WEED MANAGEMENT IN BAJRA NAPIER HYBRID
(*Pennisetum glaucum x Pennisetum purpureum*)

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by

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THESIS

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2020

DECLARATION

I, hereby declare that this thesis entitled **"WEED MANAGEMENT IN BAJRA NAPIER HYBRID (*Pennisetum glaucum x Pennisetum purpureum*)"** 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 to me of any degree, diploma, associateship, fellowship or other similar title, of any other University or Society.

Place: Vellayani

Date: 18-08-2020

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CERTIFICATE

Certified that this thesis entitled **"WEED MANAGEMENT IN BAJRA NAPIER HYBRID (*Pennisetum glaucum x Pennisetum purpureum*)"** is a record of research work done independently by Ms. Swathy A. H. under my guidance and supervision and it has not previously formed the basis for the award of any degree, diploma, fellowship or associateship to her.

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SWATHY A. H.

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LIST OF ABBREVIATIONS

a.i	Active ingredient
B:C ratio	Benefit cost ratio
BLW	Broad leaved weeds
BN	Bajra napier
CD	Critical difference
CGR	Crop growth rate
Cm	Centimeter
CP	Crude protein
CWC	Crop weed competition
DAP	Days after planting
DAS	Days after sowing
DF	Dry flowable
DMP	Dry matter production
dS m^{-1}	Deci siemens per metre

EC	Electrical conductivity
et al.	Co-workers / Co-authors
Fb	Followed by
Fig.	Figure
FYM	Farmyard manure
G	Gram
ha^{-1}	Per hectare
HW	Hand weeding
i.e.	That is
K/ K_2O	Potassium
Kg	Kilogram
kg ha^{-1}	Kilogram per hectare
L	Litre
LAI	Leaf area index
M	Metre
m^{-2}	Per square metre
Mg	Milligram
Mm	Millimetre
MOP	Muriate of potash
MSL	Mean sea level
N	Nitrogen
no.	Number
NS	Not significant
P/ P_2O_5	Phosphorus
PE	Pre emergence
$plant^{-1}$	Per plant
PPO	Proto porphyrinogen oxidase

Q	Quintals
RBD	Randomized block design
RH	Relative humidity
SE m	Standard error of mean
$spike^{-1}$	Per spike
T	Tonnes
t ha^{-1}	Tonnes per hectare
viz.	Namely
WAS	Weeks after sowing
WP	Wettable powder

LIST OF SYMBOLS

%	Per cent
₹	Indian rupee
@	At the rate of
°C	Degree Celsius
+	Plus
-	Minus

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INTRODUCTION

1. INTRODUCTION

India's cattle wealth is immense with one fifth of the world's bovine population. The livestock is the sub-sector of agriculture sector which adds almost 32 per cent of Agriculture output in India. India assists 20 per cent of the livestock population of the world covering 2.3 per cent geographical area (Datta, 2013).

In the case of dairy farmers, feed is the most important constraint and farm animals are forced to subsist on dry stalks and straw with low nutritive value during lean periods. India is currently facing a 35.6% net deficit in green fodder, 10.95% in dry fodder and 44% in feed concentrate.

Our country's fodder supplies are barely adequate to feed even half of the current cattle population and it is well known that there is a shortage of green forage. A deficit of 18.4% of green forage and 13.2% of dry forage is anticipated for Indian livestock by 2050.

Among the milk producing states in India, Kerala ranks 14 with a share of just 1.5 % of total milk production (GOK, 2017). Majority of livestock farmers in Kerala are either small and marginal or even landless. Fodder crops are grown in around 7,000 ha producing green fodder fulfill just 2 percent of the state's total dry fodder requirement. Non-availability of land stands as a major hindrance for fodder cultivation in the state (Jose *et al*., 2019). Therefore, fodder production should be increased by unit area in the current scenario by growing high yielding multi-cut forage crops such as guinea grass and Bajra Napier (BN) hybrid.

BN hybrid is a perennial, erect growing, nutritious, high yielding grass and suitable for cultivation under varying agro-climatic and soil conditions. The grass has gained considerable importance among livestock rearers because of its quick growth, good tillering and better rejuvenating capacity. In BN hybrid, Napier as a male parent is responsible for providing perenniality and tillering habit whereas quality is contributed by female parent pearl millet (Prabhu and Palsaniya, 2016). The crop becomes ready for first cut in about 65-70 DAP. Hybrid Napier planted once supplies fodder regularly and continuously up to two to three years.

BN hybrid yield is decided mainly by the extend of competition from weeds depending on weed attributes like weed flora, weed count, weed density and duration of weed infestation in the field. The crop can be kept healthy in terms of yield by avoiding competition from weeds.

Weeds compete for space, light, nutrients and water supplies with BN hybrid. Different weed management practices can be taken up to eradicate or kill the weeds. Chemical control of weeds is the most effective and easiest. However, it increases pollution due to its possiblities of mixing with air and water. The awareness of the people regarding environment and the interest in organic food products, has led to the alternative method of weed control like mechanical removal or hand weeding. Owing to the better smothering effect on weeds, BN hybrid competes very effectively with weeds once formed. But in initial crop growth period, great care is required to avoid the emergence of weeds.

In hybrid pearl millet, hand weeding has been recorded to have resulted in weed density reduction at 15 DAS (Kaur and Singh, 2006). Mulching is used for its favorable effects on crop growth and fodder yields, viz. soil temperature reduction, evaporation and emergence of weeds (Din *et al.*, 2013).

The potential role of chemical component in integrated management is well known in many crops whereas the information on selectivity of herbicides in fodder crops is scanty. Presently in sorghum, atrazine is the used as pre emergence herbicide in control of weeds. Atrazine and pendimethalin each @ 0.50 kg ha^{-1} as pre-emergent were harmless to Sorghum (Mishra *et al*., 2012).

With the application of atrazine the lowest weed density and weed dry weight was reported in fodder maize (Sanodiya *et al*., 2013). 2,4-D plus carfentrazone ethyl is reported in wheat, barley and maize for post emergence control of broadaleaved weeds (Baghestani *et al.*, 2007*)*. In fodder oats, metsulfuron methyl post-emergence application @ 0.008 kg ha^{-1} have been found effective in weed control (Sharma and Chander, 2006).

Application of oxadiargyl 80 WP @ 100 g ha^{-1} showed better performance in controlling weed population throughout the growing period of rice crop (Bhattacharya *et al*., 2005). In BN hybrid, oxadiargyl application @ 0.09 kg ha^{-1} at 3-5 DAP *fb* 2, 4 D @ 1 kg ha^{-1} at 20-25 DAP and atrazine @ 0.75 kg ha^{-1} mixed with pendimethalin @ 0.75 kg ha^{-1} at 3-5 DAP reduced the weed density (Prabhu and Palsanya, 2016). The effectiveness of applied herbicide is described using weed index, a lower value of weed index means higher herbicide efficiency.

Keeping this in view, the present study was undertaken with the objective to standardise an economic weed management strategy for BN hybrid.

REVIEW OF LITERATURE

2. REVIEW OF LITERATURE

The study entitled, “Weed management in Bajra Napier Hybrid (*Pennisetum purpureum x Pennisetum glaucum*)” was carried out at College of Agriculture ,Vellayani, Kerala Agricultural University. There is not much work available in BN hybrid on weed management so the published research works on other crops are quoted here. The title-related literature is cited in this chapter.

1. WEED FLORA

Weeds appear in combination with the rainy season crop, which causes extreme weed competition with the crop during initial growth cycle, resulting in seed yield losses up to 40% in pearl millet (Deshveer and Deshveer, 2005).

The yield of BN hybrid is influenced by the extend of weed competition that depends mainly on field’s weed flora. Gill (2016) observed the presence of grasses like *Acrachne racemosa, Dactyloctenium aegyptium*, *Eleusine indica,* broad leaved weeds like *Amaranthus viridis, Chenopodium album* and the sedge *Cyeprus rotundus* in BN hybrid. Among the weed flora categories detected, grassy weeds (50 %) dominated followed by sedges (44 %) which was followed by broad leaved weeds (6 %) with respect to relative weed density.

In a field trial carried out to test the herbicide selectivity to BN hybrid (*Pennisetum glaucum*× *Pennisetum purpureum*) during 2013-14 and 2014-15, the field was dominated by natural infestation of broad leaved weeds (BLW) like *Commelina benghalensis, Digera arvensis, Catharanthus pusillus*, *Leucas aspera, Cleome gynandra, Cucumis melo, Physalis minima, Celosia argentea, Cleome viscosa* and grasses like *Echinochloa crusgalli, Cynodon dactylon, Digitaria sanguinalis* and sedges like *Cyperus rotundus* (Prabhu and Palsaniya, 2016).

Field experiments conducted at CCS Haryana Agricultural University, Hisar, India during 2007-08 and 2008-09 exposed that the major weeds of the experimental field during both seasons in pearl millet were *Cyperus rotundus, Digera arvensis and*

Trianthema portulacastrum. Highest proportion of weed flora at 40 DAS was shared by *Trianthema monogyana* (65%), *Digera arvensis* (11%), *Commelina benghalensis* (10%), *Echinochloa colonum* (10%) and *Cyperus rotundus* (4%). At 60 DAS, broadleaf species like *Trianthema monogyana* complete its life cycle and escaped from the experimental field (Choudhary *et al.*, 2017)

At Agricultural Research Station's experimental farm Kumher, Bharatpur, *Trianthema portulacastrum* was the major weed and the other minor weeds weeds found infesting the field were *Tribulus terrestris, Cyperus compressus, Cyperus rotundus, Amaranthus spinosus, Amaranthus viridis, Euphorbia* spp., *Echinochloa colona* and *Cynodon dactylon* (Deshveer and Deshveer, 2005) .

Napier grass undergo more serious weed problem than pasture grasses, which would cause a negative effect on the growth of subsequent crops. Even when the crop is planted at the recommended plant density or harvested at the recommended height, it creates an open space likely for weed invasion. Gaps can also be created in Napier grass plots after the harvest (Farrell, 1998). *Cynodon plectostachyus , Elymus repens, and Imperata cylindrica* were the principle weed flora in East African Napier grass plots. Repeated crop cultivation facilitated the spread of the oxalis weed (Farrell 2002).

The major weeds noted by Arif *et al.* (2007) in fodder maize experiment carried out at Agricultural Research Farm of NWFP Agricultural University, Peshawar were *Cyperus rotundus*, *Cynodon dactylon*, *Chenopodium album*, *Echinochloa crusgalli* and *Cucumis prophetarum.* Melilotus alba, Rumex dentatus and Chenopodium album were found major weeds associated with fodder oat (Palsaniya *et al.*, 2015).

2. CRITICAL PERIOD OF CROP WEED COMPETITION

Responding to the resources available, crop weed competition is the competition between crops and weeds. The identification of critical duration of weed competition is very necessary for efficacious weed management and to avoid damaging effects of weeds on yield and quality of crop. Weed density has major impact on critical period starting.

According to Dillehay *et al.* (2011), the higher the density of weeds, the shorter the time that crops can tolerate competition from weeds.

Gill (2016) found that the duration of CWC (critical weed competition) will be 10-30 DAP in BN hybrid. To avoid crop yield loss, steps to control weeds are to be taken at critical weed competition period.

Lorzadeh (2011) reported that in corn the critical period varied from 5 to 9 leaf stage at 5 per cent acceptable yield loss and 6 to 8 leaf stage at appropriate yield loss of 10 per cent. Zadeh *et al*. (2011) reported early weed competition for maize, so weed control treatments can be postponed to 21 or 44 DAS based on acceptable yield losses of 5 % and 10%.

Shinggu *et al.* (2009) observed 6 WAS as the critical period of weed interference in maize and stated that the early period threshold (time of weed competition which the crop can tolerate) and the late period threshold (period after which extra weeding does not affect yield) were the first 2 WAS and 6 WAS of crop, respectively. Adigun *et al*. (2014) noted that the critical weed control period was between 3 and 6 WAS for cowpea.

Crop yield won't decrease below appropriate levels before and after the critical weed control period. The identification of the critical time of weed control and the use of weed control methods is very significant in reducing weed yield losses. The critical weed control duration could thus be used to boost the efficacy of various weed management methods.

3. WEED MANAGEMENT METHODS

3.1. Non Chemical Weed Management Methods

Weeding is a labour -intensive cultivation method. Setting a price on the research and development costs for herbicide use in crop production is extremely difficult. Many farmers soon adopted herbicide use and it became an important part of crop husbandry with some farmers still challenging the widespread use of chemicals in agriculture. Innovation in bio-farming demanded a non-chemical approach to weed control (Bhuvaneswari, 2009)**.** The public's environmental consciousness and interest in organic food production, has led to a number of non chemical weed control methods being used.

3.1.1 Hand Weeding

Singh *et al.* (2015) reported weed density of 10.1 in 0.25 m^2 with two HW and 14.4 in 0.25 m^2 in weedy check in maize crop. Significantly higher grain yield of 6785 kg ha^{-1} in maize crop was recorded with two HW over weedy check of about 4872 kg ha^{-1}. Highest plant height was recorded in treatment with one-hoe weeding at 3 WAS, two-hoe weeding at 3 and 6 WAS than unweeded treatment. One HW at 3 weeks after planting recorded maximum plant height (56.8 cm) over unweeded control (52.9 cm) plots.

In an experiment on the effect of weed dynamics on hybrid pearl millet yield HW at 15 DAS, weed density was significantly lower than weed control at 30 DAS, 50 DAS and harvest time (Kaur and Singh, 2006).

3.1.2 Mulching

Mulching means adding a protective layer of material into the soil. Native mulches such as cereal straw, legumes straw, crop stubbles or residues and synthetic mulches like pulp, manmade fiber materials and plastic are used for weed control. Weed control via residue mulches is effective because it suppresses weeds chiefly during the crop setting stage. Mulching blocks light penetration in to soil and thus prevents weed seed germination (Teasdale and Mohler, 2000).

Mulching is an effective method for managing crop growing environment to increase yield and improve quality by controlling weed production, soil temperature improvement, soil moisture retention and soil erosion reduction (Din *et al.*, 2013).

Burning of straw causes nutrient loss of about 7.6 million tonnes of carbon, 0.08 million tonnes of nitrogen and 0.008 m tonnes of sulphur .There is a need to recycle or to use straw for increasing crop production and sustaining natural resources. Covering the soil surface can prevent germination of weed seeds or suppress seedling emergence. However, it is not found to effectively control established perennial weeds. Mulch can assume different forms, viz. living ground layer, loose organic or inorganic particles, sheets of artificial or natural material placed on the surface of the soil. Residues of plants from previous crops can also be used to form mulch (Bhuvaneswari, 2009).

Iqbal *et al.* (2006) recorded a significant increase in growth, fodder yield and water efficiency in comparison with no mulch. This can be due to changes in soil hydrothermal schedules and soil moisture preservation in mulched plots.

3.2 Chemical Weed Management Methods

Different methods of weed management can be used to eliminate weeds. Chemical control is found to be the effective and easiest method. However, the use of herbicides has increased the chances of air and water pollution.

Application of oxadiargyl @ 0.09 kg ha^{-1} at 3-5 DAP *fb* 2, 4 D @ 1 kg ha^{-1} at 20-25 DAP and atrazine 0.75 kg ha^{-1} mixed with pendimethalin 0.75 kg ha^{-1} at 3-5 DAP reduced the weed density by 75 and 70 percent in BN hybrid, respectively compared with weedy check. Despite of longer persistency in soil, oxadiargyl was not toxic to cattle since the mammalian toxicity of this herbicide is high (Prabhu and Palsanya, 2016).

Singh *et al*. (2016) also reported that sequential application of oxadiargyl *fb* bispyribac - sodium had 64 - 82 percent reduction in weed density. The application of atrazine @ 3.0 kg a.i. ha^{-1}, atrazine + metolachlor @ 2.0 kg a.i ha^{-1}, bromoxynil @ 0.47 kg a.i. ha^{-1}, cinosulfuron @0.04 kg a.i. ha^{-1} and dicamba @ 0.23 kg a.i. ha^{-1} in sorghum was found to control weeds (Ishaya *et al.*, 2007).

