarization (Syriac and Geetha, 2007).

An experiment was conducted by Nandan *et al.* (2011), during rabi season at Pulses Research Sub-Station Samba, Jammu to study the efficacy of pre and post emergence herbicides in controlling weeds of black gram under rainfed subtropical conditions of Jammu. They observed that the pendimethalin 1.0 kg/ha + hand weeding at 30 days after sowing was superior in controlling the weed flora and increasing the seed yield. Smith *et al.* (2009) observed that pendimethalin-based integrated weed management systems were beneficial in both okra and Indian spinach.

A field experiment was conducted to develop an effective weed management practice of weed management practice in french bean cropping system under subtropical agro-ecosystems of western Uttar Pradesh. Pre-planting and pre-emergence application of fluchloralin and pendimethalin 1.0 kg/ha resulted in significant increase in growth and yield attributes, viz. plant height, no. of branches, dry matter accumulation, no. of pods/plant and seeds/pod as well as seed and straw yield of french bean (Panotra *et al.*, 2012).

Malunjkar *et al.* (2012) observed that among the different herbicides, pre-emergence application of pendimethalin 1.0 kg/ha + post-emergence application of imazethapyr recorded maximum weed control efficiency, minimum weed population and weed dry matter in ground nut at Jalgaon, Maharashtra. The same treatment combination recorded significantly higher dry pod yield. According to Sharma *et al.* (2014) pendimethalin was effective against *Dactyloctenium aegyptium* and *Digitaria sanguinalis.*

2. 2. 2 Use of post emergence herbicides

In USA, sponge wiper application of glyphosate was effective, economical and less time consuming in vegetable fields (Harisson, 1982). Tomatoes sown immediately after glyphosate application suffered no injury but transplanted tomatoes showed various symptoms, even when 15 days have elapsed between the herbicide application and transplanting (Andino *et al.*, 1989).

Sandhu and Bhatia (1992) observed that application of glyphosate twice @ 1 kg/ha of commercial product was effective on nut sedge. Similar result with initial spraying of 2-3.5 kg /ha of glyphosate was documented by Hawton *et al.* (1992). Seventy five per cent control was observed after first spray itself, under non crop situation. Manickam and Gnanamurthy (1994) also observed reduction of nut sedge biomass through spraying 1.0 per cent glyphosate with 0.5 per cent 2, 4-D sodium salt or 1 per cent ammonium sulphate. Satisfactory control of nut sedge and bermuda grass with glyphosate have been reported by Ahuja and Yaduraj (1995) under non cropped situation in India. Kandasamy *et al.* (1998) reported very good control of *Cynodon dactylon* with sequential application of glyphosate at monthly interval.

In a trial conducted at Kerala Agricultural University, Sainudheen (2000) found that the glyphosate 1.2 kg/ha (twice at 45 days interval) during summer season followed by pre emergence application of metolachlor 1.0 kg/ha in okra

gave good control of weeds. In summer season, solarization and glyphosate 1.2 kg/ha were very effective in reducing the weed problems and resulted in reduction of the underground vegetative propagules of perennial weeds. Rajkhowa and Barua (2006) observed that the lowest weed dry matter accumulation and density was recorded in the treatment that received carfentrazone 10 g + glyphosate 600 g/ha at Jorhat, Assam.

According to Gopalakrisnan (2007), spraying of post emergence herbicide glyphosate @ 1.2 kg/ha 45 days before sowing followed by a second application one month later on surviving weeds ensured complete control. Land preparation and sowing of the crop can be done 15 days after second application of herbicide. Upadhyay *et al.* (2012) reported that significantly higher weed control efficiency (81.82%) and seed yield was observed under Odyssey (mixture of imazethapyr + imazamox + adjuvant) in soyabean at Jabalpur. Rana *et al.* (2013) reported that post emergence application of imazethapyr and isoproturon and hand weeding twice resulted in significantly lower dry weight of weeds over pre-emergence application of pendimethalin in garden pea at Himachal Pradesh.

Field experiments were conducted to study the effect of integrated weed management practices on growth, regeneration and tuber viability of purple nut sedge in okra for two years during summer seasons at College of Agriculture, Vellayani, Thiruvananthapuram, Kerala, India. Among the treatments, stale seedbed combined with pre-plant application of glyphosate 1.5 kg/ha followed either by polythene mulching or directed application of glyphosate 1.5 kg/ha between rows of okra was the most effective treatment in controlling nut sedge tuber production (Ameena *et al.*, 2013).

2. 2. 3 Organic mulching

Natural or organic mulches are those derived from animal and plant materials which help in maintaining soil organic matter and provide food and

shelter for earthworms and other desirable soil biota. Organic farmers cite weeds as the most significant production problem they face.

Over dependence and over use of herbicides has created undesirable effects like herbicide residue and environmental pollution, resulting in greater interest from many farmers to concentrate mainly on non-chemical methods of weed management (Hosmani and Meti, 1993).

Experiments were conducted over three years (1992 to 1994) at Beltsville, USA by Abdul-Baki *et al.* (1996) to study production of fresh-market tomato in a low-input alternative system using cover crop. The system uses winter annual cover crops to fix N, recycle leftover nutrients, produce biomass, and prevent soil erosion throughout the winter and spring. Yields of tomato plants grown in hairy vetch, crimson clover, and rye plus hairy vetch mulches were higher than those grown in the conventional black polyethylene mulch system in 2 of 3 years. Fruits were heavier with the plant mulches than with black polythene mulch. Eight weeks after transplanting, N levels in tomato leaves were higher with plant mulch than with black polythene mulch, although the plant mulch plots received only 50 per cent of the N applied to the black polythene mulch plots.

Sherriff *et al.* (1998) reported wheat and oats straw were the most efficacious mulching treatments for controlling weed in cucurbits and have the potential to improve crop quality. Mulching reduced the population and dry weight of broad-leaved weeds significantly as compared to grass weeds (Radwan and Hussain, 2001). Paddy straw is one of the most commonly used organic mulch. Straw mulch decreases weed emergence and growth (Ramakrishna *et al.*, 2006). Gandhi and Bains (2006) observed that mulches modified the microclimate by modifying soil temperature, soil moisture and evaporation and the modified microclimate affected the yield contributing characters of tomato.

Kolosowski and Szafirowska (2008) reported that the row mulching by chopped rye straw prevented the weed spreading in bean plots. Weed population was only less than 50 per cent in mulched plots in comparison to non-mulched control. The data confirm results of Derek *et al.* (2006), who pointed out straw as the best mulching material in bell pepper cultivation. According to Monks and Bass (2000) straw residue of rye can inhibit early season germination of some weeds like *Chenopodium album Portulaca oleracea* and *Amaranthus retroflexus*.

A study was conducted by Shijini (2010) to find the response of papaya to organic and plastic mulching. The results revealed that the effect of biodegradable mulch on yield attributes like days taken for maturity, fruit weight and number of fruits per plant was on par with that of black polyethylene mulch. According to Bhatt *et al.* (2011), compared to unmulched control, organic mulch materials significantly advanced the flowering in summer squash plants under rainfed condition of Uttarakhand. Effectiveness of paper mulching in controlling troublesome weeds like purple nut sedge was reported by Cirujeda *et al.* (2012). Choudhary *et al.* (2012) found that black polythene mulch and paddy straw mulch restrict the weed growth and improve quality of capsicum with higher fruit yield.

Organic mulching using green gram residues recorded higher values of yield attributing characters like number of flowers/plant number of pods/plant, test weight number of seeds/pod and seed yield over the control plot with no mulch in pigeon pea at Madurai, Tamil Nadu. Chinnathurai *et al.* (2012) reported that the improvement in the yield attributes under organic mulching might be due to maintenance of higher soil moisture in root zone which resulted in better nutrient uptake, increased growth, LAI and dry matter accumulation resulting in higher yield attributes. Organic mulching resulted in a substantial increase in red gram pod yield which accounted for 48 per cent increase over no mulching. This was mainly due to optimum soil moisture content maintained in all stages of crop growth, which enabled higher nutrient uptake, greater dry matter accumulation, higher number of pods/ plant, more grains/pod and increased hundred seed

weight. Better control of weeds under mulch could have also favoured increase in yield. Abubakkar *et al.* (2004) also made similar observations in summer green gram.

2. 2. 4 Plastic mulching

Mulching is the practice of covering the soil around a plant or a row of crop plants with a suitable material to modify the soil environment favourably to optimize crop production. Mulching with organic or inorganic material creates a physical barrier that limits soil water evaporation, controls weeds, maintains a good soil structure, and protects the crop from soil contamination. Natural materials are not often available in adequate amounts and their quality is inconsistent. To overcome these problems, plastic mulches were developed for use in agriculture. Gebologlu and Saglam (2002) reported that the use of mulching materials raised the yield of pickling cucumber compared to the control in Turkey. Black plastic mulch blocked the weeds, except a few, which emerged through the planting holes (Schonbeck, 1998). Zhang *et al.* (1992) reported that black plastic film mulch resulted in 100 per cent control of all the weeds in maize that supported the present experimental result.

Plastic mulch films were first used in the late 1950s in research and have been used commercially for vegetable production since the early 1960s. Plastic materials like polyethylene and polyvinyl chloride films are used as mulch materials. Today, the vast majority of plastic mulch is based on LLDPE (Linear Low Density Polyethylene) owing to its economy in use. Plastics can be used as mulches which are available in different colours and thicknesses. Recommended thickness for seasonal crops is 20-25 micron (NCPAH, 2011). Plastic mulching is a very effective method of weed control in pumpkin and gourd (Kelley and McDonald, 2008). Black or non-light transmitting plastic is preferred, eliminating light required for weed germination and growth. Weed growth requires light to drive photosynthesis. Black pigments used in mulch significantly reduce light

transmission to very low levels, restricting photosynthesis under the sheet and hence weed growth. This will eliminate most weeds except nut sedge. The tightly folded and pointed leaves of this species will penetrate the plastic and emerge.

In a comparative study of black, silver white or transparent plastic mulch on Brassica (*Brassica oleracea* var. *gongylodes* L.), Zengerle (1981) observed that, there was increase in earliness, quality and yield due to mulching irrespective of the mulch colour. Silvestri *et al.* (1985) reported that the highest yield of tomato was produced when plastic mulching was adopted in both direct seeding and transplanting and also that coloured plastic was more efficient than transparent plastic.

Black plastic mulching enhanced early yield of grade I fruits by 0.5 lb /plant and total yield was increased by 1.7 lb/plant in bell pepper (Call and Courtar, 1989). Similar results were reported by El-Sayed and El-Fadaly (1991) in tomato, and Birge *et al.* (1996) in pumpkin. Aranjo-De *et al.* (1992) reported that harvesting 'Vista Alerge' cucumbers (*Cucumis sativus* L.) could be brought forward by seven days by mulching either with red or black plastic sheet. Abdul-Baki *et al.* (1992) reported that with black plastic mulching, total yield increased by 95 per cent in tomato in USA.

Gutal *et al.* (1992) observed that mulch with 25μ black LDPE film increased soil temperature by 5-7°C, which facilitated faster germination and better root penetration. They also found that yield could be increased by 55 per cent and weed growth was reduced by 90 per cent and soil moisture conserved was 28 per cent more than that without mulch.

In a trial conducted at Kerala Agricultural University, Sainudheen (2000) studied the integrated weed management in okra for two seasons and reported that black polythene mulching gave complete prevention of many weeds. The yield of

okra was highest in polythene mulched plot. Among the *kharif* season treatments mulching with black polythene was far better than all other treatments in improving the growth and yield. A study by Gebremedhin (2001) in oriental pickling melon revealed that mulching with black polythene gave higher fruit yield as compared to mulching with paddy waste and unmulched condition. Jimenez *et al.* (2006) reported that plastic mulching increased total yield of the water melon.

A field trial was undertaken at Darjeeling by Pramanick *et al.* (2006) to observe the effect of different coloured polythene mulches on weed management in onion. The result depicted significant reduction on weed population and biomass in blue coloured polythene mulch followed by black coloured mulch and increase in yield in mulch as compared to control were 54.21, 34.53, and 29.46 per cent respectively. According to Gopalakrishnan (2007), mulching with black polythene sheet is very effective in suppressing weed growth in cultivation of vegetables. Awodoyin *et al.* (2007) reported that mulches are effective in weed control and weed control efficiency of the mulches ranged between 91 per cent and 100 per cent. Maximum number of harvests were also obtained in plastic mulching.

Black plastic mulch was more effective than the other mulches in suppressing weed growth in chilli field. Different mulches like transparent, blue and black generated higher soil temperature and soil moisture over the control. Transparent and blue plastic mulches encouraged weed population which were suppressed under black plastic. Plant height, number of primary branches, stem base diameter, number of leaves and yield were better for the plants on plastic. Mulching produced plants with the highest chlorophyll content and also increased the number of fruits and yield. However, mulching did not affect the length and diameter of fruits and number of seeds per fruit. Plants on black plastic mulch had the maximum number of fruits and highest yield. (Ashrafuzzaman *et al.* 2011).

Hatami *et al.* (2012) demonstrated that polyethylene mulch had a significant effect on weed density in tomato. Nikolic *et al.* (2012) reported that highest yield was observed in polythene mulching as compared to organic mulching in tomato. Diaz-Perez *et al.* (2012) observed that plastic film mulch both had higher levels of weed control compared to unmulched soil in broccoli at USA. They opined that weed control was probably the main factor that explained the increased yields of plants grown on mulches.

2. 2. 5 Tillage

It is widely recognized that primary tillage influences distribution of weed seed in different soil layers (Fray and Olson, 1978). They also noticed that inversion tillage, such as mould bourd ploughing, caused burial of large portion of weed seeds. Non-inversion tillage, such as chisel ploughing left a greater portion of weed seed near the surface. Tiwari *et al.* (1987) reported that maize grain yield was reduced by 100 per cent due to uncontrolled weed competition under maize-cowpea intercropping system. Ball and Miller (1990) reported that secondary tillage practices such as hand hoeing and harrowing had less influence on weed seed bank. Chauhan and Johnson (2009) observed that the agronomic practices like tillage have implication for weed competition and weed management strategies. The effect of different tillage systems, including conventional tillage, minimum tillage and zero tillage, on the emergence pattern of different weed species was evaluated in a field experiment in the *kharif* seasons of 2007 and 2008. In both years, seedling emergence of *Digitaria ciliaris, Echinochloa colona, Eleusine indica, Ageratum conyzoides, Eclipta prostrata* was greater in zero-tillage compared with either minimum or conventional tillage where the seedling emergence was similar.

In a 20 year tillage experiment Cardina *et al.* (1991) reported that the greatest weed density was in no tillage plots and the lowest in conventional tillage plots. Similarly, Tisdale *et al.* (1995) reported that the greatest weed density was

after one year in no tillage and two year in conventional tillage. Sathyamoorthi *et al.* (2001) found that the primary tillage with country plough resulted in lower densities of grasses, sedges, whereas broad leaved weed population was reduced by tractor drawn disc or mould board plough followed by cultivator tillage in black clay and red sandy loam soils. In a study conducted at Kerala Agricultural University, George (2011) reported that the weed population and weed dry matter production were highest in zero tillage without herbicide application followed by minimum tillage and herbicide based zero tillage and the least was in normal tillage among various tillage practices in cereal fodder production in rice fallows.

2. 2. 6 Integrated Weed Management

Integration of two or more methods of weed control is a viable option in weed management. Experiments conducted for three years at All India Co-ordinated Vegetable Improvement Programme, Vellanikkara indicated superiority of hand weeding over herbicides on the productivity of chilli (KAU, 1992). In a trial conducted at Kerala Agricultural University, Sainudheen (2000) reported that soil solarization during summer season followed by pre emergence application of pendimethalin 1.0 kg/ha also gave good control of weeds in okra. Rapp *et al.* (2004) conducted field experiments to study the effects of various tillage and mulching practices on fruit maturity and weed suppression in pumpkin. They found that regardless of the herbicide, yields of mature fruit were greater in tillage treatments with higher rye residues.

The crop rotation that included one to three year of forage production showed higher densities of annual broad leaf and perennial weeds in the succeeding potato crop (Liebman *et al.*, 1996). Similarly, Stevenson *et al.* (1997) observed that the total weed density in the barley-forage rotation was about three times as that in the barley monoculture.

Pandey *et al.* (2001) reported reduced density of broad leaved and grass weeds with repeated weeding or herbicidal management with atrazine and pendimethalin in maize-wheat rotation. Mishra and Singh (2009) reported that the number of weed seeds decreased considerably in plots receiving herbicide spray + one hand weeding. Chakraborthy (2000) observed that the yield loss of brinjal was minimum under black polythene mulching followed by fluchloralin + one hand weeding. Sharma *et al.* (2005) reported the highest weed control efficiency with either trifluralin or pendimethalin @0.75 kg/ha followed by hand weeding in mustard. Nagar (2005) also reported that pendimethalin followed by hand weeding remained the most effective treatment among herbicides in improving coriander yield and other attributes with the minimum weed competition index (0.62 per cent). Shaikh (2005) opined that more than 80 per cent weed control efficiency was recorded in hand weeding, oxyfluorfen (0.10 kg/ha) and pendimethalin (0.75 kg/ha) supplemented with hand weeding. Mean chilli yield was higher in pendimethalin followed by hand weeding.

Field experiments were carried out in Ghana to assess the effect of integrated weed management on the growth and yield of tomato. Treatments comprised of hand weeding, mulching, different herbicides at two rates of application and a combination of the different herbicides with hand weeding and mulching. The integrated weed management treatments performed much better than the single herbicide application. The most cost effective method of weed control was the use of mulch followed by the post emergence application of glyphosate (2.0 1/ha) combined with mulching (Tetteh *et al.*, 2011).