Weed management practices *viz*. pendimethalin 1.0 kg a.i. ha^{-1} PE *fb* 1 HW at 25 DAS, atrazine 0.75 kg a.i. ha^{-1} *fb* 1 HW at 25 DAS, pendimethalin 1.0 kg a.i. ha^{-1} *fb* halosulfuron 67.5 g a.i. ha^{-1} at 25 DAS, atrazine 0.75 kg a.i. ha^{-1} *fb* halosulfuron 67.5 g a.i. ha^{-1} at 25 DAS were practiced in maize crop (Choudhary *et al*., 2017).

Actually the most commonly used herbicide for weed control in sorghum is atrazine as pre-emergence. Lack of soil moisture, however, can decrease the effectiveness of pre-emergence herbicides, as sorghum is grown under stress conditions of moisture. Application of herbicides decreased the weed population, but both post-emergence herbicides and oxyfluorfen (pre-emergence) resulted in substantial sorghum phytotoxicity resulting in reduced crop yield. Post-emergence application of herbicides atlantis (mesosulfuron and idosulfuron) and almix (chlorimuron and metsulfuron) caused complete sorghum plant death. Atrazine and pendimethalin were found to be safe for sorghum crops at 0.50 kg ha^{-1} each applied as a pre-emergence resulting in good weed control and increased grain yield (Mishra *et al* ., 2012).

Application of oxadiargyl 80 WP @ 100 g ha^{-1} had better controlling in weed population throughout the growing period of rice crop (Bhattacharya *et al*., 2005). Oxadiargyl blocks porphyrin biosynthesis by inhibiting protoporphyrinogen oxidase. 2,4-D plus carfentrazone ethyl and Florasulam plus flumetsulam, have been recorded effective for post-emergence control of broad leaved weeds in barley, maize and wheat (Baghestani *et al.*, 2007*).*

3.3 Integrated Weed Management

Integration of chemical weed management with hand weeding as well as mechanical weeding has been reported as effective and economically viable method of weed management (Ram *et al*., 2005). In a field experiment conducted to assess the impact of intercropping and weed management on pearlmillet growth and yield, two HW at 3 and 6 WAS and pendimethalin application @ 0.75 kg ha^{-1} as PE with one HW at 6 WAS increased growth , grain equivalent yield and straw equivalent yield in pearl millet (Mathukia *et al.*, 2015).

A field experiment was conducted at the Research Farm, JNKVV, Jabalpur, Madhya Pradesh to see the impact of integrated weed management on fodder maize production, development and seed yield. The lowest weed density and weed biomass were recorded under weed-free treatment followed closely by atrazine 1.0 kg ha^{-1} + HW (Sanodiya *et al*., 2013).

4. EFFECT OF WEED MANAGEMENT

4.1 Weed Parameters

4.1.1 Weed Density and Weed Dry Matter

Gill (2016) recorded maximum grassy weeds density in the weedy check and the minimum in weed free condition in BN hybrid. Weed density reduced when weed free of crops was continued to 30 DAP. The lower density of weeds recorded in longer weed-free treatments than weedy treatments was due to harsh temperature and climate for weed seed germination in crop season. An undeviating increase was observed in the density of BLW with the competition periods which may be attributed to the duration for germination of weed seeds.

HW at 25 and 45 DAS in pearl millet significantly reduced individual and total weeds compared to all other treatments and were comparable statistically to free weed treatment. When at 25 DAS, HW also decreased the density and dry weight of individual and total weeds by 0.1-0.2 kg ha^{-1} compared to oxyfluorfen (Kiroriwal *et al.*, 2012).

Patil and Reddy (2014) investigated the impact of weed management on irrigated finger millet and reported that with 2 HW at 20 and 30 DAP, weed count as well as dry weight were lower compared with unweeded control. The grain yield was greater in weeded plot (5460 kg ha^{-1}) compared to unweeded control (2730 kg ha^{-1}). Kaur and Singh (2006) reported a significant reduction in weed density with mulch @ 4 t ha^{-1} compared to mulch @ 2 t ha^{-1} and no mulch.

Tewari *et al.* (1989) reported that in wheat large intercrop canopy prevented the penetration of solar radiation and smothered the weeds resulting in reduced weed dry matter. Singh *et al.* (2018) recorded a significant reduction in the weed density and dry matter on intercropping Bajra Napier Hybrid and cowpea/maize/Bajra as compared to sole Bajra Napier hybrid. At 30 and 50 DAP, the lowest weed density and dry weight were observed in BN hybrid + cowpea, whereas maximum weed density and dry weight were recorded in sole BN hybrid. The lower weed density and weed biomass in intercropping might be due to higher crop canopy cover in intercropping systems than sole BN hybrid.

Application of oxadiargyl @ 0.09 kg ha^{-1} at 3-5 DAP followed by 2, 4 D @ 1 kg ha^{-1} at 20-25 DAP and atrazine @ 0.75 kg $ha-^{1}$ mixed with pendimethalin @ 0.75 kg ha^{-1} at 3-5 DAP reduced the weed density by 75% and 70%, respectively compared with the weedy check (Prabhu and Palsanya, 2016). Kiroriwal *et al.* (2012) reported that application of pendimethalin @ 0.75 kg ha^{-1} significantly reduced the individual as well as total weed density and weed biomass.

An experiment conducted at Forage Research and Management Centre, ICAR-National Dairy Research Institute showed that the weed free treatment recorded the lowest weed population in fodder pearl millet. At 40 DAS, among dicot weeds, the densities of *Commelina benghalensis, Digera arvensis* and *Trianthema monogyana* were found lowest and among monocots, the density of *Echinochloa colonum* was also found lowest with pendimethalin *fb* 1 HW at 25 DAS.

Among sedges, the density of *Cyprus rotundus* was lowest with application of both pendimethalin *fb* halosulfuron at 25 DAS and atrazine *fb* halosulfuron at 25 DAS which was significantly lower than other weed management practices. At 60 DAS, among dicots, the densities of *Dactyloctenium aegypticum* and *Commelina benghalensis, Digera arvensis* were found lowest. Among monocots, the density of *Echinochloa colonum* was found lowest with pendimethalin *fb* 1 HW at 25 DAS. Among sedges, the density of *Cyperus rotundus* was recorded lowest with atrazine *fb* halosulfuron at 25 DAS (Choudhary *et al*., 2017).

Irrigation schedules and mulch levels at 30, 45 and 60 DAP significantly influenced total weed dry matter accumulation in fodder pearl millet. Choudhary *et al.* (2017) reported an increase in weed dry matter up to 45 DAP and due to smothering effect of crop weed dry matter reduced at 60 DAP. The weed dry matter decreased significantly at greater mulch levels of 7.5 and 10 t ha^{-1} in pearl millet due to reduced weed counts. Wanjari *et al.* (2000) reported that with extending the weed free conditions from 10 DAP onwards, the weed count and dry weight was significantly reduced.

4.1.3 Weed Control Efficiency and Weed Index

Gill (2016) conducted a field experiment on BN hybrid in 2014 and 2015 and reported that the WCE was 35.1 and 36.4 % respectively with mulch @ 7.5 t ha^{-1}. Weed index is the measure of a weed control treatment’s effectiveness as opposed to weed free condition. It is expressed as a potential yield’s percentage under conditions of weed free. The higher the weed index greater the crop yield loss due to weeds.

In an experimental BN hybrid plot, the lowest weed index was reported in seasonal weed-free crops followed by weed-free crops for 40 days (2.81 and 0.81 per cent respectively in 2014 and 2015). A linear increase in yield loss was observed, when the duration of weed infestation increased from 10 days to 40 days, and yield losses reduced with increase in weed free period (Gill, 2016).

The higher WCE (75%) and the lowest WI (17.36) was found with the application of oxadiargyl @ 0.09 kg a.i. ha^{-1} at 3-5 DAP *fb* 2, 4 D @ 1 kg a.i. ha^{-1} at 20-25 DAP (Prabhu and Palsaniya, 2016). Application of pendimethalin *fb* 1 HW at 25 DAS in forage pearl millet recorded the lowest WI and the highest WCE which was closely followed by the application of atrazine *fb* 1 HW at 25 DAS (Choudhary *et al.,* 2018).

With 2 HW, the WCE was maximum followed by alachlor 2.5 kg ha^{-1} + HW at 30 DAS in maize for fodder. The lowest WCE was observed in fodder maize with pre-emergent application of pendimethalin 1.0 kg ha^{-1}, atrazine 1.0 kg ha^{-1} and alachlor 2.5 kg ha^{-1} alone (Sanodia *et al.*, 2013).

4.2 Crop Growth Factors

4.2.1 Plant Height

Losses of crops from weeds can be serious if weeding is delayed during the growing season. By competing for space, water, nutrients and sunlight, weeds reduce crop yields and quality. Naim and Abdelrhim (2010) found an increase in plant height with increased weeding frequency. Plant height is an index of growth and development and it reflects the expansion of a plant's infrastructure over a period.

In BN hybrid weed interference recorded substantially higher plant height up to 10 days than in weed interference treatment up to 20 days. The minimum plant height was recorded at harvest (in 2014 and 2015) in seasonal long weedy treatment (54.0 and 56.7 cm, respectively). Height of the plant decreased when the duration of weed intervention was increased from 10 to 40 days. At first harvest (in 2014 and 2015), keeping the crop weedy for 30 days reduced the plant height significantly (59.0 and 59.7 cm, respectively) when compared 10 and 20 days of weed interference. The lower plant height at harvest was recorded in season long weedy condition (Gill,2016).

The use of pendimethalin and oxyfluorfen (0.2 kg / ha) significantly reduced the plant height of pearl millet over all other weed control treatments at 20 DAS, which means that pendimethalin and oxyfluorfen could have some phytotoxic effect on pearl millet (Verma *et al.*,2017). An initial reduction of plant height in Bajra Napier hybrid was observed with the application of 2, 4 D + atrazine, fenoxaprop-p-ethyl + 2, 4 D , pendimethalin, atrazine and atrazine + pendimethalin (Prabhu and Palsaniya, 2016).

In sorghum crop, application of piperophos plus cinosulfuron @ 1.5 kg a.i ha^{-1} and pretilachlor + dimethametryne @ 2.5 kg a.i. ha^{-1} increased plant height over other treatments (Ishaya *et al.*, 2007).

4.2.2 Leaf Area Index

Leaf area index (LAI) indicates detection by the crop canopy of photosynthetically active radiation, which influences crop yield. The data obtained from a field experimentation done on BN hybrid recorded an increase in LAI with the age of crop and different planting materials significantly influenced the LAI (Gill, 2016). The leaf area at BN Hybrid was substantially higher than the stem cuttings at 30, 45 and 60 DAP when raised via root slips. The rise in LAI could be due to enhanced competitive ability of plants over weeds making the plants available for nutrients and moisture.

Specific mulch levels in BN hybrid had a major impact on LAI. Paddy straw mulch application @7.50 t ha^{-1} substantially increased the LAI as compared to no mulch and 5.0 t ha^{-1} at 60 DAP in BN Hybrid. Increased mulch level resulted in higher number of tillers and consequently a rise in LAI was observed (Gill, 2016).

4.2.3 Number of Tillers

Bajra Napier hybrid is a triploid grass. It produces many tillers and many leaves but no seeds. It grows rapidly and is ready to harvest in about 65-70 DAP. During this time the crop's vegetative growth is very sluggish, and has fewer tillers. The number of tillers is a key determinant that influences the crop yield.

There was increase in tiller count after first cut (60 DAP) and until last harvest (180 DAP) in BN hybrid indicating the crop 's strong regeneration potential. Gill (2016) recorded a gradual increase in tiller count, with mulch level increases in BN hybrid at different crop growth stages. At 60 DAP, application of 7.5 t ha^{-1} mulch observed significantly higher numbers of tillers per plant than no mulch application and at 5 t ha^{-1}

during 2014 and 2015 among the different mulch rates. Better hydrothermal conditions under mulching might have resulted in higher tiller production in BN hybrid.

4.2.4 Leaf Stem Ratio

Between BN hybrid weed interference treatments 60 DAP, the leaf stem ratio was significantly higher when crops were retained weed free the entire season (0.91 and 0.96, respectively in 2014 and 2015). The minimum leaf stem ratio has been recorded in crop held weedy throughout the season (Gill, 2016).

4.3 Crop Quality Parameters

Crude protein content is one of the key quality characters of fodder crops. A field experiment in BN hybrid recorded an increase crude protein content with mulching. Mulching @ 10 t ha^{-1} and 7.5 t ha^{-1} resulted in increased crude protein content of 11.3 and 10.5 % respectively. It was significantly better than mulch @ 5 t ha^{-1} and no mulch. This crude protein content increase might be due to reduced soil evaporation and moisture conservation with increase in mulch levels. Patel *et al*. (2013) also reported an increased protein content in mulch-applied pearl millet.

Among different weed management practices in forage peal millet, application of pendimethalin + 1 HW showed higher crude protein content (8.2%) over other treatments. Choudhary *et al.* (2017) concluded that the higher CP content in the treatment might be due to less weed crop competition and contribution of growth contributing characters to accumulate more nitrogen by crop.

Hand weeding twice in maize crop recorded higher protein content, was followed by insitu green manure cowpea incorporation at 45 DAS and stale seedbed technique + insitu green manure cowpea incorporation at 45 DAS . Unweeded control recorded lower crude protein content (Bhuvaneswari, 2009)

In BN hybrid, an increase in weed free length time decreased the amount of crude fibre content. The maximum crude fiber value of 33.1 percent was registered during the season in crop held weedy which was at the same time as the crop kept weedy for 40 days, 30 days and up to 10 days during the season free of weed. This increase in crude fiber with an improvement in the length of the weedy cycle can be attributed to the occurrence of high weed density in these parcels, which compete with the crop for moisture and decrease the moisture content of the crop (Gill, 2016).

Higher crude-fibre content decreases digestibility. Gill (2016) reported that BN hybrid crude fibre had a significant influence on mulch levels. The amount of crude fibers decreased significantly with an increase of 7.5 t ha^{-1} in mulch use. Crude fiber has been significantly decreased with a further rise in mulch volume to 10 t ha^{-1}. The maximum crude fibre content value was obtained without the application of any mulch followed by 5 t ha^{-1} mulch. This rise in crude fiber content at a lower mulch level may result in a reduction in the humidity content resulting in further synthesis of more structural carbohydrates and fibrous material deposition in plants (Gill, 2016).

4.4 Crop Yield

BN hybrid yield is essentially determined by weed competition that depends on the weed type, weed count, weed density, crop growth stage and weed infestation duration within the field. Weeds not only interfere with crop growth but also cause significant yield and quality losses. The yield of green fodder is taken into account, as the critical criterion for calculating crop production in different treatments.

Different levels of mulch greatly affected the yield of BN hybrid green fodder. In a field experiment conducted in BN hybrid, it was observed that considerably higher GFY were obtained with 10 t ha^{-1} mulch at first harvest in 2014 (520 q ha^{-1}) and 2015 (533 q ha^{-1}). In 2014 and 2015, total GFY increased significantly with 7.5 t ha^{-1} mulch level (1601 and 1954 q ha^{-1} , respectively) over 5 t ha^{-1} and no mulch (Gill, 2016). Mulch plays an significant role in soil moisture conservation resulting in higher growth and yield values.

Among different weed management practices in maize, higher number of spikes $plant^{-1}$ (3.5) and seed yield (2401.8 kg ha^{-1}) were recorded in weed free treatment which was significantly higher than other weed management practices. Pendimethalin (PE) *fb* 1 HW at 25 DAS recorded maximum spike length (29.6 cm) and seed weight $spike^{-1}$ (29.5 g). Higher total dry matter accumulation might be due to luxuriant crop growth as indicated by higher plant height, number of leaves and stem girth which resulted in high dry matter production (Choudhary *et al*., 2017)

Patel *et al*. (2013) conducted a pearl millet experiment and reported that mulch application significantly increased the yield of fodder (8744 kg ha^{-1}) as compared to no mulch. Kusmiyati *et al* . (2013) indicated that the GFY and DFY increased significantly by growing the level of mulch from no mulch to mulching at by 3 and 6 t ha^{-1}. Sharma *et al.* (2010) noted that 30 days of mulching with intercropped sunhemp in maize and 60 days of growth with *Leucaena leucocephala* twigs from hedge rows seemed a promising technology to lower weed growth and stabilize yield. Al-Dhuhli *et al* . (2010) recorded an increase of 13 % in sorghum GFY over date palm mulch control.

Barahenda *et al.* (2007) researched the *Pennisetum purpureum* productivity under mulching and reported that mulched plots gave high total dry matter yield compared to control (25.75 and 15.35 t ha^{-1} respectively). This represents the importance of mulching to preserve soil moisture to enhance the yield of dry matter. The green fodder yield, dry fodder yield and crude protein yield of berseem crop (452.74, 79.08 and 14.19 q ha^{-1}, respectively) were significantly higher with oxyflourfen (pre emergence application) @ 0.10 kg a.i. ha^{-1} *fb* imazethapyr (post emergence application) @ 0.100 kg a.i. ha^{-1} after first harvest over other treatments (Pathan and Kamble, 2012).

The maximum seed and fodder yields in fodder maize were observed in HW at 20 and 40 DAS followed by atrazine @ 1.0 kg ha^{-1} + HW at 30 DAS than other treatments (Sanodiya *et al*., 2013).

MATERIALS AND METHODS

3. MATERIALS AND METHODS

An experiment entitled "Weed management in Bajra Napier hybrid *(Pennisetum glaucum x Pennisetum purpureum*)" was conducted during 2018-2020 at Instructional farm, College of Agriculture, Vellayani with an objective to standardise an economic weed management strategy for BN hybrid. The details of the experimental materials and methods are described in this chapter.

3.1 EXPERIMENTAL SITE

The experiment was laid out in the Instructional Farm, College of Agriculture, Vellayani, Thiruvananthapuram, Kerala. The farm is located at latitude 8.5° North and longitude 76.9° East and 29 m above MSL altitude.

3.1.1 Season

The experiment was conducted during the period from July 2019 to January 2020.

3.1.2 Weather condition

Data were collected from the meteorological observatory of College of Agriculture, Vellayani on monthly average of weather parameters such as maximum and minimum temperature, relative humidity and rainfall obtained during the cropping season. The data is given in Appendix 1 and is illustrated graphically in Fig. 1.

The mean maximum temperature ranged between 25.3°C- 30.9°C and mean minimum temperature ranged between 23.3°C- 24.9°C during the crop growing period. The relative humidity ranged from 91.4 per cent to 92.8 per cent. During the crop period an overall rainfall of 1535 mm was recorded.

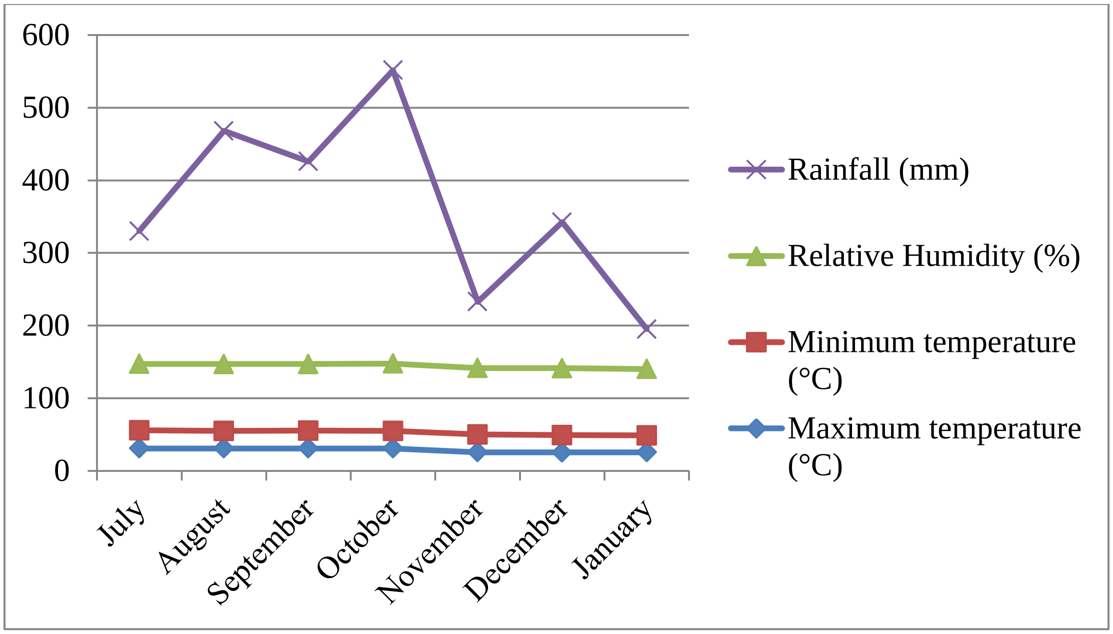

Fig 1. Weather parameters during the cropping period, July 2019 – January 2020

3.1.3. Soil

The soil of experimental site was identified as sandy clay loam. The soil samples for analyzing the chemical properties were taken from 0-15 cm depth before performing the field experiment. The data collected are illustrated in Table 1.

Table 1. Soil chemical properties of the experimental site

S. no.	Parameters	Content	Method adopted
1	Soil reaction (pH)	4.97 (very strongly acidic)	1:2.5 soil solution ratio using pH meter with glass electrode (Jackson,1973)
2	Electrical conductivity (dSm^{-1})	0.052 (Normal)	Digital conductivity meter (Jackson , 1973)
3	Organic carbon (%)	1.00 (Medium)	Walkley and Black rapid titration method (Jackson,1973)
4	Available N ($kg\ ha^{-1}$)	368.69 (Medium)	Alkaline permanganate method (Subbiah and Asija,1956)
5	Available P_2O_5 ($kg\ ha^{-1}$)	92.66 (High)	Bray colorimetric method (Jackson ,1973)
6	Available K_2O ($kg\ ha^{-1}$)	384.48 (High)	Ammonium acetate method (Jackson,1973)

3.2 MATERIALS

3.2.1 Crop and Variety

Bajra Napier hybrid variety Suguna, released from AICRP on Forage Crops, Vellayani, Kerala Agricultural University was selected for this study. It is a BN hybrid developed by crossing Composite 9 and FD 431, with high tillering capacity of 40 tillers plant^{-1}. It has long broad leaves and pale green leaf sheath with purplish segmentation and serrated leaf margin. It has better quality with 9.4 per cent crude protein and 24.0 per cent crude fibre. The average yield of the variety is 280-300 t ha^{-1}.

3.2.2 Source of planting material

The planting materials for the experiment was procured from AICRP on Forage Crops and Utilization, College of Agriculture, Vellayani.

3.2.3 Manures and fertilizers

As a source of organic manure dried cow dung having N content of 0.45 per cent, P_2O_5 content of 0.17 per cent and K_20 content of 0.5 per cent was applied. For the experiment, source of NPK used were urea (46 per cent N), factamphos (20 per cent N and 20 per cent P_2O_5) and muriate of potash (60 per cent K_2O) .

3.2.4 Herbicides

The available information of the herbicides tested in the trial, oxadiargyl and carfentrazone ethyl are given in the Table 2.

Table 2. Details of herbicides used in experiment

Common name	**General description**	**Trade name**	**Toxicity**	**Rate**
Oxadiargyl (80 WP)	• Selective • Pre emergent • Inhibition of proto porphyrinogen oxidase(PPO)	Top star	Green	₹ 290 per 22.5g
Carfentrazone Ethyl (40% DF)	• Contact • Post emergent • Inhibition of proto porphyrinogen oxidase(PPO)	Affinity	Green	₹ 300 per 25g

3.3 METHODS

3.3.1 Design and Lay out

Design	:	RBD
Replication	:	3
Treatments	:	9
Season	:	*Kharif* 2019
Spacing	:	60 cm x 60 cm
Net plot size	:	3 m x 3 m
Location	:	College of Agriculture, Vellayani.

3.3.2 Treatment details

$T_{1:}$ oxadiargyl 60 g ha^{-1} on 3-5 DAS *fb* carfentrazone ethyl 20 g ha^{-1} on 25-30 DAP

$T_{2:}$ oxadiargyl 90 g ha^{-1}on 3-5 DAP *fb* carfentrazone ethyl 20 g ha^{-1}on 25-30 DAP

$T_{3:}$ oxadiargyl 120 g ha^{-1} on 3-5 DAP *fb* carfentrazone ethyl 20 g ha^{-1}on 25-30 DAP

$T_{4:}$ oxadiargyl 60 g ha^{-1} on 3-5 DAP *fb* hand weeding on 25 - 30 DAP

$T_{5:}$ oxadiargyl 90 g ha^{-1} on 3-5 DAP *fb* hand weeding on 25 - 30 DAP

$T_{6:}$ oxadiargyl 120 g ha^{-1} on 3-5 DAP *fb* hand weeding on 25 - 30 DAP

$T_{7:}$ *bio mulching

$T_{8:}$ farmers practice (hand weeding at 20 and 40 DAP)

$T_{9:}$ weedy check

*Bio mulching with dried grass @ 7.5 t ha^{-1}

3.3.3 Field preparation

3.3.3.1 Land preparation

The field was made free of weeds initially and dry ploughed thrice manually. After leveling the field, 27 plots of size 3 m x 3 m were marked and beds were made

3.3.3.2 Fertilizer application

Dried cowdung @ 25 tha^{-1} and P_2O_5 and K_2O @50 kgha-^{1} each were applied at the time of land preparation in the form of factamphos and muriate of potash. Recommended dose of N @ 200 kg ha^{-1} was applied in splits (N @ 40 kg ha^{-1} as basal dose and @ 30 kg ha^{-1} after each harvest) in the form of urea.

3.3.3.3 Planting

Being a sterile hybrid, the grass was planted using cuttings of three months old stems, preferably from the lower two thirds of stem length. The cutting with three nodes was stuck into the soil at an angle to a depth with the basal end down so that the two nodes stayed within and one above the surface of the soil. A spacing of 60 cm x 60 cm was followed. Gap filling was carried out ten days after planting for maintaining uniform plant population.

R_1		R_2		R_3	
T_4		T_2		T_9	
T_5	T_3	T_1	T_7	T_3	T_8
T_8	T_9	T_6	T_5	T_2	T_1
T_6	T_7	T_9	T_4	T_7	T_5
T_2	T_1	T_3	T_8	T_4	T_6

Fig 2. Layout of the field experiment

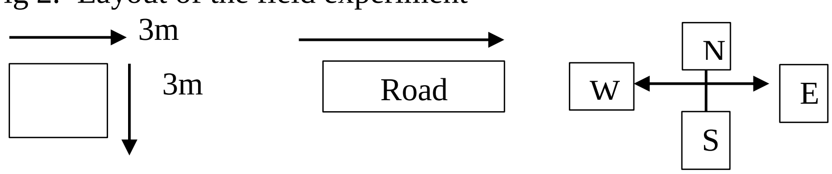

Plate 1. General view of the experimental field

3.3.3.4 Irrigation

All treatment plots were uniformly irrigated before planting to ensure uniform germination. The crop was irrigated up to harvest using sprinklers.

3.3.3.5 Herbicide spraying

Weed management procedures according to the treatment were carried out. Spraying of oxadiargyl @ 60, 90 and 120 g ha^{-1} on 3-5 DAP and carfentrazone ethyl 20 g ha^{-1} on 25-30 DAP was done using hand sprayer of spray volume 500 L ha^{-1} .

3.3.3.6 Harvesting

The first cutting was made 75 DAP and subsequent cuttings were carried out at every 45 days interval when the plants attained a height of 1.5 m. The crop's harvest was taken and recorded the yield at three harvests at 75 DAP, 120 DAP and 165 DAP.

3.4 Observation on weeds

Weed characters were studied at 25 and 50 DAP

3.4.1 Weed flora

Weed species predominant in the experimental field were found, classified and grouped as grassy weeds, broadleaved weeds (BLW) and sedges.

3.4.2 Weed count

Weed count at 25 and 50 DAP in each plot was recorded by using a quadrat (1 m x 1 m) in two random places. Grasses, sedge and BLW were recorded in each plot and expressed in number m^{-2}.

3.4.3 Weed relative density

Relative density of group wise weeds were worked and expressed as percentage (Phillips, 1959)

$$\text{Relative density (\%)} = \frac{\text{Absolute density of a given species}}{\text{Total absolute density of all species}} \text{ x } 100$$

3.4.4 Weed dry matter

During each sampling point, weeds removed from each plot were air dried for one day and then dried to obtain a constant weight during 60 ° ± 5 ° C and expressed as g m^{-2}.

3.4.5 Weed Control Efficiency (WCE)

Weed Control Efficiency (WCE) was calculated with the method suggested by Mani and Gautham (1973).

$$\text{WCE}(\%) = \left(\frac{\text{WDC} - \text{WDT}}{\text{WDC}}\right) \text{x}100$$

Where,

WDC = Weed dry weight in the unweeded plot (g m^{-2})

WDT = Weed dry weight in the treated plot (g m^{-2})

3.5 OBSERVATIONS ON CROP

3.5.1 Growth and Yield Attributes

3.5.1.1 Plant Height

The height of the plant was measured from base to tip of longest fully spread leaf from five random plants at harvest. The mean height was expressed in cm.

3.5.1.2 Number of Tillers per Plant

Total number of tillers per plant was counted from five randomly selected plants and expressed as number of tillers per plant before each cutting.

3.5.1.3 Leaf Stem Ratio

Leaf and stem portions were separated from five selected plants at each harvest and dried to a constant weight in hot air oven at 70°C. Dry weight of stem and leaves were recorded separately for each plant and leaf stem ratio was worked.

3.5.1.4 Tussock Diameter per Hill

From five randomly selected plants , diameter per hill was measured and expressed as tussock diameter per hill in cm before each cutting.

3.5.1.5 Leaf chlorophyll content

For the estimation of total leaf chlorophyll content, the fully opened second leaf from the top of the sample plant was taken, analyzed and expressed in mg g^{-1}(Arnon, 1949).

$$\text{Total chlorophyll} = 8.02\ A_{663} + 20.20\ A_{645} \times \frac{V.}{1000 \times W}$$

where,

A = Absorbance at specific wavelengths

V = Final volume of chlorophyll extract in 80 per cent acetone

W = Fresh weight of tissue extracted in 80 per cent acetone

3.5.1.6 Green Fodder Yield (GFY)

The Bajra Napier hybrid grass was cut near the ground level in each plot and the fresh weight was recorded and green fodder yield was expressed as t ha^{-1}.

3.5.1.7 Dry Matter Yield (DMY)

A weighted representative sample of green forage was obtained from each plot and was dried to constant weight in an oven at 70 ° C. Total DMY was calculated from the dry weight of the sample and expressed as t ha^{-1}.

3.5.1.8 Weed Index (WI)

WI calculation was done by using the following formula (Gill and Vijay Kumar, 1969).

$$WI(\%) = \left(\frac{X - Y}{X}\right) \times 100$$

Where, X = Yield (kg ha^{-1}) from minimum weed competition plot (maximum yield)

Y = Yield (kg ha^{-1}) of treatment plot for which the weed index is to be worked out

3.5.2 Quality Parameters

3.5.2.1 Crude Protein Content

The plant's nitrogen content multiplied by 6.25 gave the crude protein content (Simpson *et al.*, 1965).

3.5.2.2 Crude Fibre Content

AOAC method was used to determine the crude fibre content (AOAC, 1975).

3.5.3 Physiological parameters

Physiological characters of crop were taken during 25, 50 and 75 DAP.