Nandan *et al.* (2011) reported that the hand weeding twice at 20 and 40 days after sowing produced the highest average seed yield which was on par with metolachlor (0.75 kg/ha) in mung bean of Kandi belt of Jammu. Pre emergence application of pendimethalin 1.0 kg/ha followed by one hand weeding at 15 days after sowing resulted in 10.8 pods/plant as against 4.97 pods/plant in unweeded control in soyabean. Pre-emergence spray of pendimethalin @ 1.0 kg a.i./ha

followed by post emergence imazethapyr @ 75 g a.i./ha at 15 days after sowing increased pod yield of ground nut (1255 kg/ha) as compared to unweeded control (Bhàle *et al.*, 2011).

Madukwe *et al.* (2012) observed that chemical weeding at 2-3 leaf stage of weed followed by hand weeding at 50days after planting was the effective weed control method in cowpea fields at Nigeria. Yadav *et al.* (2011) reported that the highest grain yield was obtained with weed free check (1840 kg/ha) followed by two hand weeding and imazethapyr 100 g/ha + hand weeding in cluster bean at Rajasthan.

Younesabadi *et al.* (2013) reported that tank mix pre-emergence application of pendimethalin 0.5 kg/ha + imazethapyr 0.075 kg/ha was next to weed free check and superior to all other treatments for the reduction of weed density but, with respect to reduction in weed dry weight, it was comparable with pendimethalin 0.5 kg/ha + hand weeding, which resulted in the lowest weed dry weight after weed free check in soyabean. Kalhapure *et al.* (2013) reported that weed management with three hand weedings at 20, 40 and 60 days after transplanting recorded significantly lower weed density, dry weight of weeds and higher weed control efficiency and maximum values for all the growth and yield attributes of onion at Maharashtra. Gupta *et al.* (2013) observed that the highest seed yield was observed with two hand weeding followed by application of imazethapyr 25 g/ha (post-emergence) in urd bean.

2. 3 Nurtient removal under different weed control methods

Weeds accumulate higher concentration of plant nutrients in their tissues than crops (Chungi and Ramteke, 1998). Growth habits and efficient photosynthetic pathway (C_4) resulted in higher nutrient content and high removal of nutrients by most of the weeds than crops (Singh and Sharma, 1984). Weeds

are severe competitors for nutrients than for water and have high nutrient use efficiency than rice (Loomis, 1958).

Setty and Hosmani (1977) found out negative correlation coefficient between weeds and crops regarding the nutrient uptake. Maximum concentration of NPK in straw of okra at harvest was observed with the application fluchloralin @ 0.48 l/ha followed by one hand weeding (Bhalla and Parmar, 1982). Similarly, the nutrient removal by weeds under unweeded check was found to be 5-10 times higher than in weed control treatments (Suresh, 1984).

Vethamani and Balakrishnan (1990) observed that highest uptake of N, P and K occurred in okra treated with fluchloralin at 2 kg/ha and receiving N at 50 kg/ha as well as polythene mulching. Kundra *et al.* (1993) showed that application of pendimethalin resulted in the uptake of 83.6 kg N and 11.8 kg P by *Pisum sativum* while only 8.0 kg N and 0.6 kg P by weeds.

The combination of manual weeding and chemical weeding reduced the nutrient removal by weeds and the maximum N, P and K removal by weeds were recorded in unweeded check (Choubey *et al.*, 1999). Nagar (2005) reported that two hand weeding at 30 and 45 days after sowing brought about the maximum reduction in weed density and dry matter production at 60, 75, 90 days after sowing and at harvest. It also resulted in lowest depletion of nutrients (N, P, K and S) at harvest in coriander.

Yadav *et al.* (2011) reported that the uninterrupted weed growth depleted 108.5 kg N, 15.8 kg P and 151.6 kg K/ha, while such losses were lowest with two hand weeding at Rajasthan. Maximum uptake of N (133.8 kg/ha), P (32.5 kg/ha) and K (135.1 kg/ha) by cluster bean was recorded in two hand weeding (20 and 40 DAS), while in weedy check plots N, P and K uptake by crop was 40.6, 9.8 and 41.1 kg/ha, respectively.

2. 4 Economics of weed control

Reduction in yield of okra due to weed competition has been reported to range from 59 to 90 per cent (Singh *et al.*, 1993). In a trial consisting of physical, cultural and chemical methods of weed control total return was higher in treatments which received glyphosate 1.2 kg/ha in the summer season followed by polythene mulching in okra field (KAU, 1992). A study conducted by Chakraborthy (2000) to assess the technical and economic feasibility of different weed management practices in brinjal and found that the efficiency of the weed control has a direct bearing on the productivity.

The total returns was higher in plots which received polythene mulching in the okra crop, irrespective of main plot treatments given in the summer season. Among them, highest total return was obtained from glyphosate 1.2 kg/ha in the summer season followed by polythene mulching in okra crop, followed by solarization followed by black polythene mulching. However, the highest return per rupee invested on weed control was obtained from combinations of metolachlore 1.0 kg/ha with glyphosate 1.2 kg/ha in summer season, solarization and that of glyphosate 0.8 kg/ha. But, all the combinations of weed control in summer season, except that of polythene mulching resulted in loss as far as the cost of weed control and total cost is concerned (Sainudheen, 2000). The economic analysis of different mulch material including organic one revealed that mulching with black plastic in summer squash is most profitable, giving highest gross return, net return and B: C ratio (Bhatt *et al.*, 2011).

Yadav (2001) opined that higher net returns were obtained in oxyfluorfen at 0.3 kg/ha + two hoeing, closely followed by lower dose of oxyfluorfen (0.2 kg/ha) with two hoeing in transplanted chilli. Patel *et al.* (2004) observed that three hand weeding and hand hoeing gave highest net profit and B: C ratio followed by three hand weedings and pre-plant application of pendimethalin supplemented with hand weeding in transplanted chilli. Shaikh (2005) recorded

higher net monetary returns in pendimethalin followed by hand weeding over weedy check and fluchloralin. Subrao (2010) could get the highest B:C ratio with application of pendimethalin @ 1.0 kg/ha followed by pendimethalin @ 1.0 kg/ha and weed free check as compared to other treatments in brinjal. Pre-emergence application of pendimethalin 1.0 kg/ha + post-emergence application of imazethapyr recorded significantly higher gross returns, net returns and B: C ratio 2.44 (Malunjkar *et al.* 2012). Panotra *et al.* (2012) found that application of pendimethalin 1.0 kg/ha increased the net return of french bean significantly over weedy check, besides at B: C. ratio of 1.12 during two cropping seasons in Uttar Pradesh.

Upadhyay *et al.* (2012) reported that the maximum net profit (Rs.43233/ha) and B: C ratio (3.67) were also recorded under Odyssey (mixture of imazethapyr + imazamox + adjuvant) in soyabean at Jabalpur. Dev *et al.* (2013) reported that in weed management practices of wheat sulfosulfuron gave excellent control of weed population and increased the yield attributes and yield, gross return, net return and B: C ratio.

The review of literature indicated that different methods of weed control can be successfully opted in vegetable cultivation. New herbicides are also being tried and a considerable increase in yield, net return as well as B:C ratio is also reported in all studies. The recent method of plastic mulching is reported to be a promising method of weed control and means to enhance productivity. The review also revealed that the research work on weed control in cucurbits is very scanty.

MATERIALS AND METHODS

3. MATERIALS AND METHODS

A field experiment on "Weed management in ash gourd" [*Benincasa hispida* (Thunb.) Cogn.] was conducted during July to November 2013 at Krishi Vigyan Kendra (KVK) farm at KAU campus, Vellanikkara, Thrissur. The details of materials used and methods adopted are presented in this chapter.

3. 1 General details

Location

The farm is located at latitude of 10° 31' and longitude of 76° 13' in central Kerala at an altitude of 40.3 m above mean sea level.

Climate and weather conditions

The experimental site enjoys typical warm humid climate. The weather parameters during the cropping period are given in Fig. 1&2.

Soil characters

The physico-chemical characteristics of the soil of the experimental field is presented in Table 1.

Fig.1 Relative himidity and atmospheric temperature during crop period

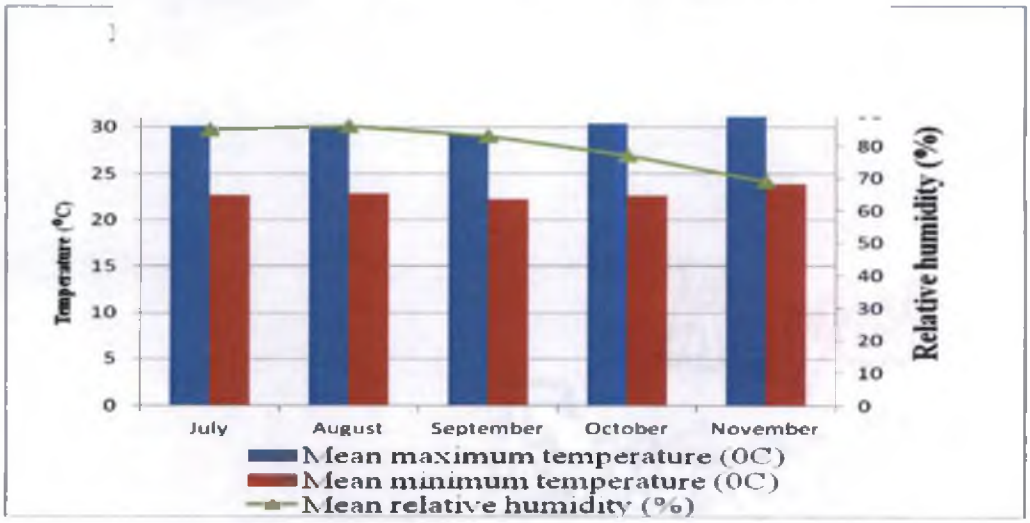


Fig.2 Rainfall and sunshine hours during crop period

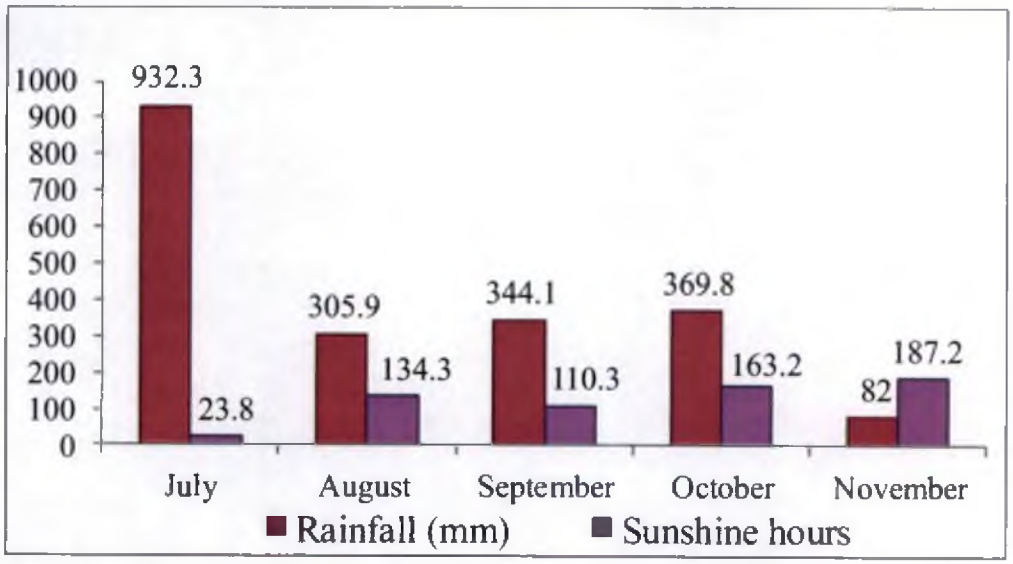


Table 1. Physico-chemical characteristics of the soil

Particular	Value		Method used
A) Particle size analysis			
Sand (%)	16.00	Sandy loam	International Pipette Method (Piper, 1966)
Silt (%)	19.59		
Clay (%)	12.02		
pH	4.75		Soil water suspension of 1:2.5 and read in pH meter (Jackson,1958)
B) Available nutrients			
Organic C (%)	1.01		Walkley and Black method (Walkley and Black, 1934)
Available N (kg/ha)	220.50		Alkaline permanganate method (Subbiah and Asija, 1956)
Available P_2O_5 (kg/ha)	18.00		Ascorbic acid reduced molybdophosphoric blue colour method (Bray and Kurtz, 1945; Watanabe and Olsen, 1965)
Available K_2O (kg/ha)	324.00		Neutral Normal Ammonium Acetate extractant using flame photometry (Jackson, 1958)
Available Calcium (mg/kg)	252.00		Neutral Normal Ammonium Acetate extractant using Atomic Absorption Spectrophotometer (Jackson, 1958)
Available Magnesium (mg/kg)	58.60		Neutral Normal Ammonium Acetate extractant using Atomic Absorption Spectrophotometer (Jackson, 1958)
Available Sulphur (mg/kg)	15.10		$CaCl_2$ extract-turbidimetry method (Chesnin and Yien, 1951)
Available Iron (mg/kg)	34.89		HCl acid extract method using Atomic Absorption Spectrophotometer (Sims

		and Johnson, 1991)
Available Manganese (mg/kg)	5.39	HCl acid extract method using Atomic Absorption Spectrophotometer (Sims and Johnson, 1991)
Available Zinc (mg/kg)	1.54	HCl acid extract method using Atomic Absorption Spectrophotometer (Sims and Johnson, 1991)
Available Copper (mg/kg)	2.28	HCl acid extract method using Atomic Absorption Spectrophotometer (Sims and Johnson, 1991)
Available Boron (mg/kg)	0.65	Hot water extraction and Azomethine-H method using Spectrophotometer (Berger and Truog, 1939; Gupta, 1967)

Season and variety

The crop period was from July-November. The ash gourd variety KAU Local, which is a high yielding variety having medium sized oval to oblong fruits with high flesh thickness was used for the experiment. The average productivity of the variety is 28 t/ha and duration 3.5-4 months.

Cropping history of the experimental site

The experimental site was under various cucurbitaceous vegetables for the past five years.

3. 2 Experimental details

The experiment was laid out in Randomized Block Design (RBD) with nine treatments replicated thrice. The treatments are given below:-

Treatments

T_1: Pre emergence application of oxyfluorfen @ 0.2 kg/ha

T_2: Pre emergence application of pendimethalin @ 1.5 kg/ha

T_3: Pre emergence application of oxyfluorfen @ 0.2kg/ha + post emergence directed application of glyphosate @ 0.8 kg/ha

T_4: Pre emergence application of pendimethalin @1.5 kg/ha + post emergence directed application of glyphosate @ 0.8 kg/ha

T_5: Mulching with coconut fronds

T_6: Mulching with polythene sheet

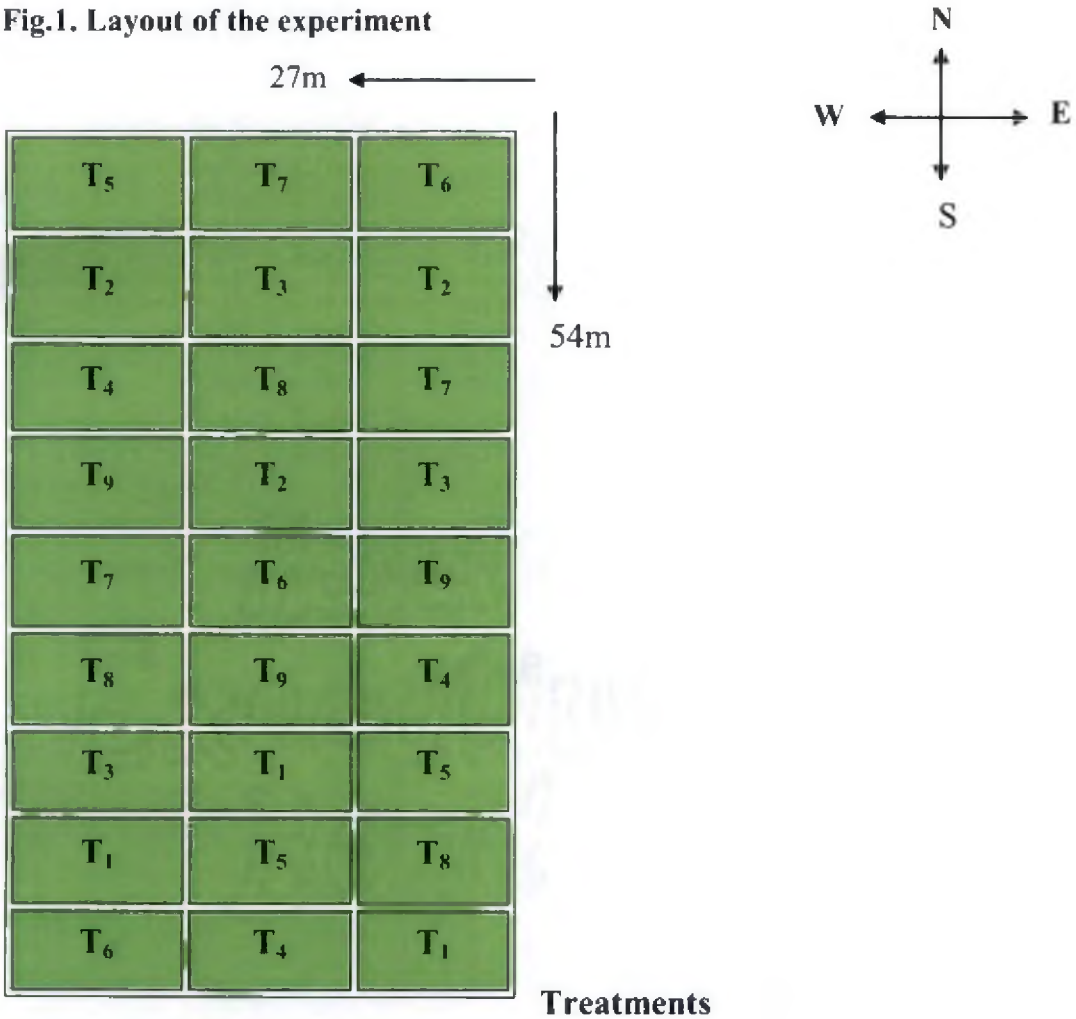
T_7: Weeding using power tiller

T_8: Manual weeding by hoeing

T_9: Unweeded check

Pre emergence herbicides were applied four days before sowing. Post emergence herbicide (glyphosate) was applied as directed spray in treatments T_3 and T_4, 50 days after sowing. Tillage of interspaces (T_7) was done twice at 30 and 60 days after sowing. Manual weeding by hoeing was also done thrice at 15, 30 and 60 days after sowing. Black polythene film was spread over the entire field and a circular portion on the top of mound was removed to facilitate sowing and top dressing of fertilizer. Mulching using coconut fronds was also done, using unplaited coconut fronds which were spread overlapping one another so as to cover the entire interspaces.

Fig.1. Layout of the experiment



Treatments

T_1	Oxyfluorfen (0.2 kg/ha)
T_2	Pendimethalin (1.5 kg/ha)
T_3	Oxyfluorfen (0.2 kg/ha) followed by glyphosate (0.8 kg/ha)
T_4	Pendimethalin (1.5 kg/ha) followed by glyphosate (0.8 kg/ha)
T_5	Mulching with coconut fronds
T_6	Plastic mulching
T_7	Mechanical weeding
T_8	Manual weeding
T_9	Unweeded check

Plate 1. General view of the experimental plot

Plate 2. Pre-emergence herbicide application

Land preparation, sowing and fertilizer application

The area was ploughed twice using rotavator attached to a tractor and levelled. The plot size was $36m^2$ (9 x 4m). Mounds were taken at a spacing of 4.5 x 2.0 m. FYM and fertilizers were mixed with soil on the mound. Five seeds were sown per mound. After two weeks, unhealthy plants were removed and three plants per mound were retained. FYM @ 20 t/ha as basal dose along with half dose of N (35 kg/ha) and full dose of P_2O_5 (25 kg/ha) were applied. The remaining dose of N (35 kg) was applied in two split doses at the time of vining and at full blooming.

Pests like pumpkin beetle and fruit fly and diseases like leaf spot and downy mildew was observed. Timely plant protection measures were taken up as per Package of Practices Recommendations for crops (POPR) of KAU (KAU, 2011).

Harvesting

Harvesting was done after the wines were dried and fruits were fully matured so as to extract seeds. Fruits were cut into two halves. Seeds along with placenta were removed by scraping and kept for fermentation for one day. Seeds were extracted the next day, washed and then dried.

3. 3 Observations

3. 3. 1 Biometric observations on crop

- Length of vine
- Number of branches /vine
- Leaves /vine
- Dry matter production at harvest
- Days to harvest

3. 3. 2 Observations on weeds

Weed count

Species wise weed count was taken using a 50 x 50cm (0.25 m^2) quadrat. The quadrat was placed at random and samples were taken from each plot at 30, 60, 90 days and at harvest and were reported as number/m^2. The weeds which germinated through unmulched top portion of mounds were collected from the entire plot and weed count expressed as number/m^2.

Dry matter production of weeds

The weeds uprooted from the quadrat were cleaned, air dried and then oven dried at 80±5^{0}C and dry weight was recorded in gm^{-2} at 30, 60 days and at harvest.

Weed Control Efficiency (WCE)

WCE was calculated using the formula suggested by Gupta, (2010)

$$WCE = \frac{*\text{WDMP in control plot} - \text{WDMP in treatment plot}}{\text{WDMP in control plot}} \times 100$$

*Weed Dry Matter Production

Weed index (WI)

WI was calculated using the formula proposed by Gill and Kumar (1969).

$$WI = \frac{X - Y}{Y} \times 100$$

X = Yield in treatments with least weeds

Y = Yield from treatment plot

In the trial, least weed incidence was noticed in the plastic mulched plots and so the yield from this treatment was taken as value for X for computing the weed index.

3. 3. 3 Chemical analysis

Soil analysis

Initial status of major nutrients in soil was estimated. Soil samples were collected before land preparation and soil analysis was done for pH, texture, organic carbon, N, available P and K using the standard procedures as shown in Table 1. The status of secondary and micro nutrients were also analysed.

Plant analysis

The N, P and K content of weeds (at 30, 60, 90 DAS and harvest) and ash gourd (at harvest) were analyzed by standard procedures (Jackson, 1958). Total N content of plant samples was determined by Microkjeldal digestion and distillation method. Plant samples were digested in diacid mixture and the P content was determined by Vanabdomolydophosphoric yellow color method. Intensity of color was read using Spectronic 20 spectrophotometer at 420nm. Potassium content in the diacid digest was estimated using flame photometer. The nutrient uptake of weeds (at 30, 60, 90 DAS and harvest) and ash gourd (at harvest) was calculated as the product of nutrient content and the plant dry weight and expressed in kg/ha.

Yield and yield attributes

Number of fruits/plant, weight of fruits/plant and seed yield/plot were recorded and expressed in kg/ha.

Incidence of diseases and pests

Incidence of pests like pumpkin beetle and fruit fly and diseases like downy mildew and leaf spot were observed and timely control measures were adopted.

3. 4 Economics of weed control

Gross return per hectare was computed by counting prevailing labour charge in the locality, cost of inputs and extra treatment costs. The price of ash gourd seed at KAU rate was taken as total receipts for computing gross return. Benefit cost ratio was worked out by dividing the gross return with total expenditure per hectare.

3. 5 Data analysis

The data were subjected to analysis of variance using the statistical package 'MSTAT-C' (Freed, 1986). Data on weed biomass, which showed wide variation, were subjected to square root transformation $\sqrt{(x+0.5)}$ to make the analysis of variance valid (Gomez and Gomez, 1984). Multiple comparisons among treatment means, where the F test was significant (at 5% level) were done with Duncan's Multiple Range Test (DMRT) (Duncan, 1955).

RESULTS

4. RESULTS

The field experiment on "Weed management in ash gourd [*Benincasa hispida* (Thunb.) Cogn.]" was conducted during July to November 2013 at Krishi Vigyan Kendra, Thrissur. The data generated from the experiment were statistically analysed and presented here.

4.1 Studies on weeds

4.1.1 Weed spectrum

Major weeds found in experimental field were broad leaved which comprised of *Celosia argentia*, *Alternanthera bettzikiana*, *Borreria hispida*, etc. among which *Celosia argentia* was the dominent one. *Pennisetum pedicellatum* was the dominant grass species followed by *Brachiaria sp.* *Cyperus iria* was the only sedge observed in the experimental field and its population was very low compared to other groups. By 60 days no sedges could be seen in the experimental field.

4. 1. 2 Weed density

Species wise weed count was taken at 30, 60, 90 DAS and at harvest stage of crop (Table 2, 3, 4 and 5). At 30 DAS, the population of total broad leaved weeds was 150.67/m^2 in unweeded control whereas it was only 0.33/m^2 in plastic mulched plots. The number of broad leaved weeds in pre-emergence herbicide applied plots and hand weeded plots were on par with count ranging from 28-41.3/m^2. Mulching with coconut frond recorded a high weed count, on par with unweeded control and mechanical weeding (Table 2).

Total monocot population was lesser compared to broad leaved. Population of grasses was also higher in unweeded check (74.7/m^2). Count of grass weeds in

Table 2. Species wise weed count at 30 DAS (No./m^2) as influenced by various weed management practices

Treatment	Weed count at 30 DAS (No./m^2)										
	Alternanthera	*Borreria*	*Celosia*	Other dicots	Total dicots	*Pennisetum*	*Brachiaria*	Other monocots	Total monocots	Total sedges	Total weed count
1.Oxyfluorfen	*1.65^{ab} (4.00)	4.86^{ab} (24.00)	1.44^{c} (2.67)	2.92^{bcd} (10.67)	6.39^{c} (41.33)	0.71^{b} (0.00)	1.18^{b} (1.33)	2.30^{b} (6.67)	2.77^{bc} (8.00)	0.71^{c} (0.00)	6.95^{c} (49.33)
2.Pendimethalin	1.65^{ab} (2.67)	2.59^{bc} (8.00)	2.99^{bc} (12.00)	2.18^{cd} (5.33)	5.31^{c} (28.00)	0.71^{b} (0.00)	1.44^{b} (2.67)	2.39^{ab} (6.67)	2.72^{bc} (9.33)	2.18^{bc} (5.33)	6.48^{c} (42.67)
3.Oxyfluorfen fb glyphosate	1.65^{ab} (4.00)	4.12^{ab} (18.67)	1.44^{c} (2.67)	2.86^{bcd} (8.00)	5.67^{c} (33.33)	1.65^{ab} (4.00)	2.56^{ab} (8.00)	1.44^{ab} (2.67)	3.727^{b} (14.67)	1.44^{c} (2.67)	7.10^{c} (50.67)
4.Pendimethalin fb glyphosate	1.18^{ab} (1.33)	3.68^{abc} (13.33)	2.59^{bc} (8.00)	4.34^{bc} (18.67)	6.46^{c} (41.33)	2.12^{ab} (8.00)	1.18^{b} (1.33)	0.71^{b} (0.00)	2.59^{bc} (9.33)	3.24^{bc} (13.33)	7.89^{c} (64.00)
5.Coconut frond mulching	3.36^{ab} (18.67)	4.16^{ab} (24.00)	5.38^{ab} (29.33)	4.99^{b} (28.00)	9.88^{b} (100.00)	2.65^{ab} (6.67)	2.59^{ab} (9.33)	2.59^{ab} (9.33)	4.97^{b} (25.33)	2.84^{bc} (12.00)	11.72^{b} (137.33)
6.Plastic mulching	0.88^{b} (0.33)	0.71^{c} (0.00)	0.71^{c} (0.00)	0.71^{d} (0.00)	0.88^{d} (0.33)	0.88^{b} (0.33)	0.71^{b} (0.00)	0.71^{b} (0.00)	0.88^{c} (0.33)	0.71^{c} (0.00)	1.00^{d} (0.67)
7.Mechanical weeding	2.84^{ab} (12.00)	6.00^{a} (40.00)	6.17^{a} (40.00)	5.42^{ab} (32.00)	10.95^{b} (124.00)	3.88^{a} (14.67)	2.30^{b} (6.67)	1.98^{ab} (6.67)	5.12^{b} (28.00)	5.01^{ab} (26.67)	13.28^{b} (178.66)
8.Manual weeding	2.86^{ab} (10.67)	2.12^{bc} (5.33)	2.77^{bc} (9.33)	3.87^{bc} (16.00)	6.42^{c} (41.33)	2.92^{ab} (10.92)	0.71^{b} (0.00)	2.30^{ab} (6.67)	4.18^{b} (17.33)	3.24^{bc} (13.33)	8.46^{c} (72.00)
9.No weeding	4.88^{a} (32.00)	6.36^{a} (42.67)	3.67^{abc} (17.33)	7.69^{a} (58.67)	12.20^{a} (150.67)	4.25^{a} (25.33)	5.00^{a} (26.67)	4.07^{a} (22.67)	8.63^{a} (74.67)	6.55^{a} (44.00)	16.37^{a} (269.33)

*$\sqrt{x+0.5}$ transformed values, original values in parentheses. In a column, means followed by same letters do not differ significantly at 5% level in DMRT.

Table 3. Species wise weed count at 60 DAS (No./m^2) as influenced by various weed management practices

Treatment	Weed count at 60 DAS (No./m^2)									
	Alternanthera	*Borreria*	*Celosia*	Other dicots	Total dicots	*Pennisetum*	*Brachiaria*	Other monocots	Total monocots	Total weed count
1.Oxyfluorfen	*1.44^{c} (2.67)	4.31^{ab} (18.67)	1.44^{a} (2.67)	3.62^{a} (20.00)	6.42^{bc} (44.00)	1.65^{ab} (2.67)	2.77^{ab} (9.33)	1.65^{a} (2.67)	3.84^{ab} (14.67)	7.47^{bc} (58.67)
2.Pendimethalin	2.18^{bc} (5.33)	1.65^{cd} (4.00)	9.33^{a} (2.77)	3.19^{a} (12.00)	5.46^{bc} (30.67)	1.44^{ab} (2.67)	0.71^{b} (0.00)	0.71^{a} (0.00)	1.44^{bc} (2.67)	5.75^{bc} (33.33)
3.Oxyfluorfen fb glyphosate	1.18^{c} (1.33)	3.33^{bc} (10.67)	2.56^{a} (4.00)	1.92^{a} (4.00)	4.51^{bc} (20.00)	1.65^{ab} (2.67)	1.44^{ab} (2.67)	0.00^{a} (0.71)	2.39^{abc} (5.33)	5.07^{c} (25.33)
4.Pendimethalin fb glyphosate	0.71^{c} (0.00)	2.77^{bcd} (8.00)	1.44^{a} (2.67)	2.39^{a} (6.67)	4.05^{cd} (17.34)	0.71^{b} (0.00)	1.44^{ab} (2.67)	1.83^{a} (5.33)	8.00^{abc} (2.12)	4.98^{c} (25.33)
5.Coconut frond mulching	3.66^{ab} (13.33)	3.84^{ab} (14.67)	1.98^{a} (6.67)	4.77^{a} (24.00)	7.65^{ab} (58.67)	2.39^{ab} (5.33)	2.77^{ab} (9.33)	0.71^{a} (0.00)	3.73^{abc} (14.67)	8.51^{b} (73.33)
6.Plastic mulching	0.88^{c} (0.33)	1.00^{d} (0.67)	0.7^{a} (0.00)	0.88^{a} (0.33)	1.29^{d} (1.33)	0.71^{b} (0.00)	0.71^{b} (0.00)	0.71^{a} (0.00)	0.71^{b} (0.00)	1.29^{d} (1.33)
7.Mechanical weeding	1.44^{c} (2.67)	1.44^{d} (2.67)	2.59^{a} (8.00)	1.92^{a} (4.00)	3.82^{cd} (17.67)	1.92^{ab} (4.00)	2.77^{ab} (9.33)	1.83^{a} (5.33)	2.59^{abc} (9.33)	5.00^{c} (26.67)
8.Manual weeding	0.71^{c} (0.00)	1.65^{cd} (4.00)	2.12^{a} (5.33)	2.99^{a} (12.00)	4.59^{c} (21.33)	1.44^{ab} (2.67)	1.44^{ab} (2.67)	1.65^{a} (4.00)	3.12^{abc} (9.33)	5.51^{bc} (30.67)
9.No weeding	4.47^{a} (22.67)	5.21^{a} (28.00)	4.59^{a} (21.33)	6.17^{a} (45.33)	10.56^{a} (117.33)	1.44^{a} (16.00)	3.03^{ab} (9.33)	0.71^{a} (0.00)	4.66^{a} (25.33)	11.55^{a} (142.67)

*$\sqrt{x}$ +0.5 transformed values, original values in parentheses. In a column, means followed by same letters do not differ significantly at 5% level in DMRT.

pre-emergence herbicide applied plots (T_1, T_2, T_3 and T_4) were statistically comparable. All the treatments except unweeded control recorded comparable values. It was found that sedges constituted only 16 per cent of total weed population (T_9) in the observations taken at 30 DAS. *Cyperus iria* was the only sedge present and its population ranged from zero to 44/m^2, the lowest being in oxyfluorfen sprayed and plastic mulched plots and highest in unweeded check. Mechanical weeding registered a sedge population of 26.67/m^2, statistically on par with unweeded check. The count of sedges present in all other treatments were on par, through the values ranged from 0 to 13.33/m^2.

At 30 DAS, significantly higher total weed count was registered in unweeded control (269.33/m^2) followed by coconut frond mulching and mechanical weeding. In all the four treatments (T_1 to T_4) where pre emergence herbicides were sprayed total weed population was in the range of 42.67 to 64.00/m^2 and were on par with manual weeding.

Statistical analysis of data on count of individual weed species at 30 DAS revealed that treatment effects are not significant (Table 2). However the highest values were observed in unweeded check. For example, though at 30 DAS population of *Celosia argentia* ranged from 0.00 to 21.33/m^2 in different treatments, statistically they were on par due to wide variation in weed count in different replications.

In general, a reduction in weed count was noticed by 60 DAS in all the treatments, and the species wise weed counts between treatments were not significant (Table 3). In the case of total broad leaved weed population, unweeded control recorded statistically higher weed count (142.67/m^2) as at 30 DAS. In the case of all other treatments except plastic mulching, values were comparable and population was in the range of 25.33 to 73.33/m^2.

By 90 DAS, further reduction in weed count could be observed (Table 4). The highest value of 68 m^{-2} registered in unweeded control was comparable with all other treatments. The reduction in weed population compared to that at 30 DAS was 75 per cent. Plastic mulched plot recorded statistically lower value for total weed count as compared to all other treatments. At 90 DAS, differences for species wise weed count and total weed count between treatments were not significant. A high count of *Borreria hispida* as compared to other weeds were observed in oxyfluorfen sprayed and oxyfluorfen followed by glyphosate sprayed treatments.

At harvest stage total weed count was lowest in plastic mulched plot which statistically differed from all other others. All other treatments were on par (Table5).

4. 1. 3 Weed dry weight

Data on weed dry weight recorded at various stages of crop growth shows a progressive increase in dry weight from 30 days after sowing to harvest from 152.29 g/m^2 to 1140.52 g/m^2 in unweeded control (Table 6). The weed dry weight in unweeded control was statistically higher than all other treatments at various stages of observation. The lowest weed dry weight was recorded in plastic mulched plots which was statistically superior to hand weeded control at all stages of observation.

Application of pre-emergence herbicides resulted in comparable values of weed dry weight at 30 days after sowing (11.83 to 16.60 g/m^2). Coconut frond mulching recorded a weed dry matter of 31.88 g/m^2 which was almost double the weed dry matter production recorded in pre-emergence herbicide applied plots. At 30 DAS, weed dry weight in mechanical weeding and no weeding plots were statistically comparable, as the observation was taken just before mechanical weeding.