3.5.3.1 Crop growth rate (CGR)

Crop growth rate was calculated using the method suggested by Watson (1958) at the time interval of 25, 50 and 75 DAP and expressed in g m^{-2} day^{-1}.

$$CGR = \frac{W_2 - W_1}{t_2 - t_1}$$

where, W_2 and W_1 are the DMP of the plant at time t_2 and t_1

3.5.3.2 Relative growth rate (RGR)

Relative growth rate was calculated at the time interval of 25, 50 and 75 DAP by using the formula suggested by Evans (1972) and expressed in g g^{-1} day^{-1}.

$$RGR = \frac{\text{Loge } W_2 - \text{Loge } W_1}{t_2 - t_1}$$

where,

W_2 and W_1 are the dry matter of the plant at time t_2 and t_1

3.6 NUTRIENT ANALYSIS

3.6.1 Soil Analysis

Composite soil samples from experimental area were taken before the experiment. After the experiment, individual soil samples were collected from each plot, air dried, powdered and passed through 2 mm sieve and analysis was done as per the standard analytical methods given below.

3.6.1.1 pH

The pH of the sample were determined by preparing soil solution in 1:2.5 ratio and using pH meter with glass electrode (Jackson, 1973).

3.6.1.2 Electrical Conductivity (EC)

Conductivity meter was used to determine EC of soil samples by preparing soil solution in 1:2.5 ratio and expressed as dSm^{-1}.

3.6.1.3 Organic Carbon Content

Walkely and Black rapid titration method (Jackson, 1973) was used to determine soil organic carbon content and expressed in percentage.

3.6.1.4 Available N

Alkaline permanganate method (Subbiah and Asija, 1956) estimated the available nitrogen content in the soil and expressed in kg N ha $^{-1}$.

3.6.1.5 Available P

Bray colorimetric method (Jackson, 1973) was used to determine available phosphorus content in the soil and expressed in kg ha $^{-1}$.

3.6.1.6 Available K

Available potassium content in soil was estimated by Ammonium acetate method (Jackson, 1973), using flame photometer and expressed in kg ha $^{-1}$.

3.6.2 Plant analysis

At harvest, samples were gathered, then chopped, shaded, and oven dried at 70°C to a constant weight. Samples were grounded so that it could pass through a 0.5 mm mesh in a Willey Mill. The required sample quantities were digested and used to analyze the nutrients.

3.6.2.1 Uptake of Nitrogen

Modified micro kjeldhal method (Jackson, 1973) was used to estimate the nitrogen content in plant. The N uptake of the fodder crop during crop growth period was calculated by multiplying the nutrient content in plants with plant's dry weight and expressed in kg ha^{-1}.

3.6.2.2 Uptake of Phosphorus

The phosphorus content in the plant was estimated calorimetrically by Vanado – molybdate yellow colour method using spectrophotometer (Jackson, 1973). Multiplying the phosphorous content with plant dry weight gave the phosphorus uptake. The values are in kg ha^{-1}.

3.6.2.3 Uptake of Potassium

Flame photometric method (Jackson, 1973) was used to determine the potassium content in the plant samples.The K uptake was calculated by multiplying the K content with the dry weight of plants and expressed in kg ha^{-1}.

3.7 Economics of cultivation

Economics of cultivation was worked out .based on the cost of cultivation and market price of the fodder crop.

The net returns and benefit: cost ratio were calculated as given below

Net returns (₹ ha^{-1}) = Gross income – Total expenditure

$$\text{Benefit: Cost ratio} = \frac{\text{Gross income}}{\text{Total expenditure}}$$

3.8 Statistical analysis

Analysis of variance were performed using the statistical package 'OPSTAT' on data collected (Sheoran *et al*., 1998). The data that required transformation were transformed and appropriate analysis was done.

RESULTS

4. RESULTS

The study entitled "Weed management in Bajra Napier hybrid (*Pennisetum glaucum x Pennisetum purpureum*)" was carried out during 2018-2020, at College of Agriculture, Vellayani, Thiruvananthapuram, Kerala with the objective to standardise an economic weed management strategy for Bajra Napier Hybrid. The experiment was laid out in randomized block design (RBD) with 9 treatments in three replications. The results of study are presented in this chapter.

4.1 OBSERVATIONS ON WEEDS

The observations on weeds like weed flora, weed count, relative density, weed dry matter and weed control efficiency at 25 and 50 DAP were recorded and the results are presented below.

4.1.1 Weed Flora

The predominant grassy weeds present in the experimental field were *Digitaria sanguinalis, Eleusine indica, Digitaria ciliaris, Dactyloctenium aegyptium*, broad leaf weeds were *Chenopodium album, Eclipta prostrata, Amaranthus viridis and Phyllanthus niruri* and the only one sedge present in the field was *Cyperus rotundus*. At 25 DAP sedges were predominant followed by broad leaved weeds and grass weeds. At 50 DAP, broad leaved weeds were predominant followed by grasses and sedges.

4.1.2 Weed Count

The effect of various treatments on the number of grassy weeds, broadleaved weeds and sedges are depicted in Table 4.

4.1.2.1 Grassy Weeds

From the results it was revealed at 25 DAP the lowest number of grassy weeds was observed in T_5 (oxadiargyl 90 g ha^{-1} on 3-5 DAP *fb* hand weeding on 25 - 30 DAP) and at 50 DAP, both T_5 and T_2 (oxadiargyl 90 g ha^{-1}on 3-5 DAP *fb* carfentrazone ethyl 20 g ha^{-1}on 25-30 DAP) recorded the lowest number of grassy weeds. At both stages, weedy check recorded significantly higher number of grassy weeds.

Table 3. Predominant weed flora of the experimental field

Scientific name	Common name	Family
Broad leaved weeds		
Chenopodium album	Lambs quarters	Amaranthaceae
Eclipta prostrata	False daisy	Asteraceae
Phyllanthus niruri	Stone breaker weed	Euphorbiaceae
Amaranthus viridis	Slender amaranthus	Amaranthaceae
Grasses		
Digitaria sanguinalis	Large crab grass	Poacea
Eleusine indica	Goose grass	Poacea
Digitaria ciliaris	Crab grass	Poacea
Dactyloctonium aegyptium	Crow foot grass	Poacea
Sedges		
Cyperus rotundus	Purple nutsedge	Cyperaceae

4.1.2.2 Broad Leaved Weeds

With regard to BLW, the lowest number of BLW was observed in T_5 (oxadiargyl 90 g ha^{-1} on 3-5 DAP *fb* hand weeding on 25 - 30 DAP) at both 25 and 50 DAP and was significantly different from others. Weedy check recorded significantly higher number of BLW at both the stages.

4.1.2.3 Sedges

At 25 DAP, T_5 (oxadiargyl 90 g ha^{-1} on 3-5 DAP *fb* hand weeding on 25 - 30 DAP) recorded zero count of sedges and at 50 DAP, T_5 (oxadiargyl 90 g ha^{-1} on 3-5 DAP *fb* hand weeding on 25 - 30 DAP) and T_2 (oxadiargyl 90 g ha^{-1}on 3-5 DAP *fb* carfentrazone ethyl 20 g ha^{-1}on 25-30 DAP) recorded zero count of sedges. At both the stages of observation, weedy check recorded significantly higher number of sedges.

4.1.2.4 Total Weeds

With respect to total weed count, at 25 and 50 DAP the lowest total weed count was observed in T_5 (oxadiargyl 90 g ha^{-1} on 3-5 DAP *fb* hand weeding on 25 - 30 DAP) and T_9 (weedy check) recorded the highest total weed count.

4.1.3 Relative Density

The effect of weed management practices on relative density of weeds at 25 and 50 DAP are given in Table 5.

At 25 DAP , weed management strategies had no significant effect on relative density of grassy weeds. At 50 DAP, lower relative density of grassy weeds was observed in T_5 (oxadiargyl 90 g ha^{-1} on 3-5 DAP *fb* hand weeding on 25 - 30 DAP),T_2 (oxadiargyl 90 g ha^{-1}on 3-5 DAP *fb* carfentrazone ethyl 20 g ha^{-1}on 25-30 DAP) and T_4 (oxadiargyl 60 g ha^{-1} on 3-5 DAP *fb* hand weeding on 25 - 30 DAP). The highest relative density of grassy weeds was observed in T_9 (weedy check).

At 25 and 50 DAP, lower relative density of broad leaved weeds was observed in T_5 (oxadiargyl 90 g ha^{-1} on 3-5 DAP *fb* hand weeding on 25 - 30 DAP) and significantly higher relative density of broad leaved weeds was observed in T_9 (weedy check).

At 25 DAP, the relative density of sedges was recorded the lowest in T_5 (Oxadiargyl 90 g ha^{-1} on 3-5 DAP *fb* hand weeding on 25 - 30 DAP).

Table 4. Effect of weed management practices on weed count, number m^{-2}

Treatments	Grasses		Broad leaved weeds		Sedges		Total	
	25 DAP	50 DAP	25 DAP	50 DAP	25 DAP	50 DAP	25 DAP	50 DAP
T_1	4.33 (2.20)	1.33 (1.47)	5.66 (2.47)	1.66 (1.62)	6.00 (2.60)	2.00 (1.71)	15.99 (4.03)	4.99 (2.40)
T_2	1.66 (1.62)	0.33 (1.13)	2.66 (1.82)	0.66 (1.27)	1.00 (1.41)	0 (1.00)	5.32 (2.44)	0.99 (1.71)
T_3	2.33 (1.82)	1.00 (1.41)	3.66 (2.02)	1.33 (1.50)	5.00 (2.42)	2.00 (1.71)	10.99 (3.45)	4.33 (2.07)
T_4	1.00 (1.41)	0.66(1.27)	3.33 (2.03)	1.00 (1.41)	1.00 (1.41)	0.50 (1.21)	5.33 (2.49)	2.16 (1.77)
T_5	0.66 (1.27)	0.33(1.13)	1.66 (1.62)	0.33 (1.26)	0(1.0 0)	0 (1.00)	2.32 (1.68)	0.66 (1.27)
T_6	2.00 (1.71)	0.66(1.27)	3.66 (2.13)	1.33 (1.50)	1.50(1.52)	2.50 (1.72)	7.16 (2.83)	4.49 (1.69)
T_7	4.33 (2.15)	1.00(1.41)	4.66 (2.34)	1.66 (1.62)	6.00 (2.62)	1.50 (1.40)	14.99 (3.98)	4.16 (1.48)
T_8	4.33 (2.24)	1.66 (1.62)	7.33 (2.64)	3.33 (1. 67)	9.00 (3.11)	2.50 (1.72)	20.66 (4.64)	7.49 (2.60)
T_9	13.33 (3.71)	5.00 (2.39)	18.66 (4.38)	6.66 (1.90)	13.50 (3.74)	5.00 (2.40)	45.49 (6.81)	16.66 (4.20)
SEm (±)	0.35	0.19	0.50	0.21	0.30	0.06	0.10	0.19
CD (0.05)	1.08	0.58	1.58	0.65	0.93	0.19	0.36	0.54

Figures in parenthesis denote transformed values

Table 5. Effect of weed management practices on weed relative density, %

Treatments	Grasses		Broad leaved		Sedges	
	25 DAP	50 DAP	25 DAP	50 DAP	25 DAP	50 DAP
T_1	16.66 (4.18)	29.84 (5.51)	48.33 (7.05)	66.66 (7.22)	50.08 (6.09)	53.17 (6.58)
T_2	15.68 (4.01)	11.11 (3.44)	39.25 (6.38)	21.66 (5.11)	13.33 (3.48)	0 (1.00)
T_3	18.34 (4.49)	21.48 (4.73)	41.57 (6.57)	33.33 (5.85)	29.58 (5.22)	30.17 (5.24)
T_4	19.19 (4.50)	11.11 (3.44)	43.20 (6.68)	24.60 (4.77)	13.33 (3.48)	0 (1.00)
T_5	8.33 (2.96)	11.11 (3.44)	38.80 (6.27)	16.66 (4.18)	0 (1.00)	0 (1.00)
T_6	14.44 (3.92)	20.63 (3.56)	40.71 (6.44)	26.19 (4.87)	19.16 (3.90)	22.22 (4.87)
T_7	19.68 (4.48)	23.14 (4.67)	45.66 (6.82)	39.97 (5.98)	38.44 (5.90)	42.06 (6.67)
T_8	18.33 (4.38)	33.33 (5.85)	48.33 (7.01)	76.85 (8.22)	64.54 (7.00)	55.55 (7.20)
T_9	20.33 (4.62)	83.33 (9.15)	56.38 (7.50)	88.88 (9.66)	74.50 (8.30)	56.85 (7.95)
SEm (±)	0.05	0.03	0.02	0.11	0.04	0.17
CD (0.05)	NS	0.11	0.08	0.21	0.12	0.39

Figures in parenthesis denote transformed values

NS – non significant

However, at 50 DAP, lower relative density of sedges was recorded in T_5 (oxadiargyl 90 g ha^{-1} on 3-5 DAP *fb* hand weeding on 25 - 30 DAP), T_4 (oxadiargyl 60 g ha^{-1} on 3-5 DAP f*b* Hand weeding on 25 - 30 DAP) and T_2 (oxadiargyl 90 g ha^{-1}on 3-5 DAP *fb* carfentrazone ethyl 20 g ha^{-1}on 25-30 DAP). At both the stages of observation, weedy check (T_9) recorded the highest relative density of sedges.

4.1.4 Total Weed Dry Matter

The data on weed dry matter at 25 and 50 DAP are represented in Table 6. At 25 and 50 DAP, the lowest weed dry matter (0.54 and 0.26 g m^{-2}, respectively) was observed in T_5 (oxadiargyl 90 g ha^{-1} on 3-5 DAP *fb* hand weeding on 25 - 30 DAP) and weedy check (T_9) recorded significantly higher weed dry matter of 16.81 and 12.11 g m^{-2}, respectively.

4.1.5 Weed Control Efficiency

The data related to weed control efficiency at 25 and 50 DAP are presented in Table 7. At 25 and 50 DAP, the highest weed control efficiency was recorded in T_5 (oxadiargyl 90 g ha^{-1} on 3-5 DAP *fb* hand weeding on 25 - 30 DAP) which was on par with T_2 (oxadiargyl 90 g ha^{-1}on 3-5 DAP *fb* carfentrazone ethyl 20 g ha^{-1}on 25-30 DAP) and T_4 (oxadiargyl 60 g ha^{-1} on 3-5 DAP *fb* hand weeding on 25 - 30 DAP).

4.1.6 Weed Index

The data pertaining to weed index is presented in Table 8. The treatment T_5 (oxadiargyl 90 g ha^{-1} on 3-5 DAP *fb* hand weeding on 25 - 30 DAP) which recorded the lowest total weed dry weight and the highest yield was taken as the best treatment for calculating weed index. During first, second and third harvest the treatment T_5 recorded zero weed index and it was significantly superior over other treatments. Weedy check recorded a weed index of 49.39, 46.87 and 45.01 per cent respectively, during first, second and third harvest.