Table 4. Species wise weed count at 90 DAS (No./m^2) as influenced by various weed management practices

Treatment	Weed count at 90 DAS (No./m^2)									
	Alternanthera	*Borreria*	*Celosia*	Other dicots	Total dicots	*Pennisetum*	*Brachiaria*	Other monocots	Total monocots	Total weed count
1.Oxyfluorfen	*2.12^{abc} (5.33)	2.92^{ab} (9.33)	1.65^{a} (4.00)	2.86^{ab} (10.67)	5.42^{ab} (29.33)	1.65^{ab} (4.00)	1.65^{abc} (2.67)	2.86^{a} (8.00)	3.87^{a} (14.67)	6.62^{ab} (44.00)
2.Pendimethalin	0.71^{c} (0.00)	1.65^{bc} (2.67)	3.96^{a} (17.33)	4.47^{a} (22.67)	6.47^{ab} (42.67)	1.65^{ab} (2.67)	1.65^{abc} (2.67)	1.65^{ab} (2.67)	2.92^{ab} (8.00)	7.07^{ab} (50.66)
3.Oxyfluorfen fb glyphosate	1.44^{abc} (2.67)	3.06^{a} (12.00)	1.65^{a} (4.00)	2.39^{ab} (6.67)	5.04^{b} (25.33)	1.65^{b} (2.67)	0.71^{c} (0.00)	1.83^{ab} (5.33)	2.92^{ab} (8.00))	5.78^{b} (33.33)
4.Pendimethalin fb glyphosate	3.06^{ab} (9.33)	2.39^{abc} (5.33)	3.42^{a} (12.00)	3.87^{ab} (14.67)	6.42^{ab} (41.33)	1.18^{b} (1.33)	0.71^{c} (0.00)	2.18^{ab} (5.33)	2.39^{ab} (6.67)	6.92^{ab} (48.00)
5.Coconut frond mulching	3.45^{a} (12.00)	1.92^{bc} (4.00)	2.39^{a} (9.33)	3.71^{ab} (18.67)	6.59^{ab} (44.00)	1.65^{ab} (2.67	3.03^{a} (9.33)	1.18^{ab} (1.33)	3.66^{a} (13.33)	7.51^{ab} (57.33)
6.Plastic mulching	0.71^{c} (0.00)	0.71^{c} (0.00)	0.71^{a} (0.00)	0.71^{c} (0.00)	0.71^{c} (0.00)	0.88^{b} (0.33)	1.05^{bc} (0.67)	0.71^{b} (0.00)	1.17^{a} (1.00)	1.17^{c} (1.00)
7.Mechanical weeding	3.06^{ab} (9.33)	2.39^{abc} (5.33)	2.86^{a} (10.67)	3.45^{ab} (12.00)	5.93^{ab} (37.33)	1.92^{ab} (4.00)	2.39^{ab} (5.33)	1.92^{ab} (4.00)	3.59^{a} (13.33)	6.91^{ab} (50.67)
8.Manual weeding	0.71^{c} (0.00)	2.39^{abc} (6.67)	0.71^{a} (0.00)	3.96^{ab} (17.33)	4.86^{b} (24.00)	2.86^{a} (8.00)	1.18^{bc} (1.33)	0.00^{b} (0.71)	9.33^{ab} (3.12)	5. 89^{b} (33.33)
9.No weeding	2.92^{ab} (10.67)	2.39^{abc} (5.33)	3.91^{a} (21.33)	3.84^{ab} (16.00)	7.33^{a} (53.33)	2.12^{ab} (4.00)	2.12^{abc} (5.33)	1.83^{abc} (5.33)	3.58^{a} (14.67)	8.24^{a} (68.00)

*$\sqrt{x+0.5}$ transformed values, original values in parentheses. In a column, means followed by same letters do not differ significantly at 5% level in DMRT.

Table 5. Species wise weed count at harvest (No./m^2) as influenced by various weed management practices

Treatment	Weed count at harvest (No./m^2)									
	Alternanthera	*Borreria*	*Celosia*	Other dicots	Total dicots	*Pennisetum*	*Brachiaria*	Other monocots	Total monocots	Total weed count
1.Oxyfluorfen	*3.96[a] (17.33)	3.58[ab] (14.67)	1.44[a] (2.67)	1.92[bcde] (4.00)	6.20[a] (38.67)	1.92[abc] (4.00)	1.65[abc] (2.67)	2.39[ab] (5.33)	3.50[bc] (12.00)	7.08[ab] (50.67)
2.Pendimethalin	0.71[b] (0.00)	2.56[abc] (8.00)	3.45[a] (12.00)	1.18[de] (1.33)	4.61[a] (21.33)	3.30[a] (10.67)	1.18[c] (1.33)	0.000[c] (0.71)	3.50[ab] (12.00)	5.80[b] (33.33)
3.Oxyfluorfen fb glyphosate	0.71[b] (0.00)	4.22[a] (17.33)	3.06[a] (20.00)	2.39[abcde] (6.67)	6.42[a] (44.00)	0.71[c] (0.00)	1.65[abc] (2.67)	1.18[bc] (1.33)	1.92[d] (4.00))	6.74[ab] (48.00)
4.Pendimethalin fb glyphosate	1.65[b] (4.00)	4.06[a] (16.00)	3.25[a] (13.33)	2.92[abc] (8.00)	6.46[a] (41.33)	1.65[bc] (2.67)	0.71[c] (0.00)	2.86[a] (8.00)	3.33[c] (10.67)	7.24[ab] (52.00)
5.Coconut frond mulching	2.39[ab] (5.33)	3.84[a] (16.00)	2.56[a] (8.00)	3.89[a] (14.67)	6.58[a] (44.00)	3.33[a] (10.67)	1.44[bc] (2.67)	2.59[ab] (8.00)	4.65[ab] (21.33)	8.08[a] (65.33)
6.Plastic mulching	0.71[b] (0.00)	0.71[c] (0.00)	0.71[a] (0.00)	0.88[e] (0.33)	0.88[b] (0.33)	0.88[c] (0.33)	0.71[c] (0.00)	0.71[c] (0.00)	0.88[d] (0.33)	1.00[c] (0.67)
7.Mechanical weeding	2.30[ab] (6.67)	2.77[abc] (8.00)	2.18[a] (5.33)	1.65[cde] (2.67)	4.51[a] (22.67)	1.92[abc] (4.00)	3.32[a] (13.33)	1.92[abc] (4.00)	4.45[abc] (21.33)	6.34[ab] (44.00)
8.Manual weeding	2.18[ab] (5.33)	1.44[bc] (2.67)	1.92[a] (4.00)	3.42[ab] (12.00)	4.83[ab] (24.00)	2.12[abc] (5.33)	1.65[abc] (2.67)	1.44[abc] (2.67)	3.33[c] (10.67)	5.85[ab] (34.67)
9.No weeding	3.89[a] (14.67)	3.50[ab] (12.00)	1.83[a] (5.33)	2.56[abcd] (8.00)	6.33[a] (40.00)	3.19[ab] (10.67)	3.12[ab] (9.33)	1.92[abc] (4.00)	4.88[a] (24.00)	8.03[ab] (64.00)

*$\sqrt{x+0.5}$ transformed values, original values in parentheses. In a column, means followed by same letters do not differ significantly at 5% level in DMRT.

Celosia argentia

Alternanthera bettzikiana

Borreria hispida

Cyperus iria

Brachiaria sp

Pennisetum pedicellatum

Plate 3. Major weeds of the experimental field

Table 6. Effect of the treatments on weed dry weight (g/m^2)

Treatment		30DAS	60DAS	90DAS	At harvest
T_1	Oxyfluorfen	*3.81[c] (14.04)	12.42[c] (104.93)	19.30[c] (372.13)	20.34[d] (413.40)
T_2	Pendimethalin	3.58[c] (12.30)	8.99[d] (80.40)	17.25[d] (279.33)	20.37[d] (414.27)
T_3	Oxyfluorfen fb glyphosate	4.13[c] (16.6)	6.66[e] (43.95)	11.60[e] (134.53)	18.45[e] (340.13)
T_4	Pendimethalin fb glyphosate	3.51[c] (11.83)	6.04[e] (36.00)	11.00[e] (120.60)	18.46[e] (340.27)
T_5	Coconut frond mulching	5.67[b] (31.88)	13.78[b] (189.40)	21.82[b] (475.87)	28.37[b] (806.00)
T_6	Plastic mulching	0.71[d] (0.00)	0.71[h] (0.01)	0.72[g] (0.02)	0.06[f] (0.11)
T_7	Mechanical weeding	11.90[a] (149.95)	5.12[f] (25.79)	18.23[cd] (332.80)	22.90[e] (525.80)
T_8	Manual weeding	3.98[c] (15.40)	3.37[g] (11.20)	8.48[f] (71.50)	17.51[e] (306.53)
T_9	Unweeded check	12.34[a] (152.29)	19.06[a] (363.87)	24.56[a] (606.40)	33.73[a] (1140.52)

*$\sqrt{x+0.5}$ transformed values, original values in parentheses. In a column, means followed by same letters do not differ significantly at 5% level in DMRT.

By 60 DAS, the total weed dry weight in treatments receiving spray of glyphosate recorded low weed dry matter production which was statistically on par with mechanical weeding (T_4 and T_7). Weed dry weight in mechanically weeded plots showed a reduction by almost 80 per cent the values at 30 DAS, still the weed dry weight (25.79 g/m^2) was statistically higher than herbicide applied plots.

By 90 DAS, treatments where post-emergence glyphosate was given registered lower values of weed dry weight compared to application of pre emergence herbicide alone. Coconut frond mulching recorded a weed dry weight 475.87 g/m^2 which was statistically higher than all other treatments. At this stage, mechanical weeding resulted in comparable weed dry matter production to that of pre-emergence application.

At harvest stage also, plastic mulching continued to register the lowest weed dry weight, the dry matter production being 0.11 g/m^2. Weed dry weight of 1140.52 g/m^2 was recorded in unweeded control and 806.00 g/m^2 in coconut frond mulching. Application of pre-emergence herbicide followed by post emergence herbicide registered weed dry weight which was statistically lower than the pre-emergence herbicide oxyfluorfen or pendimethalin alone sprayed plots. The weed dry matter in manual weeded plot showed an increase from 71.50 g/m^2 (90 DAS) to 306.53 g/m^2 by harvest stage of crop.

4. 1. 4 Nutrient removal by weeds

N, P and K removal by weeds was higher in unweeded control and lower in plastic mulched plots at all stages observation, and the uptake increased from 30 DAS to harvest stage.

Plate 4. Manual weeding at 15 DAS

Plate 5. Weeds emerging through coconut fronds

Plate 6. Weed growth in unweeded control at harvest

Plate 7. Crop growth in plastic mulched plots

At 30 DAS, N removal ranged from 0.0 (T_6) to 17.68 kg/ha (T_9) (Table 7). N uptake in hand weeded plot was statistically comparable to that in treatments which received a pre-emergence spray of oxyfluofen or pendimethalin (T_1 to T_4). N uptake by weeds in coconut frond mulch field was statistically higher compared to pre-emergence herbicide application, but lower than that in unweeded control.

At 60 and 90 DAS, N removal in the treatments which received follow up spray of glyphosate recorded comparable values which were lower than the values in pre-emergence herbicide sprayed plots. N removal by weeds almost doubled from 90 days to harvest stage. At harvest stage, T_3 to T_4 registered comparable values and were statistically on par with hand weeded control where N removal of 33.17 kg/ha was recorded. Unweeded control registered more than three times the N removed by the hand weeded control.

In the case of P uptake, trend was almost similar to that of N uptake. At 30 DAS, all treatments except coconut frond mulching, hand weeding and unweeded control registered statistically comparable values. P uptake showed a progressive increase from 30 DAS to harvest stage. The removal was 36.84 kg/ha in unweeded control at harvest stage, whereas no removal was registered in plastic mulching. Mulching using coconut frond resulted in P removal of 12.13 kg/ha which was only one third of the P removal in unweeded control (Table 8).

K removal also followed a similar pattern. There is not much nutrient removal in plastic mulched field due to the negligible weed growth whereas in unweeded control K removal was 114 kg/ha at the harvest stage of the crop (Table 9). K removal in mechanically weeded and coconut frond mulched fields were statistically on par (83.2 kg/ha and 92.67 kg/ha). Uptakes in pre-emergence herbicide followed by glyphosate applied plots were lower as compared to application of pre-emergence herbicide alone. The reduction in K removal in pre-

Table 7. Effect of the treatments on N removal by weeds (kg/ha)

Treatment		30DAS	60DAS	90DAS	At harvest
T_1	Oxyfluorfen	*1.39^{c} (1.43)	3.97^{b} (15.28)	6.26^{b} (38.74)	6.56^{d} (42.51)
T_2	Pendimethalin	1.41^{c} (1.49)	2.97^{c} (8.34)	5.23^{c} (30.10)	6.53^{d} (42.07)
T_3	Oxyfluorfen fb glyphosate	1.54^{c} (1.88)	2.33^{e} (4.92)	3.62^{d} (12.65)	6.08^{de} (36.43)
T_4	Pendimethalin fb glyphosate	1.35^{c} (1.33)	2.18^{e} (4.24)	3.26^{de} (10.11)	5.84^{e} (33.64)
T_5	Coconut frond mulching	1.98^{b} (3.42)	4.59^{b} (20.52)	7.06^{a} (49.42)	9.07^{b} (81.93)
T_6	Plastic mulching	0.71^{d} (0.00)	0.71^{h} (0.00)	0.71^{f} (0.00)	0.71^{f} (0.00)
T_7	Mechanical weeding	4.12^{a} (16.53)	1.74^{f} (2.53)	5.94^{bc} (34.87)	7.29^{c} (52.77)
T_8	Manual weeding	1.44^{c} (1.57)	1.28^{g} (1.16)	2.87^{e} (7.74)	5.80^{e} (33.17)
T_9	Unweeded check	4.26^{a} (17.68)	6.50^{a} (41.95)	7.2^{a} (51.81)	10.6^{a} (113.17)

*$\sqrt{x+0.5}$ transformed values, original values in parentheses. In a column, means followed by same letters do not differ significantly at 5% level in DMRT.

Table 8. Effect of the treatments on P removal by weeds (kg/ha)

Treatment		30DAS	60DAS	90DAS	At harvest
T_1	Oxyfluorfen	*0.80^{cd} (0.14)	1.47^{b} (1.67)	2.90^{d} (7.92)	3.13^{bc} (9.30)
T_2	Pendimethalin	0.81^{cd} (0.16)	1.20^{c} (0.96)	2.38^{e} (5.19)	3.40^{bc} (10.68)
T_3	Oxyfluorfen fb glyphosate	0.92^{c} (0.34)	1.10^{cd} (0.72)	1.77^{f} (2.64)	2.95^{cd} (8.21)
T_4	Pendimethalin fb glyphosate	0.84^{c} (0.20)	1.01^{d} (0.52)	1.65^{g} (2.22)	2.99^{c} (8.50)
T_5	Coconut frond mulching	1.13^{b} (0.78)	2.10^{a} (3.92)	3.40^{b} (11.04)	3.53^{b} (12.13)
T_6	Plastic mulching	0.71^{d} (0.00)	0.71^{f} (0.00)	0.71^{h} (0.00)	0.71^{e} (0.00)
T_7	Mechanical weeding	1.48^{a} (1.72)	0.94^{de} (0.39)	3.16^{c} (9.49)	3.51^{b} (11.90)
T_8	Manual weeding	0.92^{d} (0.34)	0.79^{ef} (0.13)	1.45^{g} (1.59)	2.57^{d} (6.08)
T_9	Unweeded check	1.42^{a} (1.54)	2.09^{a} (3.88)	3.98^{a} (15.38)	6.04^{a} (36.84)

*$\sqrt{x+0.5}$ transformed values, original values in parentheses. In a column, means followed by same letters do not differ significantly at 5% level in DMRT.

Table 9. Effect of the treatments on K removal by weeds (kg/ha)

Treatment		30DAS	60DAS	90DAS	At harvest
T_1	Oxyfluorfen	*1.73^{d} (2.50)	5.34^{c} (28.08)	8.19^{b} (66.62)	9.14^{b} (83.20)
T_2	Pendimethalin	1.72^{d} (2.46)	4.34^{d} (18.38)	7.9^{c} (59.42)	7.73^{bc} (63.02)
T_3	Oxyfluorfen fb glyphosate	1.81^{cd} (2.81)	2.90^{e} (7.91)	5.08^{d} (25.39)	5.65^{d} (28.89)
T_4	Pendimethalin fb glyphosate	1.72^{d} (2.47)	3.00^{e} (8.53)	5.16^{d} (26.17)	5.51^{d} (29.91)
T_5	Coconut frond mulching	2.84^{b} (7.50)	6.28^{b} (38.97)	9.65^{b} (92.67)	10.82^{a} (116.64)
T_6	Plastic mulching	0.71^{e} (0.00)	0.71^{h} (0.00)	0.71^{f} (0.00)	0.71^{f} (0.00)
T_7	Mechanical weeding	5.67^{a} (31.77)	2.29^{f} (4.77)	9.14^{b} (83.20)	9.16^{b} (83.64)
T_8	Manual weeding	2.05^{c} (3.71)	1.76^{g} (2.67)	3.90^{e} (14.73)	4.38^{e} (18.73)
T_9	Unweeded check	5.58^{a} (30.71)	8.87^{a} (78.66)	10.70^{a} (114.00)	10.71^{a} (114.32)

*$\sqrt{x+0.5}$ transformed values, original values in parentheses. In a column, means followed by same letters do not differ significantly at 5% level in DMRT.

emergence followed by post emergence herbicide application was conspicuous. The removal was only 28.89 kg/ha in oxyfluorfen followed by glyphosate applied plots compared to 89.20 kg/ha in oxyfluorfen alone plot. This was only 25 per cent compared to K removal in unweeded contro114.32 kg/ha.

4.2 Studies on crop growth and yield parameters

4.2.1 Crop growth parameters

All treatments were statistically comparable with respect to length of vine. However, number of branches/vine and leaves/vine were statistically higher in plastic mulched plots. Plastic mulching resulted in almost double the number of leaves compared to hand weeding or coconut frond mulching or mechanical weeding. Treatments where pre and post emergence herbicides were sprayed registered higher number of leaves (51-52) compared to application of pre-emergence herbicide alone (36-39) (Table 10). The lowest value for all growth parameters were observed in unweeded check. There was no difference among treatments at maturity and harvesting stage, when the fruits were fully mature and vines dried up.

4. 2. 2 Dry matter production of crop at harvest

The highest crop dry matter production was recorded in plastic mulched plots (4607 kg/ha) followed by manual weeding (3568 kg/ha) (Table 10). The lowest dry matter production was recorded in unweeded control with a value 899 kg/ha. In herbicide treatments, pre-emergence herbicide followed by glyphosate applied plots gave higher dry matter production than plots which did not receive follow up spray of glyphosate. But, mechanical weeding recorded dry matter production higher than pre-emergence herbicide treatments, but and lower than glyphosate applied treatments. Both the pre-emergence herbicide resulted in statistically comparable crop dry matter production.

Table 10. Effect of weed control treatments on plant growth parameters of ash gourd

Treatment		Length of vine (m)	No. of branches / vine	No. of leaves/ vine	Dry matter production at harvest (kg/ha)
T_1	Oxyfluorfen	3.27^{b}	4.66^{bc}	39.67^{bcd}	2201^{d}
T_2	Pendimethalin	3.50^{b}	5.00^{b}	36.33^{cd}	2192^{d}
T_3	Oxyfluorfen fb glyphosate	3.51^{a}	5.00^{b}	51.33^{bc}	2913^{c}
T_4	Pendimethalin fb glyphosate	4.13^{ab}	5.00^{b}	52.33^{b}	2910^{c}
T_5	Coconut frond mulching	3.30^{a}	5.33^{b}	40.33^{bcd}	1574^{e}
T_6	Plastic mulching	5.34^{a}	8.33^{a}	84.00^{a}	4607^{a}
T_7	Mechanical weeding	3.56^{ab}	5.67^{b}	48.00^{bc}	2753^{cd}
T_8	Manual weeding	4.08^{ab}	5.33^{b}	44.67^{bc}	3568^{b}
T_9	Unweeded check	2.60^{b}	3.33^{c}	28.33^{d}	899^{f}

In a column, means followed by same letters do not differ significantly at 5% level in DMRT.

4. 2. 2 Yield attributes and yield

Fruit number/plant

The number of fruits per plant did not show much variation with respect to various treatments. The values ranged from 2.47 (T_2) to 3.24 (T_6). However, unweeded check registered lowest value (1.04), which was statistically inferior to all others.

Average fruit weight

The highest (3.6 kg/fruit) and statistically superior value was registered in plastic mulched plot. The fruit weight in hand weeded check was 3.00 kg/fruit which was comparable to mechanical weeding and pre emergence followed by post emergence herbicide application. Coconut frond mulching registered average

fruit weight of 2.81 kg which was statistically on par with pre-emergence herbicide application.

Fruit yield

The highest fruit yield of 22.68 t/ha was recorded in plastic mulched plot which was statistically superior to all other treatments (Table 11). The next best practice was hand weeding where fruit yield of 16.54 t/ha only could be realized. Statistically comparable yield to that of hand weeding was observed in mechanical weeding as well as herbicide applied plots where yield level ranged from 11.16 t/ha to 15.03 t/ha. Organic mulching with coconut frond (T_5) recorded a very low yield of 8.08 t/ha compared to all other treatments except unweeded check (T_9) where fruit yield was 3.80 t/ha, which was statistically inferior to all other treatments.

Seed yield

The seed yield followed almost similar trend as that of fruit yield. Statistically significant and higher seed yield of 212.00 kg/ha was achieved with plastic mulching. Manual weeding was the next best treatment, followed by herbicide and mechanical weeding treatments. Plots which received pre-emergence herbicide together with follow up spray of glyphosate, registered statistically higher seed yield compared to pre-emergence herbicides alone. A low yield of 60.10 kg/ha was registered in coconut frond mulching, although it was statistically superior to unweeded check where seed yield was only 18.03 kg/ha. Here the reduction in seed yield due to weed competition was 91.5 per cent, over complete weed free situation in plastic mulching.

Table 11. Effect of treatments on yield attributes and yield

Treatment		Fruit no./plant	Average fruit weight (kg)	Fruit yield (t/ha)	Seed yield (kg/ha)
T_1	Oxyfluorfen	2.50^{b}	2.30^{d}	11.21^{cd}	89.67^{d}
T_2	Pendimethalin	2.47^{b}	2.34^{cd}	11.16^{cd}	88.57^{d}
T_3	Oxyfluorfen fb glyphosate	2.84^{ab}	2.90^{b}	15.03^{bc}	120.20^{c}
T_4	Pendimethalin fb glyphosate	2.67^{ab}	2.80^{bc}	14.90^{bc}	118.70^{c}
T_5	Coconut frond mulching	2.73^{ab}	2.00^{d}	8.09^{d}	60.10^{e}
T_6	Plastic mulching	3.24^{a}	3.60^{a}	22.68^{a}	212.00^{a}
T_7	Mechanical weeding	2.49^{b}	2.81^{bc}	13.75^{bc}	124.01^{c}
T_8	Manual weeding	2.91^{ab}	3.00^{b}	16.54^{b}	144.12^{b}
T_9	Unweeded check	1.04^{c}	1.07^{e}	3.90^{e}	18.03^{f}

In a column, means followed by same letters do not differ significantly at 5% level in DMRT.

4. 2. 3 Nutrient uptake by crop

The data on nutrient uptake by ash gourd at harvest revealed that, maximum N, P and K uptake was in plastic mulch treatment with 59.92 kg/ha, 11.10 kg/ha and 74.08 kg/ha respectively (Table 12). N, P and K uptake in plastic mulching was significantly higher than that in manual weeding where NPK uptake were 39.77, 4.51 and 42.36 kg/ha respectively. The nutrient uptake was statistically comparable in treatments where the pre-emergence and post emergence herbicide were sprayed and mechanical weeding. The least N, P and K uptake was in unweeded control with 8.99 kg/ha, 0.96 kg/ha and 10.60 kg/ha respectively. The trends were almost similar for N, P as well as for K uptake. The variation in NPK uptake between the plastic mulched treatment and hand weeded and unweeded check were very conspicuous. It was found that P uptake in plastic mulched field was two and half times higher than that in hand weeded check. The N and K uptake were one and half times higher in plastic mulching compared to hand

weeding. Nutrient uptake in plastic mulched field was almost seven times higher compared to unweeded control.

Table 12. Effect of treatments on uptake of nutrients by ash gourd at harvest

Treatment		N (kg/ha)	P (kg/ha)	K (kg/ha)
T_1	Oxyfluorfen	30.09^{de}	2.29^{d}	27.19^{d}
T_2	Pendimethalin	29.33^{e}	2.50^{d}	31.55^{cd}
T_3	Oxyfluorfen fb glyphosate	37.88^{bc}	3.64^{bc}	37.94^{bc}
T_4	Pendimethalin fb glyphosate	35.51^{bcd}	3.77^{bc}	37.93^{bc}
T_5	Coconut frond mulching	16.27^{f}	3.07^{d}	24.25^{d}
T_6	Plastic mulching	59.92^{a}	11.10^{a}	74.08^{a}
T_7	Mechanical weeding	33.57^{cde}	4.13^{bc}	40.30^{bc}
T_8	Manual weeding	39.77^{b}	4.51^{b}	42.36^{b}
T_9	Unweeded check	8.99^{g}	0.96^{e}	10.60^{e}

In a column, means followed by common letters do not differ significantly at 5% level in DMRT.

4. 2. 4 Incidence of pest and diseases

Incidence of pests like pumpkin beetle and fruit fly and diseases like downy mildew and leaf spot were observed and timely control measures were adopted. No variation between treatments could be observed.

4. 2. 4 Weed control efficiency and weed index

For calculating weed index, plastic mulching was taken as the treatment where no weed competition occurred. Almost cent percent weed control efficiency could be achieved by plastic mulching throughout the crop period. This was followed by manual weeding where weed control efficiency ranged from 72.75 to 96.76 per cent at different stages of crop growth and was statistically inferior to plastic mulching (Table 13). The treatments which received pre-

emergence application recorded statistically comparable values of weed control efficiency (88.89 to 92.10 per cent) at 30 DAS. Lower weed control efficiency of 79.17 per cent was recorded in coconut frond mulching. Mechanical weeding was carried out after 30 days and hence very low weed control efficiency of 6.87 per cent was recorded at this stage.

At 60 DAS, the weed control efficiency in mechanical weeding was 92.90 per cent which was superior to pre-emergence herbicide applied treatments where weed control efficiency was in the range of 57.46 to 77.74 per cent. Coconut frond mulching recorded a lower weed control efficiency of 47.43 per cent and was statistically inferior to all treatments except unweeded control.

By 90 DAS, weed control efficiency in treatments where directed application of glyphosate was done, was statistically superior to pre-emergence herbicide alone. In mechanical weeding, weed control efficiency of 44.37 per cent was recorded and was statistically on par with pre-emergence herbicide alone treatments, with values ranging from 38.22 to 50.35 per cent.

At harvest stage, glyphosate applied treatments were on par and superior to pre-emergence alone applied treatments. The herbicide applied treatments were superior to mechanical weeding with values ranging from 63.28 to 69.93 per cent.

Compared to plastic mulching, hand weeding resulted in weed index of 25.55 per cent. Higher values of weed index were observed in pre-emergence alone applied treatments as compared to treatments where follow up spray of glyphosate was given. High weed index of 83.12 per cent was recorded in unweeded control which was statistically comparable that of pre-emergence application of oxyflourfen or pendimethalin and coconut frond mulching.

Table 13. Effect of treatments on weed control efficiency and weed index

Treatment		Weed control efficiency (%)				Weed index (%)
		30DAS	60DAS	90DAS	At harvest	
T_1	Oxyfluorfen	*9.55^{ab} (90.68)	7.61^{e} (57.46)	6.22^{d} (38.22)	7.89^{c} (63.28)	7.11^{abc} (50.15)
T_2	Pendimethalin	9.61^{ab} (91.85)	8.85^{d} (77.74)	7.12^{c} (50.35)	7.98^{c} (63.30)	7.13^{abc} (50.45)
T_3	Oxyfluorfen fb glyphosate	9.45^{b} (88.89)	9.40^{c} (87.81)	8.23^{b} (77.48)	8.40^{b} (69.93)	5.61^{cd} (32.63)
T_4	Pendimethalin fb glyphosate	9.62^{ab} (92.10)	9.51^{c} (89.97)^{c}	8.97^{b} (79.95)	8.37^{b} (69.69)	5.82^{cd} (34.08)
T_5	Coconut frond mulching	8.93^{c} (79.17)	6.91^{f} (47.43)	4.52^{e} (20.71)	5.44^{e} (29.11)	8.04^{ab} (64.16)
T_6	Plastic mulching	10.03^{a} (100.0)	10.03^{a} (100.0)	10.03^{a} (100.0)	10.03^{a} (100.00)	0.71^{e} (0.00)
T_7	Mechanical weeding	2.63^{d} (6.87)	9.66^{bc} (92.90)	6.67^{cd} (44.37)	7.37^{d} (53.86)	6.25^{bcd} (39.30)
T_8	Manual weeding	9.51^{b} (89.91)	9.86^{ab} (96.76)	9.41^{ab} (88.02)	8.56^{b} (72.75)	4.38^{d} (25.55)
T_9	Unweeded check	0.71^{e} (0.00)	0.71^{g} (0.00)	0.71^{f} (0.00)	0.71^{f} (0.00)	9.14^{a} (83.12)

*$\sqrt{x+0.5}$ transformed values, original values in parentheses. In a column, means followed by same letters do not differ significantly at 5% level in DMRT.

4.3 Economics of cultivation

Among different treatments, plastic mulching recorded highest B: C ratio of 2.90 (Table 14). Although hand weeded treatment produced net profit of Rs.146,950/ha, due to high cost of cultivation (Rs.101,150/ha) the B: C ratio was reduced to 2.45 and the least B: C ratio of 0.82 was noted in unweeded check where the crop production was at a loss. Treatments where pre-emergence herbicides were followed by directed application of glyphosate, recorded slightly higher ratio (2.87 and 2.84) than manual weeding. Total cost, total return and net return were also highest in plastic mulching and lowest in unweeded check. B: C

ratio of mechanical weeded treatment was lower (2.07) as compared to treatments where herbicide application was done. Mulching using coconut frond resulted in a lower B: C ratio of 1.41. It was found that a single spray of pre-emergence herbicide resulted in higher returns than coconut frond mulching and a higher B: C ratio of 2.24 and 2.22, for oxyfluorfen and pendimethalin respectively.

Table 14. Economics of cultivation under various treatments (Rs./ha)

Treatment		Total cost (Rs./ha)	Total income (Rs./ha)	Net profit (Rs./ha)	B:C ratio
T_1	Oxyfluorfen	75,025	1,68,150	93,125	2.24
T_2	Pendimethalin	75,375	1,67,400	92,025	2.22
T_3	Oxyfluorfen fb glyphosate	78,438	2,25,450	1,47,012	2.87
T_4	Pendimethalin fb glyphosate	78,638	2,23,500	1,44,862	2.84
T_5	Coconut frond mulching	86,150	1,21,350	35,200	1.41
T_6	Plastic mulching	1,17,400	3,40,200	2,22,800	2.90
T_7	Mechanical weeding	99,525	2,06,250	1,06,725	2.07
T_8	Manual weeding	1,01,150	2,48,100	1,46,950	2.45
T_9	Unweeded check	71,150	58,500	-12,650	0.82

DISCUSSION

5. DISCUSSION

The results of the experiment on "Weed management in ash gourd [*Benincasa hispida* (Thunb.) Cogn.]" are discussed below.

5.1 Studies on weeds

5.1.1 Weed spectrum, density and dry weight

The study aimed at comparing the effect of different methods of weed control in ash gourd and to arrive at the best weed management practice.

One of the major observations recorded was pertaining to weed spectrum and density at various stages of crop growth. It was found that broad leaved weeds accounted for the major portion of the weed flora of the field. Of the total weed flora present, 56 per cent were broad leaved during initial phase of crop growth, which increased to 82 per cent by 60 DAS and then declined to 63 per cent at harvest stage (Fig. 4). Grasses were also present which constituted 28 per cent of total weed population at 30 DAS and 37 per cent at harvest stage. The decrease in population of broad leaved weeds was probably due to increase in population of grassy weeds which were perennial in nature whereas some broad leaved weeds completed their life span by this time. In the initial stages of observation some sedges could be observed which was 16 per cent of total weed count (Fig. 4). However by 60 days there was no sedges in the field, probably due to the luxurious growth of broad leaved weeds and grasses like *Pennisetum pedicellatum*, which suppressed the growth of sedges.

The weed spectrum in different treatments varied. In the treatments where the pre-emergence herbicides were sprayed (T_1 to T_4) the population of weeds at 30 DAS ranged between 28 to 41.33 /m^2 for broad leaved where as it was 8-14.67 /m^2 for grasses. Kumar *et al.* (2013) also observed that efficacy of oxyfluorfen and pendimethalin was more on grasses than broad leaved weeds. This may be

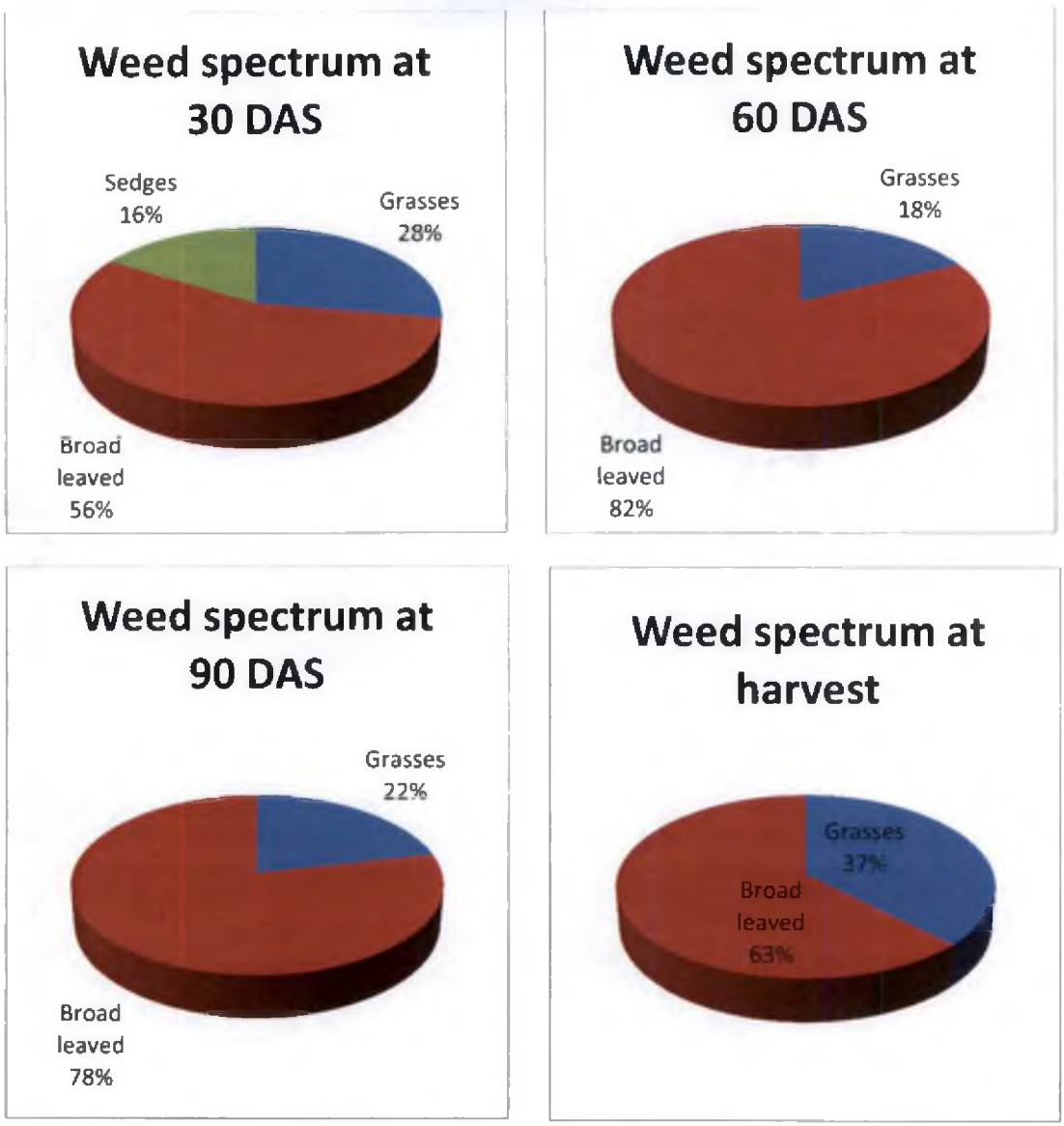


Fig. 4. Weed spectrum in experimental area at various stages of the crop growth in unweeded control