Table 6. Effect of weed management practices on total weed dry matter, g/m^2

Treatments	25 DAP	50 DAP
T_1. oxadiargyl 60 g ha^{-1} on 3-5 DAP *fb* carfentrazone ethyl 20 g ha^{-1} on 25-30 DAP	8.43	2.82
T_2. oxadiargyl 90 g ha^{-1} on 3-5 DAP *fb* carfentrazone ethyl 20 g ha^{-1} on 25-30 DAP	1.22	0.35
T_3. oxadiargyl 120 g ha^{-1} on 3-5 DAP *fb* carfentrazone ethyl 20 g ha^{-1} on 25-30 DAP	6.13	1.04
T_4. oxadiargyl 60 g ha^{-1} on 3-5 DAP *fb* hand weeding on 25 - 30 DAP	1.67	0.39
T_5. oxadiargyl 90 g ha^{-1} on 3-5 DAP *fb* hand weeding on 25 - 30 DAP	0.54	0.26
T_6. oxadiargyl 120 g ha^{-1} on 3-5 DAP *fb* hand weeding on 25 - 30 DAP	3.25	0.42
T_7. Biomulching	7.49	2.82
T_8. farmers practice (hand weeding at 20 and 40 DAP)	12.45	3.17
T_9. weedy check	16.81	12.11
SEm (±)	0.24	0.12
CD (0.05)	0.46	0.24

Table 7. Effect of weed management practices on weed control efficiency, %

Treatments	25 DAP	50 DAP
T_1. oxadiargyl 60 g ha^{-1} on 3-5 DAP *fb* carfentrazone ethyl 20 g ha^{-1} on 25-30 DAP	49.52 (7.44)	96.65 (8.70)
T_2. oxadiargyl 90 g ha^{-1} on 3-5 DAP *fb* carfentrazone ethyl 20 g ha^{-1} on 25-30 DAP	92.46 (8.99)	96.82 (9.54)
T_3. oxadiargyl 120 g ha^{-1} on 3-5 DAP *fb* carfentrazone ethyl 20 g ha^{-1} on 25-30 DAP	63.27 (7.74)	76.55 (7.94)
T_4. oxadiargyl 60 g ha^{-1} on 3-5 DAP *fb* hand weeding on 25 - 30 DAP	89.96 (9.48)	96.38 (9.47)
T_5. oxadiargyl 90 g ha^{-1} on 3-5 DAP *fb* hand weeding on 25 - 30 DAP	96.72 (9.61)	98.19 (9.90)
T_6. oxadiargyl 120 g ha^{-1} on 3-5 DAP *fb* hand weeding on 25 - 30 DAP	80.98 (7.94)	90.18 (8.59)
T_7. Biomulching	55.77 (7.06)	75.96 (7.27)
T_8. farmers practice (hand weeding at 20 and 40 DAP)	25.10 (4.69)	74.03 (7.89)
T_9. weedy check	0 (0)	0 (0)
SEm (±)	0.46	0.16
CD (0.05)	1.40	0.48

Figures in parenthesis denote transformed values

Table 8. Effect of weed management practices on weed index , %

Treatments	75 DAP (1st harvest)	120 DAP (2nd harvest)	165 DAP (3rd harvest)
T_1. oxadiargyl 60 g ha^{-1} on 3-5 DAP *fb* carfentrazone ethyl 20 g ha^{-1} on 25-30 DAP	23.81 (4.85)	27.91 (5.27)	26.25 (5.11)
T_2. oxadiargyl 90 g ha^{-1}on 3-5 DAP *fb* carfentrazone ethyl 20 g ha^{-1}on 25-30 DAP	8.64 (2.92)	11.41 (3.36)	11.29 (3.35)
T_3. oxadiargyl 120 g ha^{-1} on 3-5 DAP *fb* carfentrazone ethyl 20 g ha^{-1} on 25-30 DAP	16.62 (4.07)	21.97 (4.67)	20.76 (4.54)
T_4. oxadiargyl 60 g ha^{-1} on 3-5 DAP f*b* hand weeding on 25 - 30 DAP	20.01 (4.46)	19.74 (4.44)	17.57 (4.19)
T_5. oxadiargyl 90 g ha^{-1} on 3-5 DAP *fb* hand weeding on 25 - 30 DAP	0 (0)	0 (0)	0 (0)
T_6. oxadiargyl 120 g ha^{-1} on 3-5 DAP *fb* hand weeding on 25 - 30 DAP	25.65 (5.04)	21.18 (4.58)	18.85 (4.32)
T_7. Biomulching	30.16 (5.49)	23.53 (4.84)	23.97 (4.89)
T_8. farmers practice (hand weeding at 20 and 40 DAP)	42.03 (6.45)	34.63 (5.88)	34.28 (5.85)
T_9. weedy check	49.39 (7.02)	46.87 (6.84)	45.01 (6.70)
SEm (±)	0.22	0.18	0.16
CD (0.05)	0.68	0.55	0.51

Figures in parenthesis denote transformed values

4.2 OBSERVATIONS ON CROP

4.2.1 Growth and Yield Attributes

4.2.1.1 Plant Height

The effect of treatments on plant height at three different harvests (at 75 DAP, 120 DAP and 165 DAP) are documented in Table 9. At first harvest (75 DAP), second harvest (120 DAP) and third harvest (165 DAP), treatment T_5 (oxadiargyl 90 g ha^{-1} on 3-5 DAP *fb* hand weeding on 25 - 30 DAP) recorded the highest plant height which was on par with T_2 (oxadiargyl 90 g ha^{-1}on 3-5 DAP *fb* carfentrazone ethyl 20 g ha^{-1}on 25-30 DAP). At all three harvests, weedy check recorded significantly lower plant height

4.2.1.2 Leaf Area

Data pertaining to leaf area is furnished in Table 10. In the first, second and third harvests significantly higher leaf area of 4.72, 7.97 and 9.17, respectively were recorded in T_5 (oxadiargyl 90 g ha^{-1} on 3-5 DAP *fb* hand weeding on 25 - 30 DAP) and the lowest leaf area of 0.43, 0.74 and 1.12, respectively were recorded in T_9 (weedy check- 0).

4.2.1.3 Number of Tillers

The data on number of tillers per plant is furnished in Table 11. During all the three harvests, significantly higher number of tillers of 15.66,18.33 and 23.00 per plant, respectively were observed in T_5 (oxadiargyl 90 g ha^{-1} on 3-5 DAP *fb* hand weeding on 25 - 30 DAP) and the lowest number of tillers per plant (4.33,7.33 and 9.66 respectively)was recorded in T_9 (weedy check).

4.2.1.4 Leaf Stem Ratio

The data on leaf stem ratio is presented in Table 12.

During first, second and third harvest, the highest leaf stem ratio (0.86, 1.24 and 1.24, respectively) were registered in T_5 (oxadiargyl 90 g ha^{-1} on 3-5 DAP *fb* hand weeding on 25 - 30 DAP) . However, during second harvest it was on par with T_2 (oxadiargyl 90 g ha^{-1}on 3-5 DAP *fb* carfentrazone ethyl 20 g ha^{-1}on 25-30 DAP) and on par with T_2 and T_3 during third harvest. In all the three harvests, lowest leaf stem ratios (0.48, 0.61 and 1.19, respectively) were recorded in T_9 (weedy check).

Table 9. Effect of weed management practices on plant height at each harvest, cm

Treatments	75 DAP (1st harvest)	120 DAP (2nd harvest)	165 DAP (3rd harvest)
T_1. oxadiargyl 60 g ha^{-1} on 3-5 DAP *fb* carfentrazone ethyl 20 g ha^{-1} on 25-30 DAP	240.33	218.50	200.00
T_2. oxadiargyl 90 g ha^{-1}on 3-5 DAP *fb* carfentrazone ethyl 20 g ha^{-1}on 25-30 DAP	281.29	250.60	228.06
T_3. oxadiargyl 120 g ha^{-1} on 3-5 DAP *fb* carfentrazone ethyl 20 g ha^{-1} on 25-30 DAP	249.33	232.50	199.16
T_4. oxadiargyl 60 g ha^{-1} on 3-5 DAP f*b* hand weeding on 25 - 30 DAP	257.00	224.66	220.00
T_5. oxadiargyl 90 g ha^{-1} on 3-5 DAP *fb* hand weeding on 25 - 30 DAP	283.00	252.50	235.66
T_6. oxadiargyl 120 g ha^{-1} on 3-5 DAP *fb* hand weeding on 25 - 30 DAP	236.33	234.49	199.49
T_7. Biomulching	253.66	250.15	220.10
T_8. farmers practice (hand weeding at 20 and 40 DAP)	267.33	241.39	209.06
T_9. weedy check	235.00	217.66	192.61
SEm (±)	1.27	2.07	2.58
CD (0.05)	3.83	6.27	7.82

Table 10. Effect of weed management practices on leaf area at each harvest, m^2 per plant

Treatments	75 DAP (1st harvest)	120 DAP (2nd harvest)	165 DAP (3rd harvest)
T_1. oxadiargyl 60 g ha^{-1} on 3-5 DAP *fb* carfentrazone ethyl 20 g ha^{-1} on 25-30 DAP	1.17	2.33	2.78
T_2. oxadiargyl 90 g ha^{-1}on 3-5 DAP *fb* carfentrazone ethyl 20 g ha^{-1}on 25-30 DAP	3.93	5.46	6.16
T_3. oxadiargyl 120 g ha^{-1} on 3-5 DAP *fb* carfentrazone ethyl 20 g ha^{-1} on 25-30 DAP	1.61	3.47	3.97
T_4. oxadiargyl 60 g ha^{-1} on 3-5 DAP f*b* hand weeding on 25 - 30 DAP	2.26	2.78	3.42
T_5. oxadiargyl 90 g ha^{-1} on 3-5 DAP *fb* hand weeding on 25 - 30 DAP	4.72	7.97	9.17
T_6. oxadiargyl 120 g ha^{-1} on 3-5 DAP *fb* hand weeding on 25 - 30 DAP	1.73	1.84	2.35
T_7. Biomulching	1.39	1.59	2.06
T_8. farmers practice (hand weeding at 20 and 40 DAP)	0.69	1.24	1.62
T_9. weedy check	0.43	0.74	1.12
SEm (±)	0.10	0.19	0.21
CD (0.05)	0.21	0.26	0.44

Table 11. Effect of weed management practices on number of tillers per plant at each harvest

Treatments	75 DAP (1st harvest)	120 DAP (2nd harvest)	165 DAP (3rd harvest)
T_1. oxadiargyl 60 g ha^{-1} on 3-5 DAP *fb* carfentrazone ethyl 20 g ha^{-1} on 25-30 DAP	6.33	10.66	14.00
T_2. oxadiargyl 90 g ha^{-1}on 3-5 DAP *fb* carfentrazone ethyl 20 g ha^{-1}on 25-30 DAP	12.33	15.33	19.00
T_3. oxadiargyl 120 g ha^{-1} on 3-5 DAP *fb* carfentrazone ethyl 20 g ha^{-1} on 25-30 DAP	7.66	14.33	20.33
T_4. oxadiargyl 60 g ha^{-1} on 3-5 DAP f*b* hand weeding on 25 - 30 DAP	12.00	11.66	13.66
T_5. oxadiargyl 90 g ha^{-1} on 3-5 DAP *fb* hand weeding on 25 - 30 DAP	15.66	18.33	23.00
T_6. oxadiargyl 120 g ha^{-1} on 3-5 DAP *fb* hand weeding on 25 - 30 DAP	8.33	10.00	12.66
T_7. Biomulching	6.66	9.33	12.33
T_8. farmers practice (hand weeding at 20 and 40 DAP)	5.66	8.33	10.33
T_9. weedy check	4.33	7.33	9.66
SEm (±)	0.64	0.57	0.73
CD (0.05)	1.26	1.16	1.47

Table 12. Effect of weed management practices on leaf stem ratio at each harvest

Treatments	75 DAP (1st harvest)	120 DAP (2nd harvest)	165 DAP (3rd harvest)
T_1. oxadiargyl 60 g ha^{-1} on 3-5 DAP *fb* carfentrazone ethyl 20 g ha^{-1} on 25-30 DAP	0.54	1.04	1.21
T_2. oxadiargyl 90 g ha^{-1}on 3-5 DAP *fb* carfentrazone ethyl 20 g ha^{-1}on 25-30 DAP	0.85	1.19	1.23
T_3. oxadiargyl 120 g ha^{-1} on 3-5 DAP *fb* carfentrazone ethyl 20 g ha^{-1} on 25-30 DAP	0.59	1.09	1.23
T_4. oxadiargyl 60 g ha^{-1} on 3-5 DAP f*b* hand weeding on 25 - 30 DAP	0.69	1.09	1.22
T_5. oxadiargyl 90 g ha^{-1} on 3-5 DAP *fb* hand weeding on 25 - 30 DAP	0.86	1.24	1.24
T_6. oxadiargyl 120 g ha^{-1} on 3-5 DAP *fb* hand weeding on 25 - 30 DAP	0.6	0.98	1.21
T_7. Biomulching	0.57	0.70	1.20
T_8. farmers practice (hand weeding at 20 and 40 DAP)	0.53	0.69	1.20
T_9. weedy check	0.48	0.61	1.19
SEm (±)	0.02	0.04	0.006
CD (0.05)	0.06	0.12	0.01

4.2.1.5 Tussock Diameter

The data on effect of weed management strategies on tussock diameter is presented in Table 13.

During the first, second and third harvest significantly higher tussock diameter (93.23, 98.23 and 100.43cm, respectively) was observed in T_5 (oxadiargyl 90 g ha^{-1} on 3-5 DAP *fb* hand weeding on 25 - 30 DAP) and the lowest tussock diameter (50.00, 55.00 and 55.75 cm, respectively) was recorded in T_9 (weedy check).

4.2.1.6 Leaf Chlorophyll

The results on the effect of treatments on leaf chlorophyll content at each harvest is presented in Table 14. During first harvest the highest leaf chlorophyll content (1.2 mg g^{-1}) was observed in T_9 (weedy check) which was on par with T_8 (farmers practice - hand weeding at 20 and 40 DAP) and the lowest chlorophyll content (0.58 mg g^{-1}) was registered in T_2 (oxadiargyl 90 g ha^{-1}on 3-5 DAP *fb* carfentrazone ethyl 20 g ha^{-1}on 25-30 DAP). During second harvest the highest leaf chlorophyll content (1.14 mg g^{-1}) was observed in T_8 (farmers practice hand weeding at 20 and 40 DAP) which was on par with plants in T_7 (biomulching - 1.11 mg g^{-1}) and the lowest (0.62 mg g^{-1}) was observed in T_2 (oxadiargyl 90 g ha^{-1}on 3-5 DAP *fb* carfentrazone ethyl 20 g ha^{-1}on 25-30 DAP) and during third harvest, the highest leaf chlorophyll content was observed in T_7 (biomulching) which was on par with T_8 (farmers practice - hand weeding at 20 and 40 DAP) and T_9 (weedy check) and the lowest (0.78 mg g^{-1}) was observed in T_3 (oxadiargyl 120 g ha^{-1} on 3-5 DAP *fb* carfentrazone ethyl 20 g ha^{-1} on 25-30 DAP

4.2.1.7 Green Fodder Yield

The data on green fodder yield is presented in Table 15.

The treatment T_5 (oxadiargyl 90 g ha^{-1} on 3-5 DAP *fb* hand weeding on 25 - 30 DAP) recorded significantly higher green fodder yield of 54.09, 50.12 and 50.62 t ha^{-1}, respectively during the first, second and third harvest and the treatment T_5 was followed by T_2 (oxadiargyl 120 g ha^{-1} on 3-5 DAP *fb* carfentrazone ethyl 20 g ha^{-1} on 25-30 DAP-45.09 t ha^{-1}). The treatment T_9 (weedy check) recorded the lowest green fodder yield of 27.34, 26.64 and 27.85 t ha^{-1}, respectively at all the three harvests.