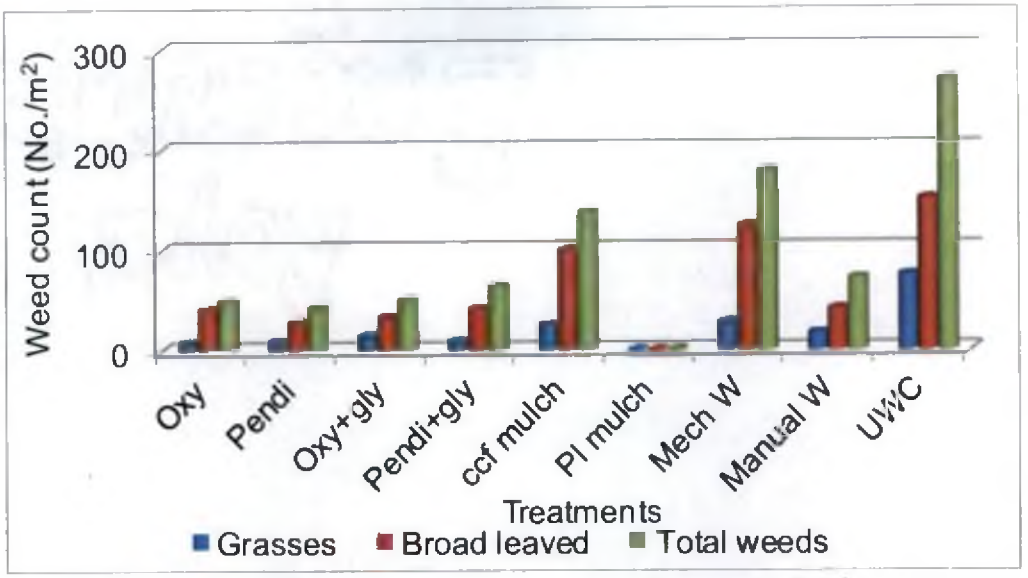


Fig. 5. Effect of weed control treatments on weed count (No./m^2) at 30 DAS

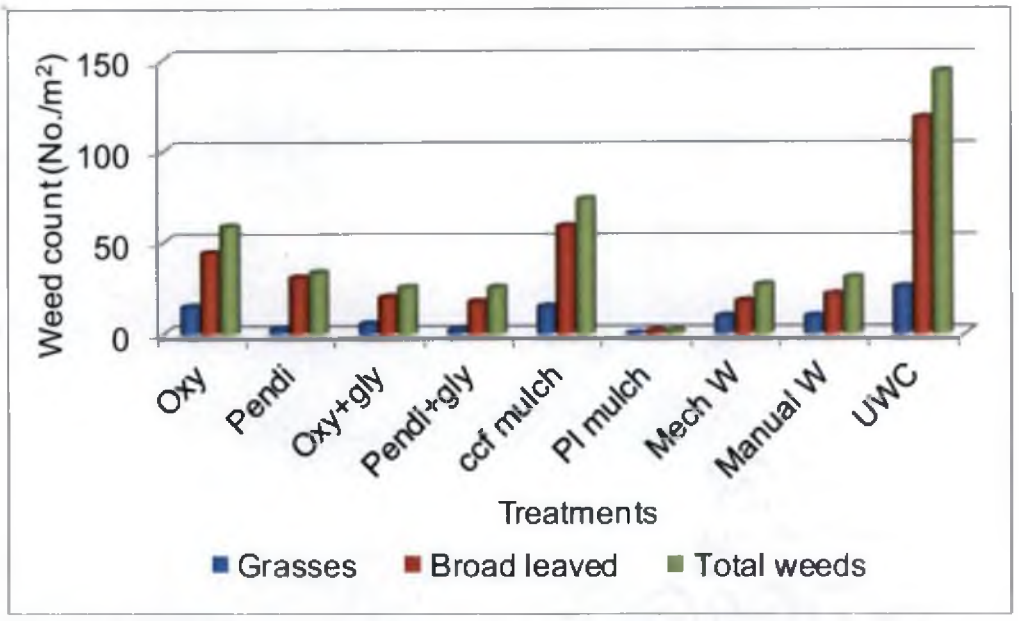


Fig. 6. Effect of weed control treatments on weed count (No./m^2) at 60 DAS

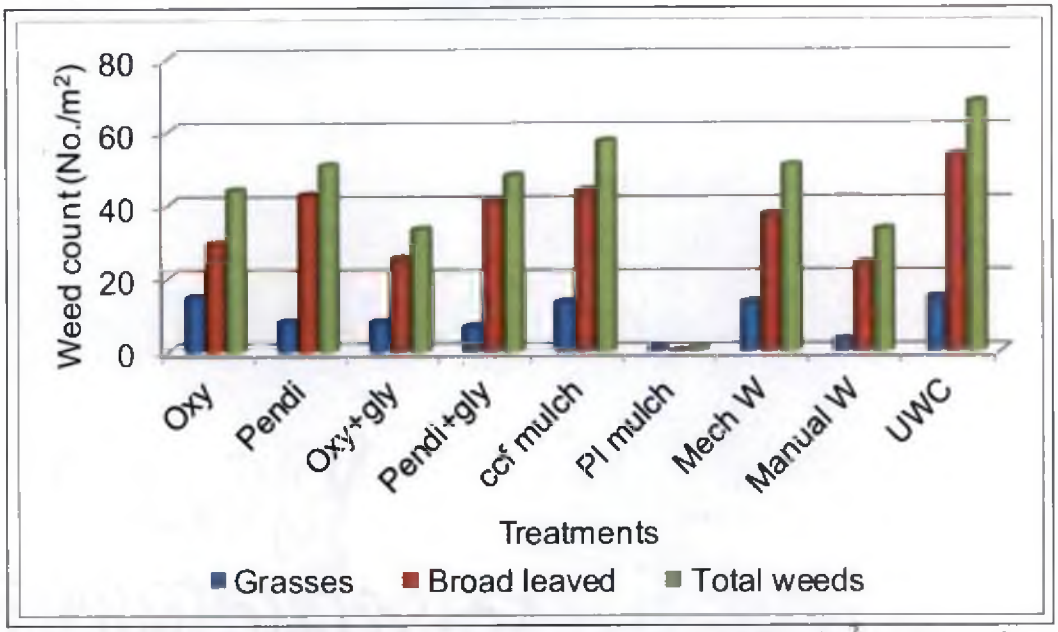


Fig.7 Effect of weed control treatments on weed count (No./m^2) at 90 DAS

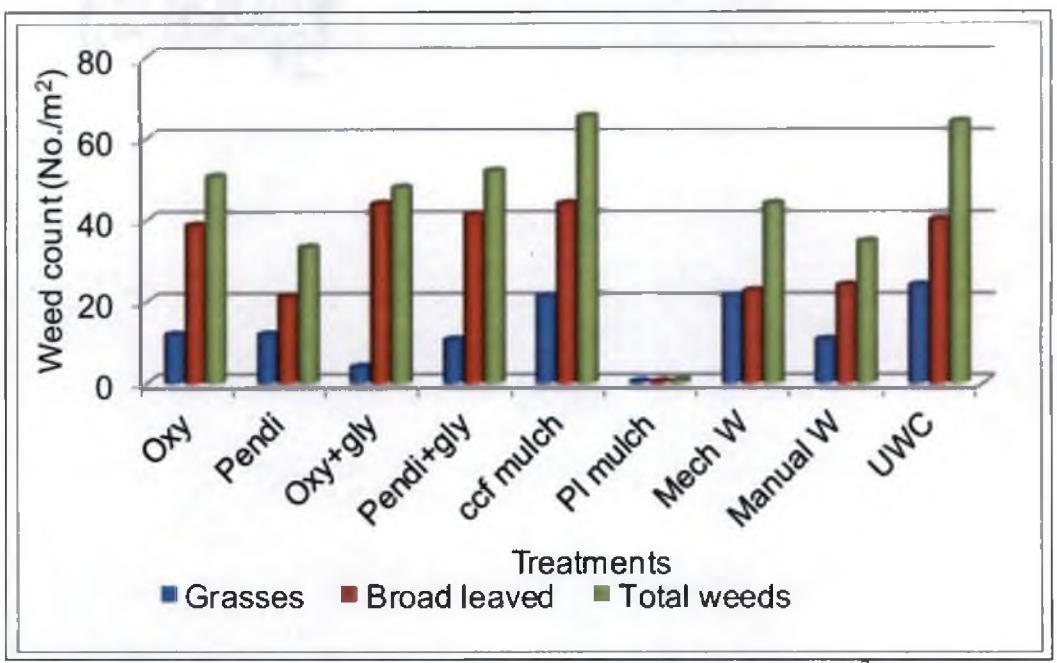


Fig. 8. Effect of weed control treatments on weed count (No./m^2) at harvest (110 DAS)

due to the fact that broad leaved constituted dominant weed flora of the area due to which there is a good seed bank of broad leaved weed seeds in the soil. It could be seen that compared to unweeded control, there was conspicuous reduction in population of both grasses and dicots in these treatments due to herbicidal activity on germinating seeds. It was found that both oxyfluorfen and pendimethalin were effective in reducing the population of major monocot weeds of the experimental area ie; *Pennisetum* and *Brachiaria* at 30 DAS. On an average the population of *Pennisetum* was reduced by about 90 per cent and of *Brachiaria* by 87.5 per cent in pre-emergence herbicide applied plots over unweeded control.

It could be observed that by the time of harvest, the treatment differences were not very conspicuous in the case of total weed count, with exception of plastic mulching where no weed growth was practically possible. The weed population in unweeded plot was statistically on par with all treatments. This is because no weed control operation was carried out after 60 DAS and a gap of almost two months was available for free growth of weeds in the interspaces.

At 30 DAS, the weed density was low in pre-emergence herbicide applied plots (42.67-64/m^2) which was comparable to hand weeding (172/m^2) (Fig.5). In unweeded control the population was as high as 269.33 weeds /m^2. The decrease in population in pre-emergence herbicide applied plots compared to unweeded control was about 80 per cent. The decrease was due to the action of herbicides which inhibited the germination of weeds from soil seed bank. There was no significant difference between the weed population in oxyfluorfen applied plots and pendimethalin applied plots. It can be inferred that, these two herbicides were equally effective in inhibiting the weed germination and establishment.

At 30 DAS, the weed density in coconut frond mulched field was very high (137.33/m^2) which was comparable to unweeded control (269.33/$m^{2)}$ and mechanical weeding (178.66/m^2). This was due to the emergence of weeds

through the coconut fronds indicating its ineffectiveness in suppressing weed growth. However, the plastic mulching was found effective in suppressing weed growth, as total ground area except planting holes were covered. Due to this, almost 100 per cent efficiency in weed control could be achieved throughout the crop growth. Only a few weeds that emerged through the planting holes were present which were removed at the time of taking observation. In mechanical weeding, high weed population observed at 30 DAS was due to the fact that weeding was carried out at 30 DAS, after taking observation on weed count.

A reduction in weed count was observed from 30 DAS to 60 DAS and 90 DAS, probably due to the fact that only a few weed seedlings survived, and continued growth and suppressed others. Similar reduction in weed count with increasing crop growth has been reported by Sainudheen (2000) also in bhindi.

It was found that the weed count in different treatments except the unweeded control and plastic mulching were on par due to the fact that in these treatments weed population was reduced due to treatment effects. For example, in T_4 and T_5 glyphosate application resulted in decrease in population from 50.67 to 25.33/m^2 (T_3) and 64 to 24.33/m^2 (T_4) during 30 to 60 DAS (Fig. 6). In mechanical weeding the population reduced from 178.66 to 26.67/m^2. Mechanical weeding was carried out immediately after recording weed count at 30 DAS and hence comparable values to that of no weeding was observed as up to 30 DAS no weed control measures were taken up. In glyphosate applied plots, the initial population was low due to the pre-emergence herbicide application at the beginning.

At 30 DAS, weed dry weight in pre-emergence herbicide applied plots were (T_1 to T_4) were an average of 13.69 g/m^2 which was significantly low compared to unweeded check (Fig. 9). The reduction was to the tune of 90 per cent compared to no weeding. This was due to the reduction in weed population as indicated by the reduced weed count. The effectiveness of pre-emergence

herbicides in weed control up to 30 DAS has been reported by Leela (1993), where pendimethalin was found good for early weed control. Decrease in weed dry weight by pre-emergence application of oxyfluorfen and pendimethalin was also reported by Singh *et al.* (1993) in capsicum.

Mechanical weeding was carried out immediately after recording weed count at 30 DAS and hence comparable values to that of no weeding could be observed. It was found that weed dry matter production in coconut frond mulching was almost double that of pre-emergence herbicide application as many weed seedlings could emerge through the mulch. However considerable reduction in weed dry matter production resulted compared to unweeded check as the weed dry matter production was only 20 per cent of unweeded check, at 30 DAS.

Weed dry weight doubled by 60 DAS in unweeded check with a value of 363.87 gm^{-2}. The weed dry weight was lower in glyphosate applied treatments as compared to plots with a spray of pre-emergence herbicide alone. This decrease was due to the herbicidal action of glyphosate. Sainudheen (2000) and Ameena *et al.* (2013) also reported advantage of directed application of glyphosate for weed control for vegetables. Mechanical weeding and manual weeding also showed decrease in weed dry weight from 30 DAS to 60 DAS as weed control operation was done twice.

In all the treatments except plastic mulching, weed dry weight increased from 60 DAS to 90 DAS and till harvest stage of the crop, due to progressive increase in weed growth. It was found that weed dry matter production to the tune of 11.41 t/ha was produced if weeds are allowed to grow freely. Mulching using coconut fronds was not effective in suppressing weeds due to emergence and growth of weeds through the interspaces and only partial control of weeds could be achieved as evidenced by reduction of only 30 per cent in weed dry matter production compared to unweeded control. It was found that even a single spray

of pre-emergence herbicide is more effective than mulching with coconut fronds in suppressing weeds. Further reduction in weed growth on par with manual weeding could be achieved by follow up spray of glyphosate. However, there was practical difficulty in directed application as the crop was in the active trailing phase.

5.1.2 Nutrient uptake by weeds

Nutrient uptake by the weeds followed a trend similar to dry matter production. Negligible removal of nutrients in plastic mulched field was due to very low weed growth. The uptake of nutrients increased with progressive increase in crop growth, as the weed dry matter production increased with time. The reduction in nutrient uptake registered at 60 DAS in mechanical weeded and hand weeded plot was due to weed removal and resultant lower weed dry matter production recorded at this stage (Fig.10,11and 12). Nagar (2005) also reported the lowest depletion of nutrients by two hand weedings.

The directed application of glyphosate resulted in lesser weed dry weight at 90 DAS, and hence lower values in nutrient uptake. Choubey *et al.* (1999) reported reduced nutrient removal by weeds in the combination of manual weeding and chemical weeding.