Table 13. Effect of weed management practices on tussock diameter at each harvest, cm per hill

Treatments	75 DAP (1st harvest)	120 DAP (2nd harvest)	165 DAP (3rd harvest)
T_1. oxadiargyl 60 g ha^{-1} on 3-5 DAP *fb* carfentrazone ethyl 20 g ha^{-1} on 25-30 DAP	54.88	59.88	62.33
T_2. oxadiargyl 90 g ha^{-1}on 3-5 DAP *fb* carfentrazone ethyl 20 g ha^{-1}on 25-30 DAP	76.50	84.50	86.16
T_3. oxadiargyl 120 g ha^{-1} on 3-5 DAP *fb* carfentrazone ethyl 20 g ha^{-1} on 25-30 DAP	60.83	65.20	65.50
T_4. oxadiargyl 60 g ha^{-1} on 3-5 DAP f*b* hand weeding on 25 - 30 DAP	62.00	70.00	70.50
T_5. oxadiargyl 90 g ha^{-1} on 3-5 DAP *fb* hand weeding on 25 - 30 DAP	93.23	98.23	100.43
T_6. oxadiargyl 120 g ha^{-1} on 3-5 DAP *fb* hand weeding on 25 - 30 DAP	56.44	61.44	62.83
T_7. Biomulching	56.61	62.61	64.85
T_8. farmers practice (hand weeding at 20 and 40 DAP)	60.00	65.00	65.55
T_9. weedy check	50.00	55.00	55.75
SEm (±)	1.13	0.92	1.06
CD (0.05)	3.42	2.80	3.20

Table 14. Effect of weed management practices on leaf chlorophyll content at each harvest, mg g^{-1}

Treatments	75 DAP (1st harvest)	120 DAP (2nd harvest)	165 DAP (3rd harvest)
T_1. oxadiargyl 60 g ha^{-1} on 3-5 DAP *fb* carfentrazone ethyl 20 g ha^{-1} on 25-30 DAP	0.67	0.83	0.84
T_2. oxadiargyl 90 g ha^{-1}on 3-5 DAP *fb* carfentrazone ethyl 20 g ha^{-1}on 25-30 DAP	0.58	0.62	0.79
T_3. oxadiargyl 120 g ha^{-1} on 3-5 DAP *fb* carfentrazone ethyl 20 g ha^{-1} on 25-30 DAP	0.77	0.99	0.78
T_4. oxadiargyl 60 g ha^{-1} on 3-5 DAP f*b* hand weeding on 25 - 30 DAP	0.86	1.07	0.96
T_5. oxadiargyl 90 g ha^{-1} on 3-5 DAP *fb* hand weeding on 25 - 30 DAP	0.97	1.07	1.01
T_6. oxadiargyl 120 g ha^{-1} on 3-5 DAP *fb* hand weeding on 25 - 30 DAP	0.92	1.06	1.00
T_7. Biomulching	1.10	1.11	1.09
T_8. farmers practice (hand weeding at 20 and 40 DAP)	1.19	1.14	1.06
T_9. weedy check	1.20	0.97	1.06
SEm (±)	0.02	0.07	0.023
CD (0.05)	0.08	0.22	0.07

The total green fodder yield also followed the same trend as that of green fodder yield at each harvest. The treatment T_5 (oxadiargyl 90 g ha^{-1} on 3-5 DAP *fb* hand weeding on 25 - 30 DAP) recorded the highest total green fodder yield (154.84 t ha^{-1}) and the weedy check (T_9) recorded the lowest total green fodder yield (81.84 t ha^{-1}).

4.2.1.8 Dry Fodder Yield

Table 16. shows the effect of treatments on dry fodder yield.

Results on dry fodder yield followed the same trend of green fodder yield. The treatment T_5 (oxadiargyl 90 g ha-1 on 3-5 DAP *fb* hand weeding on 25 - 30 DAP) recorded significantly higher dry fodder yield of 10.81, 10.02 and 10.12 t ha^{-1}, respectively during first, second and third harvests and was significantly superior to other treatments. Weedy check (T9) recorded the lowest dry fodder yields of 5.46, 5.82 and 5.57 t ha^{-1}, respectively during first, second and third harvests.

Total dry fodder yield also followed the same trend of dry fodder yield of individual harvests. The highest total dry fodder yield was registered in T_5 (oxadiargyl 90 g ha^{-1} on 3-5 DAP *fb* hand weeding on 25 - 30 DAP) (30.96 t ha^{-1}) and the lowest total dry fodder yield was obtained in T_9 (weedy check) (16.36 t ha^{-1}).

4.2.2 Quality Characters

4.2.2.1 Crude Protein Content

The results on the effect of weed management practices on crude protein content is presented in Table 17. The highest crude protein content (9.70 %) was recorded in T_2 (Oxadiargyl 90 g ha^{-1}on 3-5 DAP fb Carfentrazone ethyl 20 g ha^{-1}on 25-30 DAP) which was on par with T_5 (Oxadiargyl 90 g ha^{-1} on 3-5 DAP *fb* Hand weeding on 25 - 30 DAP -9.40 %) and the lowest crude protein was recorded in T_9 (weedy check - 8.14 %).

Table 15. Effect of weed management practices on green fodder yield at each harvest, t ha^{-1}

Treatments	75 DAP (1^{st} harvest)	120 DAP (2^{nd} harvest)	165 DAP (3^{rd} harvest)	Total green fodder yield
T_1. oxadiargyl 60 g ha^{-1} on 3-5 DAP *fb* carfentrazone ethyl 20 g ha^{-1} on 25-30 DAP	41.14	36.14	37.34	114.63
T_2. oxadiargyl 90 g ha^{-1}on 3-5 DAP *fb* carfentrazone ethyl 20 g ha^{-1}on 25-30 DAP	49.39	44.39	44.89	138.68
T_3. oxadiargyl 120 g ha^{-1} on 3-5 DAP *fb* carfentrazone ethyl 20 g ha^{-1} on 25-30 DAP	45.09	39.09	40.09	124.29
T_4. oxadiargyl 60 g ha^{-1} on 3-5 DAP f*b* hand weeding on 25 - 30 DAP	43.22	40.22	41.72	125.18
T_5. oxadiargyl 90 g ha^{-1} on 3-5 DAP *fb* hand weeding on 25 - 30 DAP	54.09	50.12	50.62	154.84
T_6. oxadiargyl 120 g ha^{-1} on 3-5 DAP *fb* hand weeding on 25 - 30 DAP	40.28	39.495	41.06	120.84
T_7. Biomulching	37.76	38.33	38.49	114.58
T_8. farmers practice (hand weeding at 20 and 40 DAP)	31.25	32.76	33.26	97.27
T_9. weedy check	27.34	26.64	27.85	81.84
SEm (±)	1.40	0.90	0.79	2.58
CD (0.05)	4.25	2.73	2.41	7.81

Table 16. Effect of weed management practices on dry fodder yield at each harvest, t ha^{-1}

Treatments	75 DAP (1st harvest)	120 DAP (2nd harvest)	165 DAP (3rd harvest)	Total dry fodder yield
T_1. oxadiargyl 60 g ha^{-1} on 3-5 DAP *fb* carfentrazone ethyl 20 g ha^{-1} on 25-30 DAP	8.22	7.22	7.46	22.92
T_2. oxadiargyl 90 g ha^{-1}on 3-5 DAP *fb* carfentrazone ethyl 20 g ha^{-1}on 25-30 DAP	9.87	8.87	8.97	27.73
T_3. oxadiargyl 120 g ha^{-1} on 3-5 DAP *fb* carfentrazone ethyl 20 g ha^{-1} on 25-30 DAP	9.02	7.82	8.02	24.85
T_4. oxadiargyl 60 g ha^{-1} on 3-5 DAP f*b* hand weeding on 25 - 30 DAP	8.64	8.04	8.34	25.03
T_5. oxadiargyl 90 g ha^{-1} on 3-5 DAP *fb* hand weeding on 25 - 30 DAP	10.81	10.02	10.12	30.96
T_6. oxadiargyl 120 g ha^{-1} on 3-5 DAP *fb* hand weeding on 25 - 30 DAP	8.05	7.89	8.21	24.16
T_7. Biomulching	7.55	7.66	7.69	22.91
T_8. farmers practice (hand weeding at 20 and 40 DAP)	6.25	6.55	6.65	19.45
T_9. weedy check	5.46	5.32	5.57	16.36
SEm (±)	0.28	0.18	0.16	0.51
CD (0.05)	0.85	0.54	0.48	1.56

4.2.2.2 Crude Fibre Content

The results on the effect of weed management practices on crude fibre content is presented in Table 17. The lowest crude fibre content was recorded in T_2 (Oxadiargyl 90 g ha^{-1}on 3-5 DAP *fb* Carfentrazone ethyl 20 g ha^{-1}on 25-30 DAP-35.2 %) which was on par with T_5 (Oxadiargyl 90 g ha^{-1} on 3-5 DAP *fb* Hand weeding on 25 - 30 DAP- 36.03 %). The highest crude fibre content (38.11 %) was recorded in T_9 (weedy check).

4.2.3 Physiological Parameters (at 25, 50 and 75 DAP)

4.2.3.1 Crop Growth Rate (CGR)

The results on the effect of treatments on CGR is presented in Table 18.

During both the time intervals (25- 50 DAP and 50-75 DAP), T_5 (oxadiargyl 90 g ha^{-1} on 3-5 DAP *fb* hand weeding on 25 - 30 DAP) recorded significantly higher CGR and T_9 (weedy check) recorded the lowest CGR.

4.2.3.2 Relative Growth Rate (RGR)

The results on the effect of treatments on RGR is presented in Table 19 . Weed management practices had no significant effect on RGR at both the time intervals (25-50 and 50-75 DAP, respectively).

4.2.3.3 Total Chlorophyll Content

The results on the effect of treatments on total chlorophyll content is presented in Table 20. At 25 and 50, higher total chlorophyll content (1.16, 1.17 mg g^{-1}, respectively) was observed in T_5 (Oxadiargyl 90 g ha^{-1} on 3-5 DAP *fb* hand weeding on 25 - 30 DAP) which was on par with T_2 (Oxadiargyl 90 g ha^{-1}on 3-5 DAP *fb* Carfentrazone ethyl 20 g ha^{-1}on 25-30 DAP-1.11 mg g^{-1}). However, at 75 DAP, higher chlorophyll content was observed in T_7 (biomulching- 1.15 g g^{-1} day^{-1}) which was on par with T_2 (oxadiargyl 90 g ha^{-1}on 3-5 DAP *fb* Carfentrazone ethyl 20 g ha^{-1}on 25-30 DAP -1.10 g g^{-1} day^{-1}) and T_6 (oxadiargyl 120 g ha^{-1} on 3-5 DAP fb Hand weeding on 25 - 30 DAP-1.10 g g^{-1} day^{-1}. Weedy check (T_9) recorded the lowest was total chlorophyll content at all the three stages of observation.

Table 17. Effect of weed management practices on crude protein content and crude fibre content, per cent

Treatments	Crude protein	Crude fibre
T_1. oxadiargyl 60 g ha^{-1} on 3-5 DAP *fb* carfentrazone ethyl 20 g ha^{-1} on 25-30 DAP	8.45	37.88
T_2. oxadiargyl 90 g ha^{-1}on 3-5 DAP *fb* carfentrazone ethyl 20 g ha^{-1}on 25-30 DAP	9.70	35.20
T_3. oxadiargyl 120 g ha^{-1} on 3-5 DAP *fb* carfentrazone ethyl 20 g ha^{-1} on 25-30 DAP	8.74	36.77
T_4. oxadiargyl 60 g ha^{-1} on 3-5 DAP f*b* hand weeding on 25 - 30 DAP	8.84	36.43
T_5. oxadiargyl 90 g ha^{-1} on 3-5 DAP *fb* hand weeding on 25 - 30 DAP	9.4	36.03
T_6. oxadiargyl 120 g ha^{-1} on 3-5 DAP *fb* hand weeding on 25 - 30 DAP	8.78	37.51
T_7. Biomulching	8.56	37.07
T_8. farmers practice (hand weeding at 20 and 40 DAP)	8.19	38.05
T_9. weedy check	8.14	38.11
SEm (±)	0.10	0.59
CD (0.05)	0.33	1.17

Table 18. Effect of weed management practices on crop growth rate (CGR) , g m^{-2} day^{-1}

Treatments	25-50 DAP	50-75 DAP
T_1. oxadiargyl 60 g ha^{-1} on 3-5 DAP *fb* carfentrazone ethyl 20 g ha^{-1} on 25-30 DAP	1.33	1.41
T_2. oxadiargyl 90 g ha^{-1}on 3-5 DAP *fb* carfentrazone ethyl 20 g ha^{-1}on 25-30 DAP	1.54	1.61
T_3. oxadiargyl 120 g ha^{-1} on 3-5 DAP *fb* carfentrazone ethyl 20 g ha^{-1} on 25-30 DAP	1.38	1.48
T_4. oxadiargyl 60 g ha^{-1} on 3-5 DAP f*b* hand weeding on 25 - 30 DAP	1.52	1.54
T_5. oxadiargyl 90 g ha^{-1} on 3-5 DAP *fb* hand weeding on 25 - 30 DAP	1.58	1.68
T_6. oxadiargyl 120 g ha^{-1} on 3-5 DAP *fb* hand weeding on 25 - 30 DAP	1.40	1.50
T_7. Biomulching	1.33	1.44
T_8. farmers practice (hand weeding at 20 and 40 DAP)	1.27	1.38
T_9. weedy check	1.07	1.17
SEm (±)	0.02	0.03
CD (0.05)	0.08	0.08

Table 19. Effect of weed management practices on relative growth rate (RGR), g g^{-1} day^{-1}

Treatments	25-50 DAP	50-75 DAP
T_1. oxadiargyl 60 g ha^{-1} on 3-5 DAP *fb* carfentrazone ethyl 20 g ha^{-1} on 25-30 DAP	0.01	0.01
T_2. oxadiargyl 90 g ha^{-1}on 3-5 DAP *fb* carfentrazone ethyl 20 g ha^{-1}on 25-30 DAP	0.01	0.01
T_3. oxadiargyl 120 g ha^{-1} on 3-5 DAP *fb* carfentrazone ethyl 20 g ha^{-1} on 25-30 DAP	0.02	0.01
T_4. oxadiargyl 60 g ha^{-1} on 3-5 DAP f*b* hand weeding on 25 - 30 DAP	0.01	0.01
T_5. oxadiargyl 90 g ha^{-1} on 3-5 DAP *fb* hand weeding on 25 - 30 DAP	0.02	0
T_6. oxadiargyl 120 g ha^{-1} on 3-5 DAP *fb* hand weeding on 25 - 30 DAP	0.01	0.01
T_7. Biomulching	0.01	0
T_8. farmers practice (hand weeding at 20 and 40 DAP)	0.01	0
T_9. weedy check	0.01	0.01
SEm (±)	0	0
CD (0.05)	N/S	N/S

NS-non significant

Table 20. Effect of weed management practices on total chlorophyll content, mg g^{-1}

Treatments	25 DAP	50 DAP	75 DAP
T_1. oxadiargyl 60 g ha^{-1} on 3-5 DAP *fb* carfentrazone ethyl 20 g ha^{-1} on 25-30 DAP	0.86	0.99	0.95
T_2. oxadiargyl 90 g ha^{-1}on 3-5 DAP *fb* carfentrazone ethyl 20 g ha^{-1}on 25-30 DAP	1.11	1.16	1.10
T_3. oxadiargyl 120 g ha^{-1} on 3-5 DAP *fb* carfentrazone ethyl 20 g ha^{-1} on 25-30 DAP	0.92	1.06	0.97
T_4. oxadiargyl 60 g ha^{-1} on 3-5 DAP f*b* hand weeding on 25 - 30 DAP	1.06	1.13	0.98
T_5. oxadiargyl 90 g ha^{-1} on 3-5 DAP *fb* hand weeding on 25 - 30 DAP	1.16	1.17	0.96
T_6. oxadiargyl 120 g ha^{-1} on 3-5 DAP *fb* hand weeding on 25 - 30 DAP	1.03	1.06	1.10
T_7. Biomulching	0.91	1.04	1.15
T_8. farmers practice (hand weeding at 20 and 40 DAP)	0.76	0.94	1.07
T_9. weedy check	0.74	0.83	0.91
SEm (±)	0.02	0.01	0.01
CD (0.05)	0.08	0.03	0.05

4.3 SOIL ANALYSIS AFTER THE EXPERIMENT

4.3.1 Organic Carbon Content

The results on the effect of weed management treatments on the organic carbon content of soil is presented in Table 21. The results revealed that the highest organic carbon content of the soil was recorded in T_7 (biomulching-1.02 %) and the lowest organic carbon content (0.92 %) in T_1 (oxadiargyl 60 g ha^{-1} on 3-5 DAP *fb* carfentrazone ethyl 20 g ha^{-1} on 25-30 DAP).

4.3.2 Soil pH

The results on the effect of weed management treatments on the pH of soil is presented in Table 21. Weed management showed significant influence on the pH of the soil. The pH of the soil was significantly higher in T_2 (oxadiargyl 90 g ha^{-1}on 3-5 DAP *fb* carfentrazone ethyl 20 g ha^{-1}on 25-30 DAP) and the lowest in T_9 (weedy check).