5.2 Studies on crop

5.2.1 Plant growth parameters

The plant growth parameters like length of vine, number of branches/vine and leaves/vine were higher in plastic mulched plot. This may be due to weed free condition which favoured better plant nutrition and growth. The weed dry matter recorded at various stages of crop growth showed that the field was practically devoid of weeds. Ashrafuzzaman *et al.* (2011) also reported higher

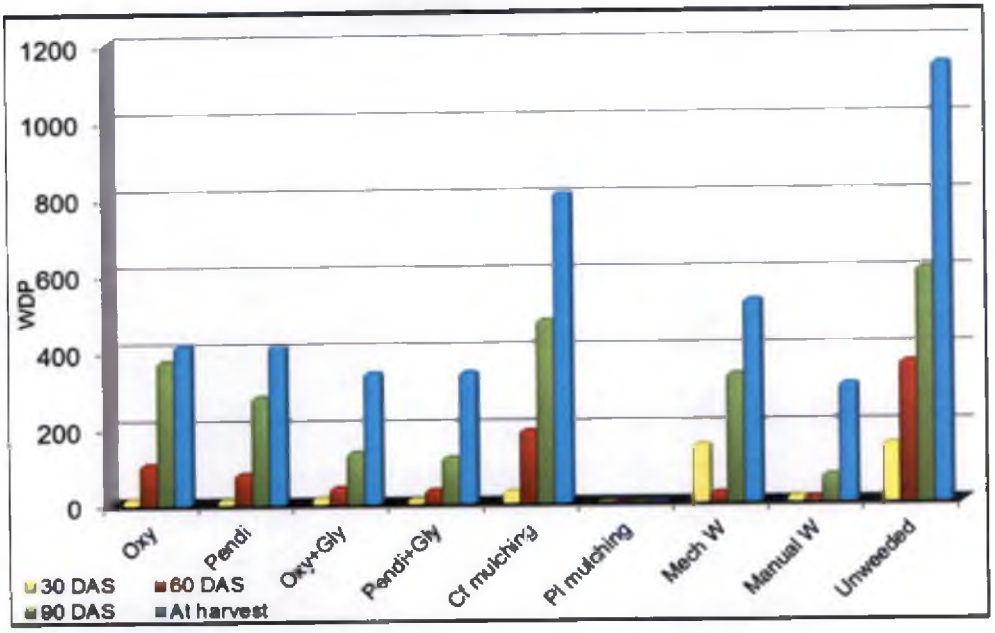


Fig. 9. Effect of weed control treatments on weed dry matter production at various stages of crop

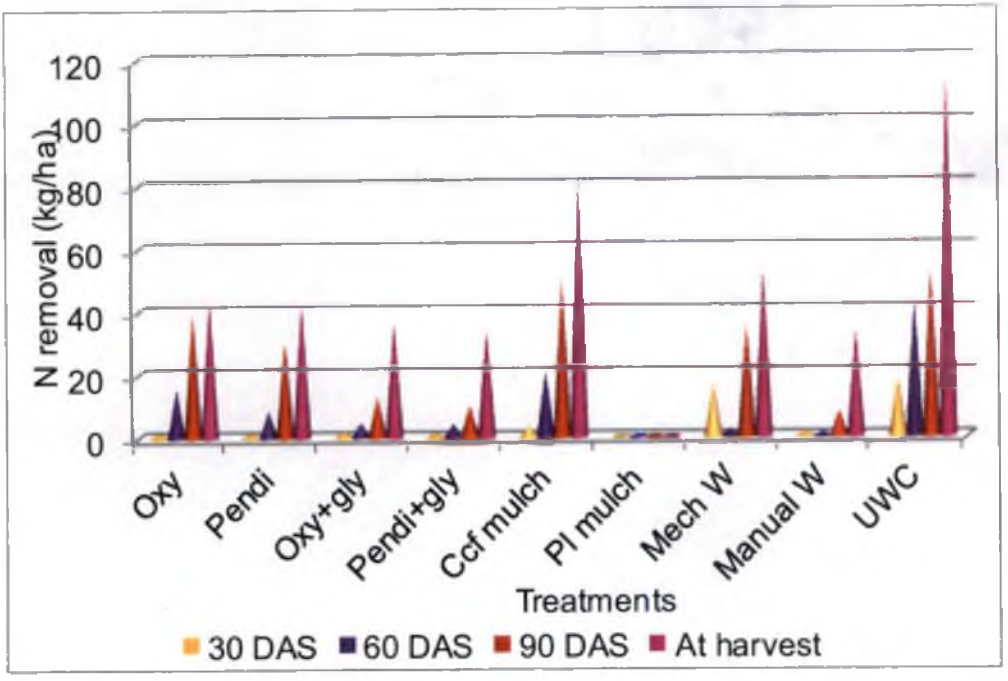


Fig. 10. Effect of weed control treatments on N removal by weeds at various stages of crop

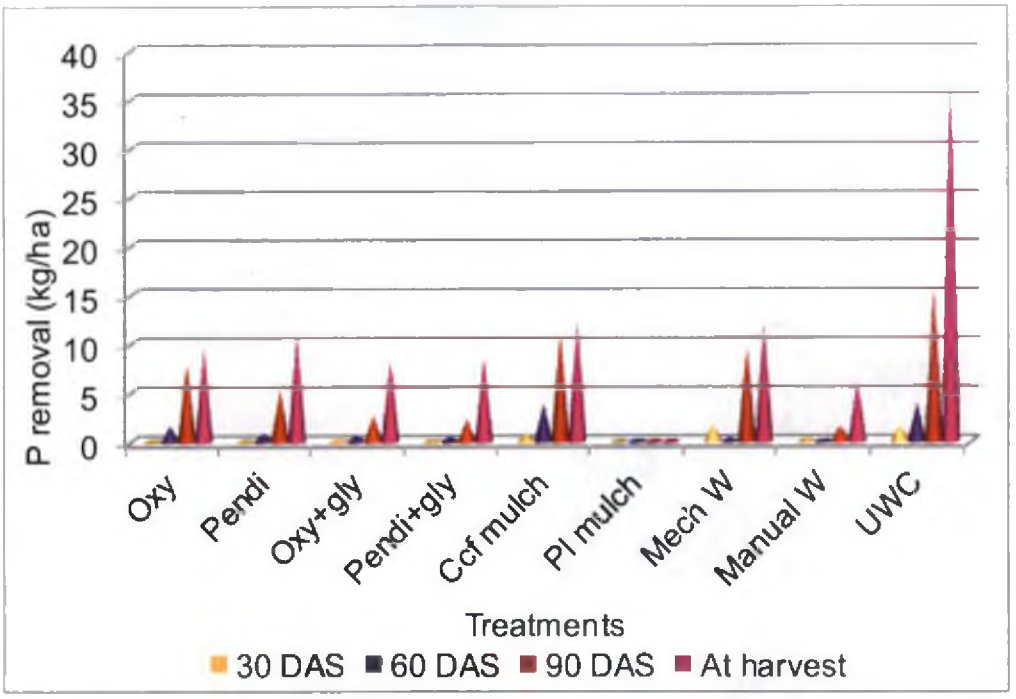


Fig. 11. Effect of weed control treatments on P removal by weeds at various stages of crop

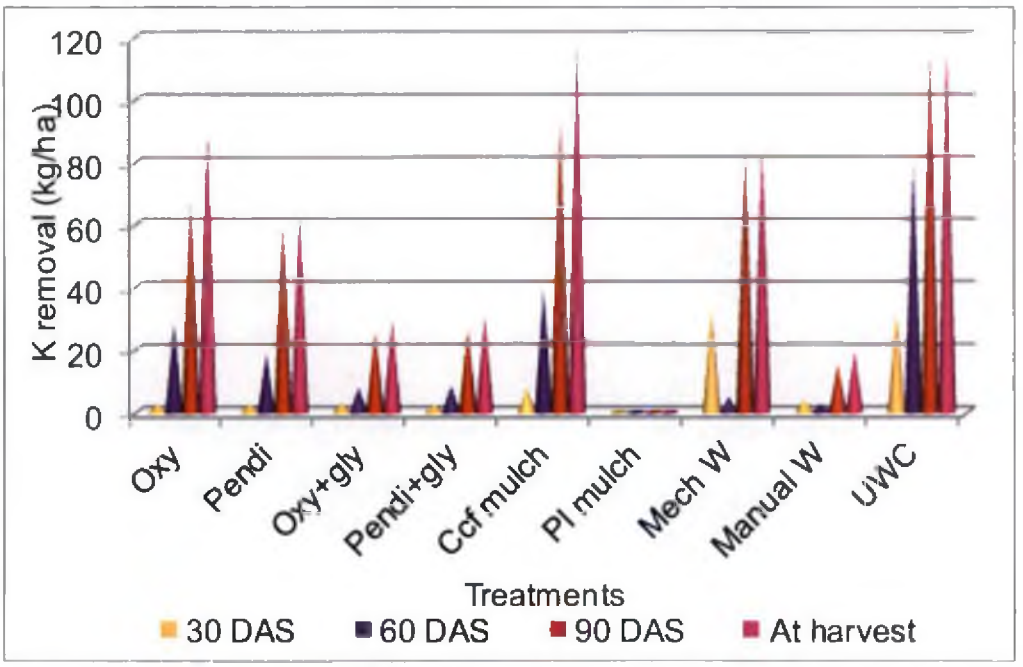


Fig.12. Effect of weed control treatments on K removal by weeds at various stages of crop

plant growth parameters in chilli crop under plastic mulching. Apart from weed competition, other favourable effects like good soil moisture regime, soil temperature etc. were found to promote the plant growth in plastic mulched fields (Gutal *et al.*, 1992; Chinnathurai *et al.*, 2012). The better nutrient uptake and higher crop dry matter production in this treatment indicates favourable effect of mulching on crop growth. Similar result was also reported by Sainudheen (2000) in bhindi.

As the vine growth was more, more number of branches were formed which in turn resulted in more number of leaves. The leaf number in this treatment was 84/vine compared to 28.33/vine in unweeded check, where the crop suffered severe weed competition.

The negative effect of weed competition in various plant growth parameters are evident from the low values observed in unweeded check. Similar results were also noticed by Manjunath *et al.* (1989) and Singh and Singh (1994) in onion. The variations in number of branches/vine between treatments were not very wide, probably because crop experienced weed competition in almost all treatments except plastic mulching. The competition was very severe in unweeded check, which resulted in a low value of 3.33. The number of leaves and length of vine are related and hence treatment with higher length of vine resulted in more number of leaves. It was found that the treatments T_3 and T_4, where a follow up spray of glyphosate was done, resulted in higher values of growth parameters compared to application of pre-emergence herbicide alone because of the reduced weed competition due to the post emergence herbicide application.

Though manual weeding was done thrice, complete weed control was not achieved and hence crop growth and yield were lesser in this treatment compared to weed free situation as in plastic mulching. However the reduction was to the tune of 25.55 per cent only. As in the case of manual weeding, mechanical

weeding also could not ensure a weed free situation as it was done only twice, before the crop started to trail. Here also a reduction in dry matter accumulation up to 40 per cent could be observed. However, a reduction up to 66 per cent in dry matter accumulation was seen in coconut frond mulching as the crop suffered from severe weed competition.

The low values of crop growth parameters together with low yield resulted in lower dry matter accumulation in treatments where weed competition was severe. Similar results were also reported by Subrao (2010) in brinjal.

5.2.2 Yield and yield attributes

Highest fruit yield, seed yield and yield attributes were recorded in plastic mulching. The increase in fruit yield was 83.12 per cent in plastic mulching as compared to unweeded check (Fig. 13). Abdul-Baki *et al.* (1992) also reported 95 per cent increase in yield of tomato by plastic mulching. In this treatment, there was no weed competition at all and this helped the crop to make use of the nutrients applied which favourably influenced yield attributes and ultimately yield. Apart from this, the applied nutrients were not lost by run off, erosion or leaching which might have also helped the crop in better growth which is evident from higher dry matter accumulation. Gutal *et al.* (1992) observed that polythene mulching increased soil temperature by 5-7^{0}C, and soil moisture conservation which facilitated better root penetration in tomato by which yield could be increased by 55 per cent. The crop was raised in rainy season and the frequent and intensive rain might have also resulted in poor nutrient use efficiency in treatments where soil was not covered. The plastic mulching resulted in higher nutrient removal by the crop, which was 33 per cent higher than the hand weeding. Sainudheen (2000) also reported that number of leaves, plant height, crop dry matter production, number of fruit per plant and total yield of okra were higher in plastic mulching.

It was found that all the yield attributes as well as fruit and seed yield were low in mulching using coconut fronds. The reduction in fruit yield was 64.16 per cent over plastic mulching. This was due to high weed competition, as indicated by high weed dry matter production at all stages of crop growth. Due to this, nutrient removal by weeds was also high. Nikolic *et al.* (2012) also reported the higher yield of tomato with plastic mulching compared to organic mulching.

Fruit number/plant, average fruit weight as well as fruit yield were found to be influenced by weed competition and the treatments where weed competition was very high, yield and yield parameters were negatively affected. Even in hand weeding yield was 25.55 per cent less than plastic mulching. About 39.30 per cent yield reduction was observed in mechanical weeding as the plants suffered from weed competition as indicated by high values of weed dry matter production. A single spray of pre-emergence herbicide was not effective in controlling weed growth effectively and resulted in 50 per cent reduction in fruit yield and 58 per cent reduction in seed yield. This may be due to the fact that effectiveness of pre-emergence herbicides last only for a short span of about 30 days and after that uncontrolled weed growth was occurred and adversely affected crop performance. It can be inferred that early season weed control alone is not enough for ash gourd. The two pre-emergence herbicides oxyfluorfen and pendimethalin, had similar performance. Even a follow up spray of post emergence herbicide was found not sufficient to enhance the yield equivalent to plastic mulched plots, reduction in fruit and seed yield were 34 per cent and 43 per cent respectively, in these treatments. This is because once the crop started to trail, complete spray of interspaces was not possible. Same is the case with mechanical weeding where complete and efficient weed control could not be achieved. Here also about 40 per cent reduction in fruit and seed yield resulted.

5.2.3 Nutrient uptake by crop

The crop uptake of nutrients crop was found to be influenced by weed competition. The treatments where the removal of nutrients by weeds were high, crop uptake was low. In the plastic mulched field, there was no nutrient removal by weeds or nutrient loss from soil due to soil loss and leaching, there was high crop dry matter production and ultimately high nutrient uptake. High nutrient uptake by crop by plastic mulching has been reported by Vethamani and Balakrishnan (1990), Sainudheen (2000) and many other workers. Black and Greb (1962) presented evidence in support of an increased efficiency of water and fertilizer use by tomato plants under black polythene mulching.

Hand weeding thrice during the crop season could not completely control weed growth and hence crop dry matter production and nutrient uptakes was lower than that in plastic mulching. Sainudheen (2000) also found higher nutrient uptake by crop by plastic mulching over hand weeding. The crop performance was poor in coconut frond mulched treatments due to severe weed competition as evidenced by higher values of weed dry matter accumulation. Hence crop nutrient uptake was very low compared to the herbicide treatments. However, Chinnathurai *et al.* (2012) have reported that organic mulches like legume residues are very effective in controlling weed growth and enhancing crop nutrient uptake. Abdul-Baki *et al.* (1992) opined that the N dose can be reduced under organic mulching in tomato as the leaf N content was found to be higher in organic mulched crop as compared to plastic mulch at eight weeks after transplanting.

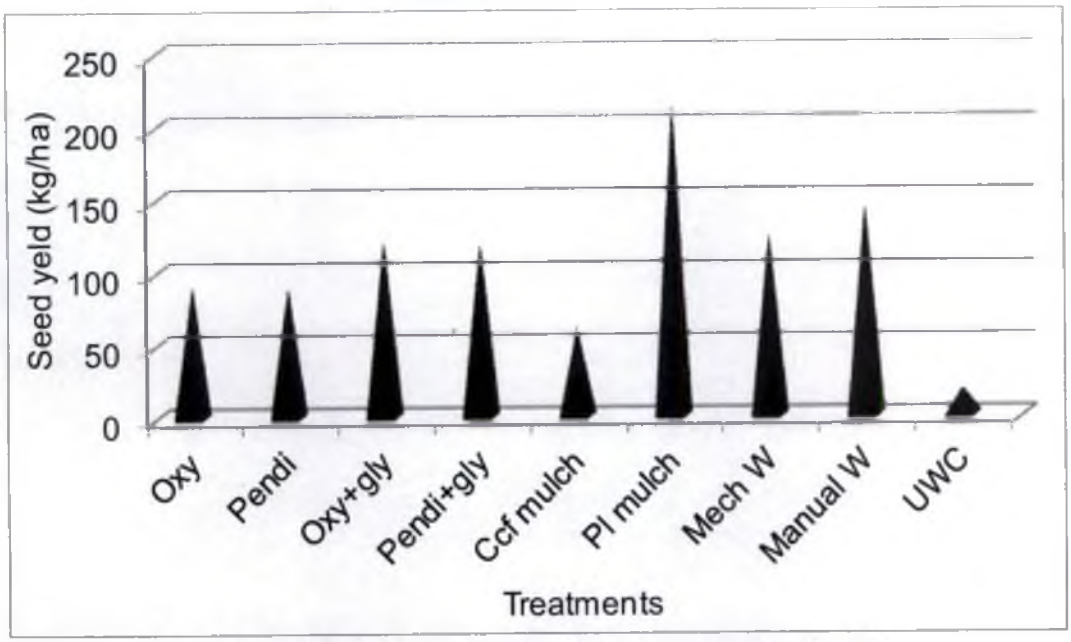


Fig. 13. Effect of weed control treatments on seed yield

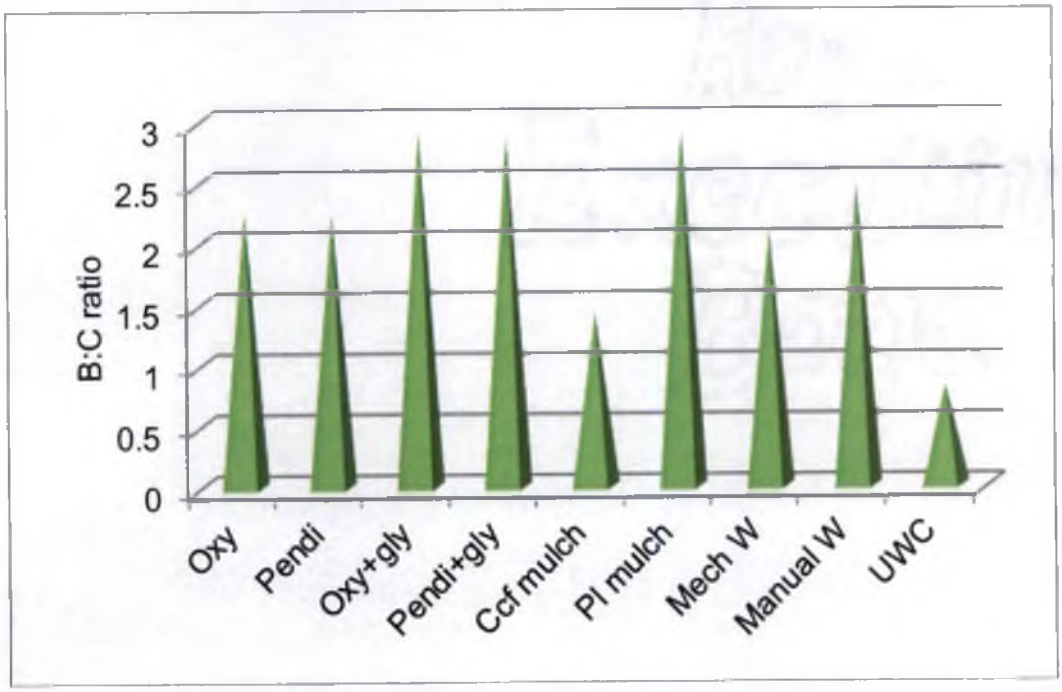


Fig. 14. Effect of weed control treatments on B:C ratio

5.3 Weed control efficiency and weed index

Analysis of weed control efficiency (WCE) of different treatments at various stages of crop growth showed variation in (WCE), due to changes in treatment effects with time. The application of pre-emergence herbicides resulted in high weed control efficiency of up to 92 per cent at 30 DAS which was reduced to 38.22 per cent and 50.35 per cent by 90 DAS, in oxyfluorfen and pendimethalin sprayed fields. This is due to the fact that the weed control effect of these herbicides could last only for a few days. Leela (1993) and many other workers also reported similar findings. It can be seen that a follow up spray of glyphosate could enhance the weed control efficiency to 87.81 (T_3) and 89.97 (T_4) per cent compared to 57.46 per cent (T_1) and 77.74 per cent (T_2) in pre-emergence herbicide applied plots. Sainudheen (2000) and Ameena *et al.* (2013) also reported good weed control efficiency with follow up spray of glyphosate in bhindi crop. However in the present trial even with follow up glyphosate spray, the weed control efficiency at 90 DAS was nearly 70 per cent due to population of weeds which escaped glyphosate application.

It was found that coconut frond mulching could not control weeds effectively and weed control efficiency reduced from 79.17 per cent at 30 DAS to 29.11 per cent by harvest stage of crop. This was due to emergence of weeds through the coconut leaflets and their further vigorous growth, probably due to better soil moisture condition and organic matter addition through mulching. In the case of mechanical weeding, the effect could last for only a few days. Mechanical weeding was done at 30 and 60 DAS by which weed control efficiency of 92.9 per cent could be achieved up to 60 DAS. But the crop suffered from weed competition till 30 DAS and weed control efficiency decreased to 44.37 per cent by 90 DAS due to further weed growth. Manual weeding could ensure weed control efficiency of 89.91 per cent at 30 DAS and 72.75 per cent by harvest stage.

In the case of weed index, it was found that even manual weeding resulted in 25.55 per cent reduction in yield as complete weed control was not possible. Same is in the case of mechanical weeding where weed index was 39.30 per cent.

The highest weed index of 83.12 per cent was recorded in unweeded check, which was followed by coconut frond mulching where weed index was 64.16 per cent. A single spray of pre-emergence herbicide resulted in yield loss up to 50.45 per cent whereas a follow up spray of glyphosate could enhance the crop yield by a narrow margin of 16 per cent over these treatments (weed index 34.08 per cent). Kalhapure *et al.* (2013) also reported weed index of 41.97 per cent by pendimethalin followed by post emergence herbicide spray.

5.4 Economics of weed control

A final recommendation on weed management method can be arrived at only by cost benefit analysis.

Analysis of the returns from the production of ash gourd under various weed control methods indicated that net return of Rs.2,22,800/ha could be achieved through plastic mulching, which was found to maximize the productivity of the crop also. Here B:C ratio was 2.90 (Fig. 14) (The black polythene mulch can be used for two successive crops and hence only half the price was included in the total cost of cultivation. The cost of cultivation also was the highest for this treatment; however, increased yield resulted in high returns and B:C ratio. This corroborates with the findings of Bhatt *et al.* (2011) who reported that mulching with black polythene in summer squash was the most profitable treatment giving highest gross return, net return and B:C ratio. In the present study fruit yield of 22.68 t/ha could be realized by plastic mulching and it resulted in a total return of Rs. 3,40,200/ha and hence higher B:C ratio. The next best practice in terms of total return was hand weeding. Here the B:C ratio was slightly lower than

treatments where pre-emergence herbicide followed by post emergence herbicide was applied (B:C ratio 2.87 and 2.84). This is due to additional cost of about Rs.30,000/ha for manual weeding. Hence it can be inferred that in ash gourd production, the next best and ecofriendly practice is manual weeding. Pre-emergence herbicide application alone is not feasible as it resulted in lower yields due to severe competition and B:C ratio of only 2.24 and 2.22 could be realized. Subrao (2010) could get the highest B:C ratio of 5.06 with application of pendimethalin @ 1.5 kg ai/ha followed by pendimethalin @1.5 kg ai/ha and weed free check as compared to other treatments in brinjal. Panotra *et al.* (2012) found out that application of pendimethalin 1.0 kg/ha increased the net return of french bean significantly over weedy check, besides B:C. ratio of 1.12 during two cropping seasons in Uttar Pradesh. A better option is mechanical control of weeds twice, as a net return of Rs.1,06,725/ha and B:C ratio of 2.07 was registered. The directed application of glyphosate as an operation for weed control can be recommended wherever possible in integrated weed management programmes. It can be combined with manual, mechanical and organic mulching methods so as to increase net return from cultivation. It is not advisable to go for mulching using coconut fronds as there is lower additional benefit on amount invested, B:C ratio being 1.41. In areas of severe weed problem there is no meaning raising a crop without going for any weed control measure as this resulted in a loss of Rs. 12,650/ha.

The study indicated the possibility of using various methods of weed control in ash gourd. Each method is efficient in weed control, however cannot ensure complete control of weeds throughout crop period hence resulted in yield reduction. It is also evident that weed competition can result in severe yield reduction. The results give various options of weed control methods which can be integrated so as to ensure maximum weed control efficiency. For example, though coconut frond mulching was not found effective, mulching after a pre-emergence herbicide application would be more economic and efficient. Similar as in the case of mechanical weeding, which can be taken up after a pre-

emergence spray. Manual weeding integrated using some organic mulching can also be thought of. In the case of plastic mulching, though entire area was covered in the present experiment in practical situation, mulching a strip of land area where effective root zone of crop is present can be resorted to, by which cost involved in mulching can be reduced. Moreover it can facilitate the trailing of the crop, as it strikes roots from each node. The practical difficulty in directed application is another aspect, and hence this can be advised only in initial stages or in zero tillage cultivation where application can be resorted to before crop is actually sown. There is also possibility of reducing weed competition by giving directed application by around 20 DAS by which disturbance to crop can be minimized and at the same time weeds can be controlled.

The results of the study warrants detailed results on the effects of plastic mulching on soil properties, microbial dynamics, plant root growth and effects on soil, water and nutrient conservation. Further its long time effect also should be studied so as to confirm the sustainability of this practice. Research on High Density Planting of ash gourd may also be carried out. This can probably reduce weed problem and at the same time lead to maximum productivity per unit area.

SUMMARY

6. SUMMARY

A field experiment on "Weed management in ash gourd [*Benincasa hispida* (Thunb.) Cogn.]" was conducted during July to November, 2013 at Krishi Vigyan Kendra (KVK) farm at KAU campus, Thrissur, using the variety KAU Local. The main objectives of the study were to compare the efficacy of cultural, physical and chemical methods of weed control and their combinations to arrive at an integrated weed management practice in ash gourd and to work out its economics. The experiment was laid out in Randomised Block Design with three replications. The treatments included pre emergence application of oxyfluorfen @ 0.2 kg/ha and pendimethalin @ 1.5 kg/ha, followed by post emergence directed application of glyphosate @ 0.8 kg/ha, mulching with coconut fronds, mulching with polythene sheet, weeding using power tiller, manual weeding by hoeing and unweeded control. The study resulted in the following findings.

- Major weeds found in experimental field were dicots which comprised of *Alternanthera bettzikiana*, *Borreria hispida* and *Celosia argentia.*

- *Pennisetum pedicellatum* was the dominant grass species followed by *Brachiaria sp.*

- Plastic mulching of the field resulted in almost cent percentage weed control efficiency.

- A reduction in weed count and increase in weed dry matter production could be observed with progress in crop growth stage in unweeded plot.

- The weed dry weight in unweeded control was statistically higher than all other treatments at various stages of observation. The lowest weed dry weight was recorded in plastic mulched plots the weed control in which was statistically superior to all other treatments at all stages of observation.

- N, P and K removal by weeds was higher in unweeded control and lower in plastic mulched plots at all stages observation, and the uptake increased from 30 DAS to harvest stage.

- The plant growth parameters like branches/vine and leaves/vine were significantly high in plastic mulched plots. The lowest value of all growth parameters were observed in unweeded check.

- The highest fruit yield (22,680 kg/ha) and seed yield (212 kg/ha) were recorded in plastic mulched plots which was statistically superior to all other treatments. Manual weeding was the next best practice.

- The highest crop dry matter production also was recorded in plastic mulched plots followed by manual weeding and the lowest in unweeded control.

- Maximum N, P and K uptake was also in plastic mulch treatment with 59.92 kg/ha, 11.10 kg/ha and 74.08 kg/ha respectively.

- Weed competition resulted in 91.5 per cent reduction in crop yield. Even with hand weeding complete weed control could not be achieved and hence resulted in 32 per cent yield loss over plastic mulching.

- Though total cost of cultivation was the highest for plastic mulching, it resulted in the highest net return and B:C ratio (2.73) due to higher yield.

- Coconut frond mulching cannot be recommended as a weed control measure as it was found ineffective in suppressing weed growth and no net profit could be obtained.

- Application of pre-emergence herbicide alone could not take care of weed problem and hence can be recommended only for weed control during a short span of 30 days.

- Pre-emergence herbicide spray followed by post emergence directed application of glyphosate could control weeds better compared to pre-emergence herbicide alone, and resulted in substantial increase in net profit compared to pre-emergence herbicide spray alone.

Conclusion

Weed management is an important operation in ash gourd cultivation and complete control of weeds is possible by plastic mulching. The organic mulching using coconut fronds was not effective in suppressing weeds due to emergence and growth of weeds through the interspaces. It was found that even a single spray of pre-emergence herbicide is more effective than mulching using coconut fronds in suppressing weeds. However, weed control efficiency lasted only upto 30 DAS. This may be probably due to the fact that effectiveness of pre-emergence herbicide only for a short span of about 30 days and after that uncontrolled weed growth was found which adversely affected crop performance. It can be inferred that early season weed control alone cannot be recommended for ash gourd. The two pre-emergence herbicide oxyfluorfen and pendimethalin had similar performance. Even a follow up spray of post emergence herbicide was found not sufficient to enhance the yield level. Though manual weeding was done thrice, complete weed control was not achieved and hence crop growth and yield were less in this treatment compared to weed free situation in plastic mulching. As in the case of manual weeding, mechanical weeding also could not ensure a weed free situation as it was done only twice, before the crop started to trail. It is concluded that plastic mulching is the best method of weed control in trailing vegetable crops like cucurbits. Application of pre-emergence herbicide can be integrated with any other weed control methods like manual weeding or mechanical weeding.

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*Originals not seen

APPENDICES

Appendix – 1 **Details of cost of cultivation**

Sl.No.	Particular	Men (Rs.450/day)	Women (Rs.300/ day)	Amount (Rs./ha)
	Field operation			
1	Land preparation	25		11,250
2	Sowing + fertilizer application		35	10,500
3	PP chemical application	5	5	3750
4	Harvesting		38	11,400
	Total cost			**36,900**

Appendix – 2 **Details of cost of inputs**

Sl.No.	Particular	Quantity /ha	Amount (Rs./ha)
	Input		
1	Tractor for land preparation (Rs.500/hr)		12,500
2	FYM	12.5t	12,500
3	Urea @ Rs.10/kg Factom phos @ Rs.20/kg MOP @ Rs.20/kg	27kg 125 42	3750 3610
4	Seed @ Rs.1750/kg	1.0kg	1750
5	PP chemicals		3890
	Total cost		**34,250**
	TOTAL		**71,150**

Appendix – 3 **Details of cost of other inputs**

Sl.No.	Particular	Quantity /ha	Amount (Rs./ha)
1	Black polythene mulch sheet (Rs.7/m^2)		35,000
2	Oxyfluorfen @ Rs.800/340ml	850ml	2000
3	Pendimethalin @ Rs.940/2L	5L	2350
4	Glyphosate @ Rs.315/800ml	2L	787.5
5	Coconut frond		11,250

Appendix- 4 **Nutrient contents of weeds (%) at 30 DAS**

Treatments	N	P	K
Oxyfluorfen	1.0	0.10	1.8
Pendimethalin	1.2	0.13	2.0
Oxyfluorfen fb glyphosate	1.1	0.20	1.7
Pendimethalin fb glyphosate	1.1	0.17	2.1
Coconut frond mulching	1.1	0.24	2.3
Plastic mulching	1.1	0.28	2.3
Mechanical weeding	1.2	0.12	2.2
Manual weeding	1.0	0.22	2.2
Unweeded control	1.2	0.10	2.0

Appendix- 5 **Nutrient contents of weeds (%) at 60 DAS**

Treatment	N	P	K
Oxyfluorfen	1.0	0.11	1.8
Pendimethalin	1.0	0.12	2.3
Oxyfluorfen fb glyphosate	1.1	0.12	1.8
Pendimethalin fb glyphosate	1.2	0.14	2.4
Coconut frond mulching	1.1	0.21	2.1
Plastic mulching	1.2	0.23	2.2
Mechanical weeding	1.0	0.15	1.9
Manual weeding	1.0	0.12	2.4
Unweeded control	1.2	0.11	2.2

Appendix- 6 **Nutrient contents of weeds (%) at 90 DAS**

Treatment	N	P	K
Oxyfluorfen	1.0	0.21	1.8
Pendimethalin	1.0	0.17	2.1
Oxyfluorfen fb glyphosate	0.9	0.20	1.9
Pendimethalin fb glyphosate	0.8	0.18	2.2
Coconut frond mulching	1.0	0.23	2.0
Plastic mulching	1.1	0.22	2.5
Mechanical weeding	1.1	0.29	2.0
Manual weeding	1.1	0.22	2.1
Unweeded control	0.9	0.25	1.9

Appendix- 7 **Nutrient contents of weeds (%) at harvest**

Treatment	N	P	K
Oxyfluorfen	1.0	0.23	2.0
Pendimethalin	1.0	0.26	1.5
Oxyfluorfen fb glyphosate	1.1	0.24	1.0
Pendimethalin fb glyphosate	1.0	0.25	1.0
Coconut frond mulching	1.0	0.15	1.4
Plastic mulching	1.1	0.25	1.9
Mechanical weeding	1.0	0.23	1.6
Manual weeding	1.1	0.20	1.0
Unweeded control	1.0	0.33	1.0

Appendix – 8 **Nutrient content of ash gourd (%)**

Treatment	N	P	K
Oxyfluorfen	1.4	0.12	1.2
Pendimethalin	1.3	0.11	1.4
Oxyfluorfen fb glyphosate	1.3	0.13	1.3
Pendimethalin fb glyphosate	1.2	0.13	1.3
Coconut frond mulching	1.0	0.20	1.5
Plastic mulching	1.3	0.24	1.6
Mechanical weeding	1.2	0.12	1.5
Manual weeding	1.1	0.25	1.2
Unweeded control	1.0	0.09	1.2

WEED MANAGEMENT IN ASH GOURD
[*Benincasa hispida* (Thunb.) Cogn.]

By

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ABSTRACT OF THE THESIS

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ABSTRACT

A field experiment on "Weed management in ash gourd" [*Benincasa hispida* (Thunb.) Cogn.] was conducted during July to November 2013 at Krishi Vigyan Kendra farm at KAU campus, Thrissur using the variety KAU local. The main objectives of the study were to compare the efficacy of cultural, physical and chemical methods of weed control and their combinations to arrive at an integrated weed management practice in ash gourd and to work out the economics of various weed management practices. The experiment was laid out in a Randomised Block Design with three replications. The treatments included pre-emergence application of oxyfluorfen @ 0.2 kg/ha, pre emergence application of pendimethalin @ 1.5 kg/ha, pre emergence application of oxyfluorfen @ 0.2 kg/ha followed by post emergence directed application of glyphosate @ 0.8 kg/ha, pre emergence application of pendimethalin @1.5 kg/ha followed by post emergence directed application of glyphosate @ 0.8 kg/ha, mulching with coconut fronds, mulching with polythene sheet, weeding using tiller, manual weeding by hoeing and no weeding.

Major weeds found in experimental field were dicots which comprised of *Alternanthera betzikiana, Borreria hispida, Celosia argentia* etc. *Pennisetum pedicellatum* was the dominant grass species followed by *Brachiaria sp.* Plastic mulching of the field resulted in almost cent percent weed control efficiency. The lowest weed dry weight and highest nutrient uptake was recorded in plastic mulched plot which was statistically superior to all other treatments at all stages of observation. N, P and K uptake by weeds was higher in unweeded control and lower in plastic mulched, and the uptake increased from 30 DAS to harvest stage. The plant growth parameters like branches/vine and leaves/vine were significantly high in plastic mulched plots followed by hand weeded plot. The highest fruit yield (22,680 kg/ha) and seed yield (212 kg/ha) was recorded in plastic mulched plots which was statistically superior to all other treatments. Manual weeding was

the next best practice and resulted in 16.54 t/ha fruit yield and 144.12 kg/ha of seed yield. Weed competition resulted in 91.5 per cent reduction in crop yield.

Though total cost of cultivation was the highest for plastic mulching, it resulted in the highest net return and B:C ratio (2.73). Coconut frond mulching cannot be recommended as a weed control measure as it was found ineffective in suppressing weed growth and no net profit could be obtained. Application of pre-emergence herbicide alone could not take care of weed problem and hence can be recommended only for weed control during a short span of 30 days. The two pre-emergence herbicides tried *viz;* oxyfluorfen and pendimethalin had similar performance. Even a follow up spray of post emergence herbicide was found not sufficient to enhance the yield level. However this can be integrated with other weed control methods like manual weeding or mechanical weeding. It is concluded that plastic mulching is the best method for weed control in ash gourd in areas where weed problem is very severe.