4.3.3 Soil EC

The results on the effect of weed management treatments on the EC of soil is presented in Table 21. The results revealed that the weed management strategies had no significant effect on soil EC.

4.3.4 Available Nitrogen

The results on the available soil N of post-harvest soil is presented in Table 22. The results revealed that higher available soil N was observed in T_9 (weedy check) (336.99 kg ha^{-1}) which was on par with T_8 (farmers practice). The treatment T_5 (oxadiargyl 90 g ha^{-1} on 3-5 DAP *fb* hand weeding on 25 - 30 DAP) recorded the lowest available soil N (320.16 kg ha^{-1}).

4.3.5 Available Phosphorus

The results on the available P content of soil is presented in Table 22. The results revealed that available soil P was higher in T_4 (oxadiargyl 60 g ha^{-1} on 3-5 DAP *fb* hand weeding on 25 - 30 DAP) (79.15 kg ha^{-1}) and was on par with T_5 (oxadiargyl 90 g ha^{-1} on 3-5 DAP *fb* hand weeding on 25 - 30 DAP) and T_1 (oxadiargyl 60 g ha^{-1} on 3-5 DAP *fb* Carfentrazone ethyl 20 g ha^{-1} on 25-30 DAP). The lowest available soil P was observed in T_8 (farmers practice) (69.61 kg ha^{-1}).

Table 21. Effect of weed management practices on organic carbon (per cent), pH and EC (dSm^{-1}) of soil after the experiment

Treatments	Organic carbon (per cent)	pH	EC (dSm^{-1})
T_1. oxadiargyl 60 g ha^{-1} on 3-5 DAP *fb* carfentrazone ethyl 20 g ha^{-1} on 25-30 DAP	0.92	5.28	0.86
T_2. oxadiargyl 90 g ha^{-1}on 3-5 DAP *fb* carfentrazone ethyl 20 g ha^{-1}on 25-30 DAP	0.95	5.50	0.88
T_3. oxadiargyl 120 g ha^{-1} on 3-5 DAP *fb* carfentrazone ethyl 20 g ha^{-1} on 25-30 DAP	0.99	5.44	0.86
T_4. oxadiargyl 60 g ha^{-1} on 3-5 DAP f*b* hand weeding on 25 - 30 DAP	0.96	5.29	0.87
T_5. oxadiargyl 90 g ha^{-1} on 3-5 DAP *fb* hand weeding on 25 - 30 DAP	0.95	5.20	0.87
T_6. oxadiargyl 120 g ha^{-1} on 3-5 DAP *fb* hand weeding on 25 - 30 DAP	0.98	5.12	0.85
T_7. Biomulching	1.02	5.14	0.87
T_8. farmers practice (hand weeding at 20 and 40 DAP)	0.98	5.12	0.86
T_9. weedy check	1.01	5.07	0.87
SEm (±)	0.01	0.01	0
CD (0.05)	0.04	0.04	NS

4.3.6 Available Potassium

The results on the available soil K of post-harvest soil is presented in Table 22. The results revealed that available soil K was higher in T_9 (weedy check) (258.88 kg ha^{-1}), on par with T_8 (farmers practice). The lowest available soil K was observed in T_5 (oxadiargyl 90 g ha^{-1} on 3-5 DAP *fb* hand weeding on 25 -30 DAP) (243.97 kg ha^{-1}).

4.4 PLANT ANALYSIS

4.4.1 Nitrogen Uptake

The results on the effect of weed management practices on N uptake by BN hybrid is presented in Table 23. The results revealed that significantly higher N uptake (318.97 kg ha^{-1}) was observed in T_5 (oxadiargyl 90 g ha^{-1} on 3-5 DAP *fb* hand weeding on 25 - 30 DAP) and lower N uptake was observed in T_9 (weedy check (168.59 kg ha^{-1}).

4.4.2 Phosphorus Uptake

The results on the effect of weed management practices on P uptake by BN hybrid is presented in Table 23. The results revealed that significantly higher P uptake was observed in T_5 (oxadiargyl 90 g ha^{-1} on 3-5 DAP *fb* hand weeding on 25 - 30 DAP) (27.87 kg ha^{-1}) and lower P uptake was observed in T_9 (weedy check (14.73 kg ha^{-1}).

4.4.3 Potassium Uptake

The results on the effect of weed management practices on K uptake by BN hybrid is presented in Table 23. The results revealed that significantly higher K uptake was observed in T_5 (oxadiargyl 90 g ha^{-1} on 3-5 DAP *fb* hand weeding on 25 - 30 DAP (356.14 kg ha^{-1}) and lower K uptake was observed in T_9 (weedy check) (188.23 kg ha^{-1}).

Table 22. Effect of weed management practices on available nitrogen, phosphorus and potassium status of soil after the experiment, kg ha^{-1}

Treatments	N	P	K
T_1. oxadiargyl 60 g ha^{-1} on 3-5 DAP *fb* carfentrazone ethyl 20 g ha^{-1} on 25-30 DAP	331.63	77.62	256.49
T_2. oxadiargyl 90 g ha^{-1}on 3-5 DAP *fb* carfentrazone ethyl 20 g ha^{-1}on 25-30 DAP	321.65	71.53	247.42
T_3. oxadiargyl 120 g ha^{-1} on 3-5 DAP *fb* carfentrazone ethyl 20 g ha^{-1} on 25-30 DAP	326.89	74.30	255
T_4. oxadiargyl 60 g ha^{-1} on 3-5 DAP f*b* hand weeding on 25 - 30 DAP	322.67	79.15	248
T_5. oxadiargyl 90 g ha^{-1} on 3-5 DAP *fb* hand weeding on 25 - 30 DAP	320.16	78.69	243.97
T_6. oxadiargyl 120 g ha^{-1} on 3-5 DAP *fb* hand weeding on 25 - 30 DAP	326.73	72.92	248
T_7. Biomulching	330.64	76.70	255.333
T_8. farmers practice (hand weeding at 20 and 40 DAP)	332.93	69.61	257.76
T_9. weedy check	336.99	72.77	258.88
SEm (±)	1.38	0.87	0.709
CD (0.05)	4.17	2.63	2.144

Table 23. Effect of weed management practices on the uptake of nitrogen, phosphorus and potassium, kg ha^{-1}

Treatments	N Uptake	P Uptake	K Uptake
T_1. oxadiargyl 60 g ha^{-1} on 3-5 DAP *fb* carfentrazone ethyl 20 g ha^{-1} on 25-30 DAP	236.15	20.63	263.66
T_2. oxadiargyl 90 g ha^{-1}on 3-5 DAP *fb* carfentrazone ethyl 20 g ha^{-1}on 25-30 DAP	285.69	24.96	318.98
T_3. oxadiargyl 120 g ha^{-1} on 3-5 DAP *fb* carfentrazone ethyl 20 g ha^{-1} on 25-30 DAP	256.05	22.37	285.88
T_4. oxadiargyl 60 g ha^{-1} on 3-5 DAP f*b* hand weeding on 25 - 30 DAP	257.88	22.53	287.93
T_5. oxadiargyl 90 g ha^{-1} on 3-5 DAP *fb* hand weeding on 25 - 30 DAP	318.97	27.87	356.14
T_6. oxadiargyl 120 g ha^{-1} on 3-5 DAP *fb* hand weeding on 25 - 30 DAP	248.93	21.75	277.93
T_7. Biomulching	236.05	20.62	263.55
T_8. farmers practice (hand weeding at 20 and 40 DAP)	200.37	17.50	223.72
T_9. weedy check	168.59	14.73	188.23
SEm (±)	5.32	0.46	5.94
CD (0.05)	12.10	1.40	17.98

4.5 ECONOMICS OF CULTIVATION

4.5.1 Net Returns

The data on net returns is given in Table 24. The highest net returns (₹ 123758.50 ha^{-1}) was obtained in T_5 (oxadiargyl 90 g ha^{-1} on 3-5 DAP *fb* hand weeding on 25 - 30 DAP) and the lowest was obtained in T_9 (weedy check).

4.5.2 B: C ratio

The data on B:C ratio is given in Table 24. The results revealed that the weed management strategies had significant effect on B:C ratio. Higher B:C ratio (1.66) was obtained in T_5 (oxadiargyl 90 g ha^{-1} on 3-5 DAP *fb* hand weeding on 25 - 30 DAP) and lower B:C ratio (0.88) was obtained in T_9 (weedy check).

Table 24. Economics of cultivation

Treatments	Net returns (₹ ha^{-1})	Benefit : Cost ratio
T_1. oxadiargyl 60 g ha^{-1} on 3-5 DAP *fb* carfentrazone ethyl 20 g ha^{-1} on 25-30 DAP	43493.00	1.23
T_2. oxadiargyl 90 g ha^{-1}on 3-5 DAP *fb* carfentrazone ethyl 20 g ha^{-1}on 25-30 DAP	91206.00	1.48
T_3. oxadiargyl 120 g ha^{-1} on 3-5 DAP *fb* carfentrazone ethyl 20 g ha^{-1} on 25-30 DAP	62038.77	1.33
T_4. oxadiargyl 60 g ha^{-1} on 3-5 DAP f*b* hand weeding on 25 - 30 DAP	64833.00	1.34
T_5. oxadiargyl 90 g ha^{-1} on 3-5 DAP *fb* hand weeding on 25 - 30 DAP	123758.50	1.66
T_6. oxadiargyl 120 g ha^{-1} on 3-5 DAP *fb* hand weeding on 25 - 30 DAP	55368.40	1.29
T_7. Biomulching	44409.80	1.24
T_8. farmers practice (hand weeding at 20 and 40 DAP)	9772.66	1.05
T_9. weedy check	-21085.2	0.88

Price of 1 kg green fodder = Rs. 2.00
Price of 22.5g Oxadiargyl =Rs.290
Price of 25g Carfentrazone ethyl=Rs.300

DISCUSSION

5. DISCUSSION

The study entitled "Weed management in Bajra Napier hybrid (*Pennisetum glaucum x Pennisetum purpureum*)" was carried out to standardise an economic weed management strategy for Bajra Napier Hybrid. The results obtained in the study are briefly discussed in this chapter.

5.1 WEED CHARACTERS

The predominant weeds in the experimental site comprised of *Digitaria sanguinalis, Eleusine indica, Digitaria ciliaris, Dactyloctenium aegyptium*, *Chenopodium album*, *Eclipta prostrata, Amaranthus viridis, Phyllanthus niruri* and *Cyperus rotundus.* Gill (2016) and Prabhu and Palsaniya (2016) reported similar weed flora in in BN hybrid.

The weed count per square metre was significantly influenced by different weed control treatments at both observation periods (25 and 50 DAP). From the results, it was observed that grassy weeds, broad leaved weeds and sedges were found to be more at 25 DAP and reduced thereafter. The reduction in weed count at 50 DAP might be due to increase in crop plant height, tiller number, tussock diameter per hill and that would lead to more leaf area. Enhancement in the vegetative growth of the crop suppressed the weed growth due to its shading effect.

At 25 DAP, the highest total weed count (Fig. 3) of 45.49 no. m^{-2} was recorded under weedy check and the lowest total weed count of 2.32 no. m^{-2} was observed in T_5 (oxadiargyl 90 g ha^{-1} on 3-5 DAP *fb* hand weeding on 25 - 30 DAP). At 50 DAP the highest total weed count (16.66 no. m^{-2}) was observed under weedy check and the lowest (0.66 no. m^{-2}) was observed in T_5 (oxadiargyl 90 g ha^{-1} on 3-5 DAP *fb* hand weeding on 25 - 30 DAP). This reduction of weed count in T_5 (oxadiargyl 90 g ha^{-1} on 3-5 DAP *fb* hand weeding on 25 - 30 DAP) might be due to the effective control of weeds by the preemergence application of oxadiargyl along with the removal of weeds by hand weeding. Similar findings have been reported by Satao and Padole (1994) and Charles (2013), Prabhu and Palsaniya (2016) and Choudhary *et al.* (2017).

The weed management treatments significantly influenced the relative density and dry weight of weeds. It was observed that the relative density and dry weight of grassy weeds, broad leaved weeds and sedges was higher at 25 DAP and reduced thereafter. At 25 DAP, analogous to weed count, lower weed dry matter was observed in T_5 (oxadiargyl 90 g ha^{-1} on 3-5 DAP *fb* hand weeding on 25 - 30 DAP) and the treatment T_9 (weedy check) recorded significantly higher weed dry matter (Fig. 4). Similarly at 50 DAP, the lowest weed dry matter was observed in T_5 (oxadiargyl 90 g ha^{-1} on 3-5 DAP *fb* hand weeding on 25 - 30 DAP) and significantly higher weed dry matter was observed in T_9 (weedy check). The weed dry weight in almost all treatments corresponded to the weed count that was recorded therein. Similar findings were reported by Singh *et al.* (2011), Charles (2013) and Prabhu and Palsaniya (2016).

This reduction in weed count, relative density and weed dry weight at 50 DAP might be due to the favourable effect of the weed control treatments and also due to the increase in crop plant height, tiller number, tussock diameter per hill and more leaf area. Kaur and Singh (2006) recorded that pearl millet had a smothering effect on weed counts at later crop growth stages. Pre emergence application of oxadiargyl 90 g ha^{-1} on 3-5 DAP *fb* hand weeding on 25 - 30 DAP resulted in lower weed count, relative density and weed dry weight at 25 DAP and 50 DAP, respectively.

The weed count of different species under hand weeding condition and weedy check conditions were significantly more over biomulched plots (7.5 t ha^{-1}) and it might be due to the exposure of soil to sunlight, this would favoured the emergence of weed seeds. Kaur and Singh (2006) also stated that mulch application (8 t ha^{-1}) decreased the weed density significantly compared to no mulch treatments in pearl millet.

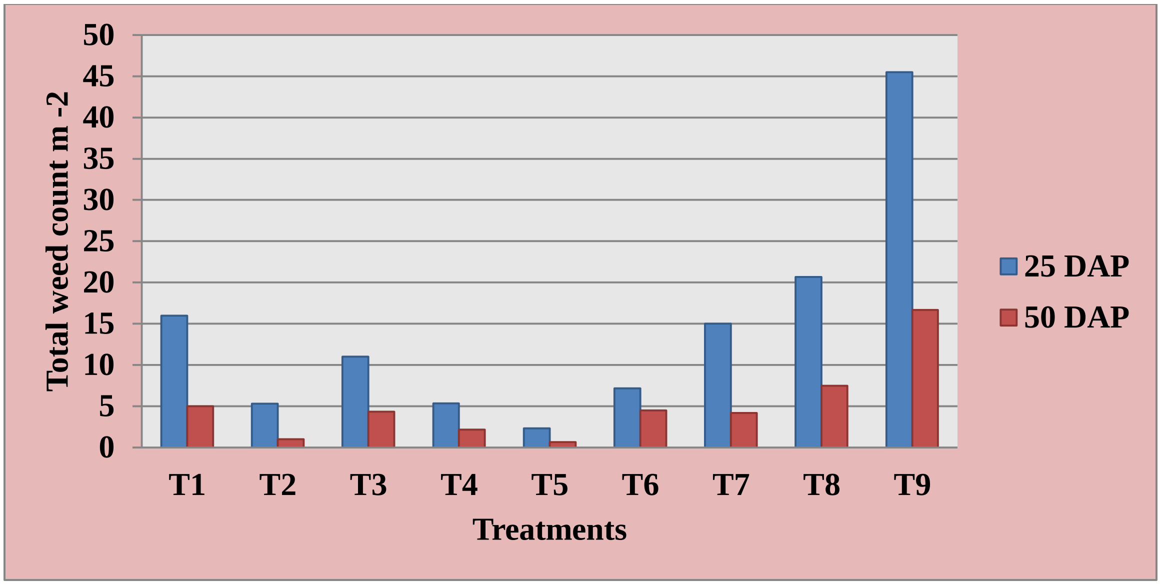

Fig 3. Effect of weed.management practices on weed count

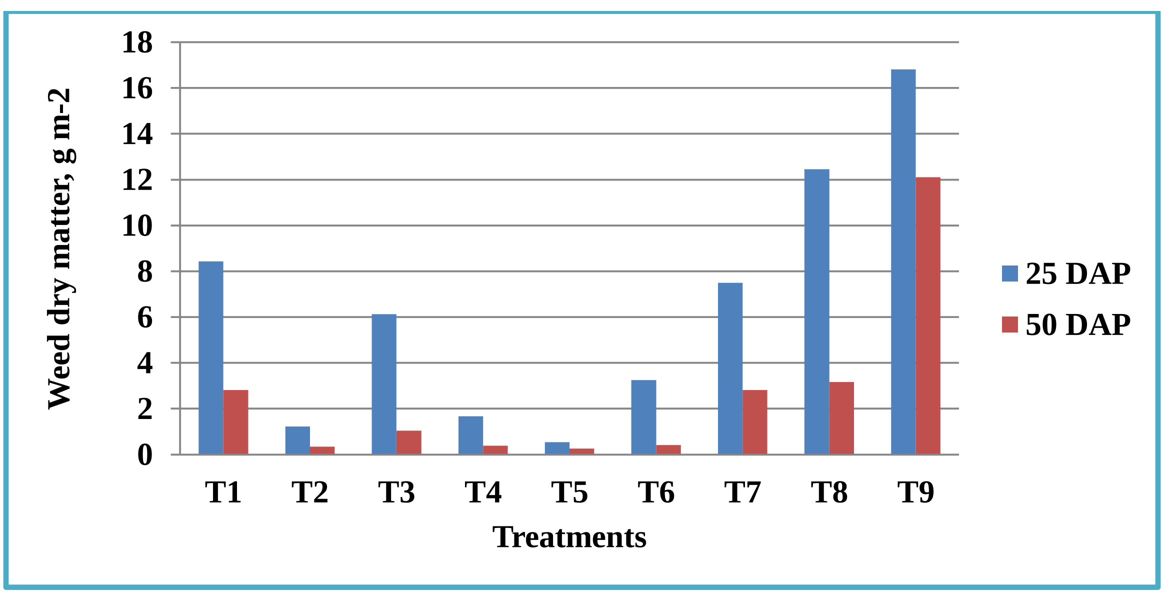

Fig 4. Effect of weed management practices on total weed dry matte

The weed control efficiency (WCE) was significantly influenced by the integration of chemical and cultural methods (Fig. 5). At 25 and 50 DAP, the highest weed control efficiency was recorded under T_5 (oxadiargyl 90 g ha^{-1} on 3-5 DAP *fb* hand weeding on 25 - 30 DAP) which was on par with T_2 (oxadiargyl 90 g ha^{-1}on 3-5 DAP *fb* carfentrazone ethyl 20 g ha^{-1}on 25-30 DAP) and T_4 (oxadiargyl 60 g ha^{-1} on 3-5 DAP *fb* hand weeding on 25 - 30 DAP). The higher weed control efficiency achieved in these treatments may be attributed to the substantial reduction of weed dry matter due to successful weed control by herbicide application or through the integration of chemical and cultural methods. Patel *et al.* (2000) also reported that the integrated methods showed superiority over single methods. Similar results were recorded by Tiwari *et al.* (2011) and Charles (2013).

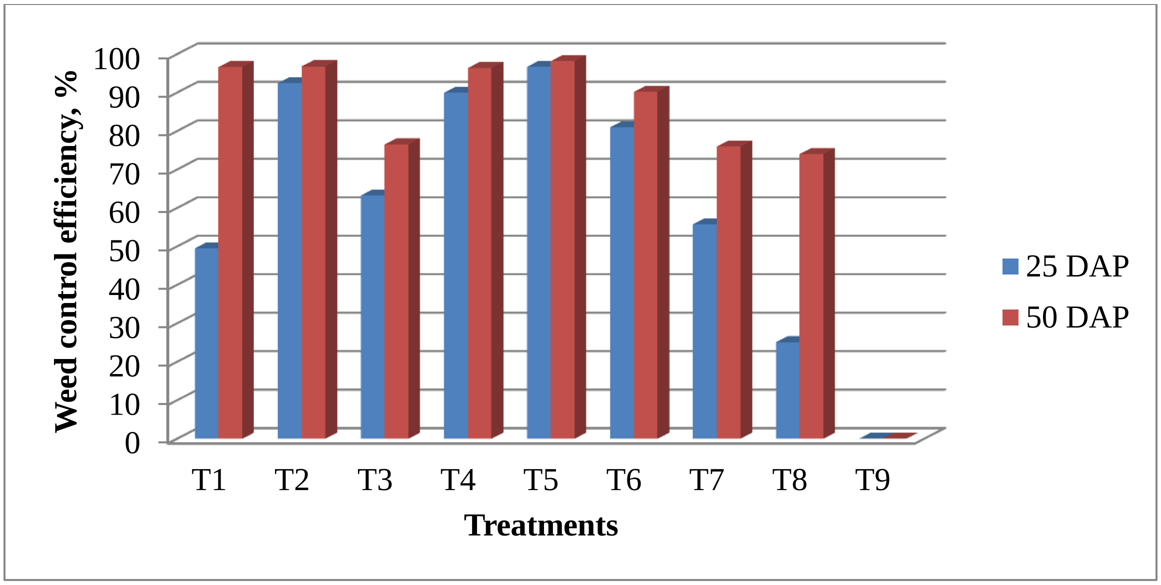

Fig 5. Effect of weed management practices on weed control efficiency

5.2 CROP CHARACTERS

5.2.1 Growth Characters

In weedy check, the crop growth as for plant height, leaf area, number of tillers, leaf stem ratio and tussock diameter were significantly reduced as compared to all other treatments. The reduction in crop growth characters was attributed to weed competition. The weeds competed with the crop for light, space, water, carbon di oxide and nutrients which resulted in the reduction of crop growth. Similar view was expressed by Yadav *et al.* (1995).

The integration of chemical and cultural methods improved the crop growth characters. Growth attributes were significantly influenced by weed management practices and at first harvest (75 DAP), second harvest (120 DAP) and third harvest (165 DAP), treatment T_5 (oxadiargyl 90 g ha^{-1} on 3-5 DAP *fb* hand weeding on 25 - 30 DAP) recorded the highest plant height which was on par with T_2 (oxadiargyl 90 g ha^{-1}on 3-5 DAP *fb* carfentrazone ethyl 20 g ha^{-1}on 25-30 DAP). This might be due to reduced crop weed competition for light, space, water, carbon di oxide and nutrients which resulted in better root development, high photosynthesis rate, better utilization of carbohydrates in the synthesis of more protoplasm which would have enhanced the plant growth. Weedy check (T_9) recorded significantly lower values for all the treatments at all the three harvests. Higher weed count, weed relative density and weed dry matter accumulation in weedy check which increased crop weed competition for light, space, water, carbon di oxide and nutrients resulted in reduced root development, low photosynthesis rate, lesser utilization of carbohydrates which ultimately affected the plant growth. Similar findings were reported by Mathukia *et al.* (2015) and Choudhary *et al.* (2017).

The treatment T_5 (oxadiargyl 90 g ha^{-1} on 3-5 DAP *fb* hand weeding on 25 - 30 DAP) recorded significantly higher leaf area during first, second and third harvests (Fig. 6). This might be due to the better control of weeds in the treatment which resulted in reduced competition for light, space, water, carbon di oxide and nutrients which paved the way for better root development and higher photosynthesis which enhanced the plant growth with more leaf area. Shinde *et al.* (2001) and Arvadiya *et al.* (2012) also found similar results.

During all the three harvests, significantly highest number of tillers (Fig. 7) were observed in T_5 (oxadiargyl 90 g ha^{-1} on 3-5 DAP *fb* hand weeding on 25 - 30 DAP) and the lowest tiller number was recorded in T_9 (weedy check). The weed control treatment which resulted in reduced weed crop competition and increased the weed control efficiency and hence resulted in better root development and photosynthesis rate which ultimately resulted in increase in the number of tillers. Similar findings were reported by Dhage *et al.* (2008).

During first, second and third harvest, the highest leaf stem ratio was registered in T_5 (oxadiargyl 90 g ha^{-1} on 3-5 DAP *fb* hand weeding on 25 - 30 DAP). However, during second harvest it was on par with T_2 (oxadiargyl 90 g ha^{-1}on 3-5 DAP *fb* carfentrazone ethyl 20 g ha^{-1}on 25-30 DAP) and on par with T_2 and T_3 during third harvest. This might be due to the effective utilization of light, space, water, carbon di oxide and nutrients under the treatment and thus increase in number of leaves and leaf area. The results agree with the results of Choudhary *et al.* (2017).

The treatment T_5 (oxadiargyl 90 g ha^{-1} on 3-5 DAP *fb* Hand weeding on 25 - 30 DAP) recorded significantly higher tussock diameter during all the three harvests. This might be due to the better nutrient uptake and less crop weed competition. The lowest tussock diameter was reported in T_9 (weedy check). The higher weed count, weed density, weed dry weight and lower weed control efficiency would have increased the weed crop competition for light, space, water, carbon di oxide and nutrients which reduced the plant growth and might have decreased the tussock diameter in T_9 (weedy check). Similar findings were reported by Silva *et al.* (2014) and Choudhary *et al.* (2017).

5.2.2 Yield Characters

The green fodder (Fig. 8) and dry fodder yield (Fig. 9) were significantly reduced under weedy check compared to all other treatments due to high weed infestation. The treatment T_5 (oxadiargyl 90 g ha^{-1} on 3-5 DAP *fb* hand weeding on 25 - 30 DAP) recorded the highest green fodder and dry fodder yield. This might due to reduced crop weed competition for light, space, water, carbon di oxide and nutrients which resulted in better root development, high photosynthesis rate, better utilization of carbohydrates in the synthesis of more protoplasm which ultimately resulted in increased leaf area, number of tillers, leaf stem ratio and tussock diameter over all other treatments. Similar findings were reported by Choudhary *et al.* (2017). Greater weed density and accumulation of weed dry matter under weedy check resulted in more crop weed competition for light, space, water, carbon di oxide and nutrients which reduced the rate of photosynthesis and thus reduced the plant height, number of tillers, leaf stem ratio and tussock diameter resulting in reduced fodder yield. These findings were similar to that of Rao *et al.* (2007) and Kumar *et al.* (2012).

The increase in the yield of green fodder in biomulched parcels compared to weedy check may be due to the fact that mulch plays an important role in adjusting the soil's hydrothermal regime and in the conservation of soil moisture, resulting in higher growth and yield values or might be due to the reduced exposure of soil to sunlight, unfavourable for emergence of weed seeds which reduced the crop weed competition and ultimately resulted in increased green fodder yield. However, the yield characters under biomulching were lower than in the integration of chemical and cultural methods. These findings are in line with that of Dannhauser (2004) and Barahenda *et al.* (2007).

Besides the lowest weed count and the lowest weed index (Fig. 10) was registered in T_5 (oxadiargyl 90 g ha^{-1} on 3-5 DAP *fb* hand weeding on 25 - 30 DAP). This might be due to the effective weed control under these treatments, which resulted in less weed count, relative density and ultimately weed dry weight. In addition, dense crop canopy might have suppressed the weed growth and good crop yield was obtained under this treatment. These findings are in close agreement to those of Das *et al*. (2003).

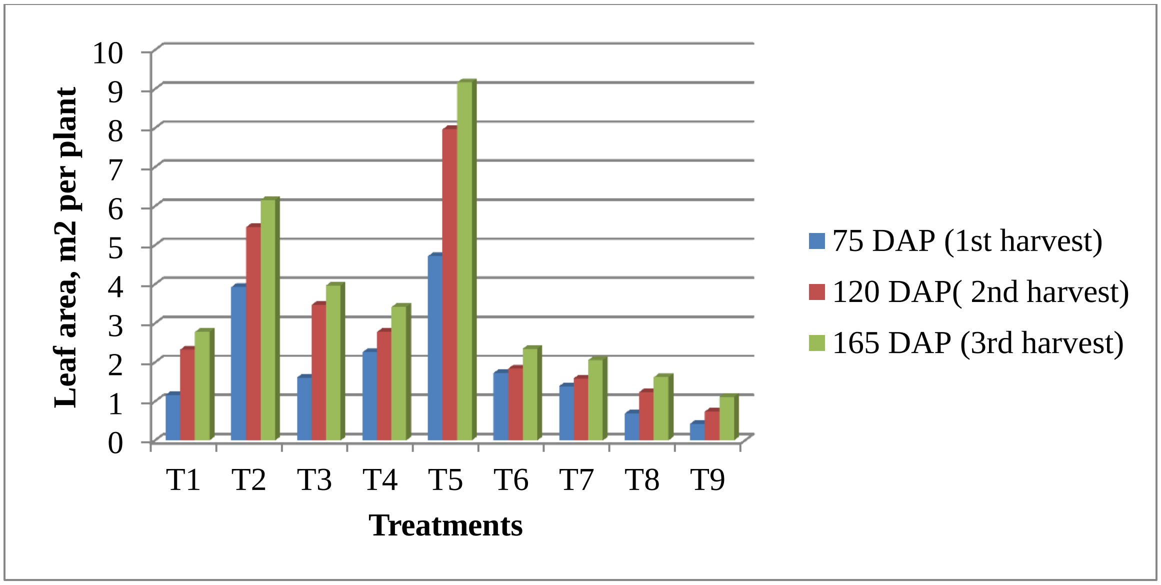

Fig 6. Effect of weed management practices on leaf area at each harvest

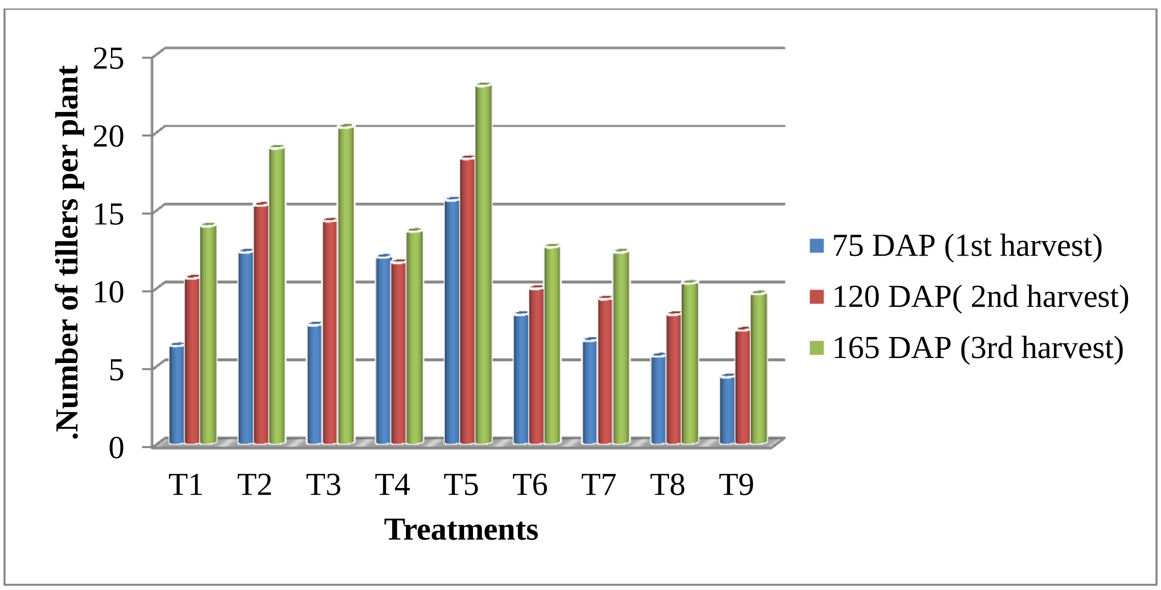

Fig 7. Effect of weed management practices on number of tillers per plant at each harvest

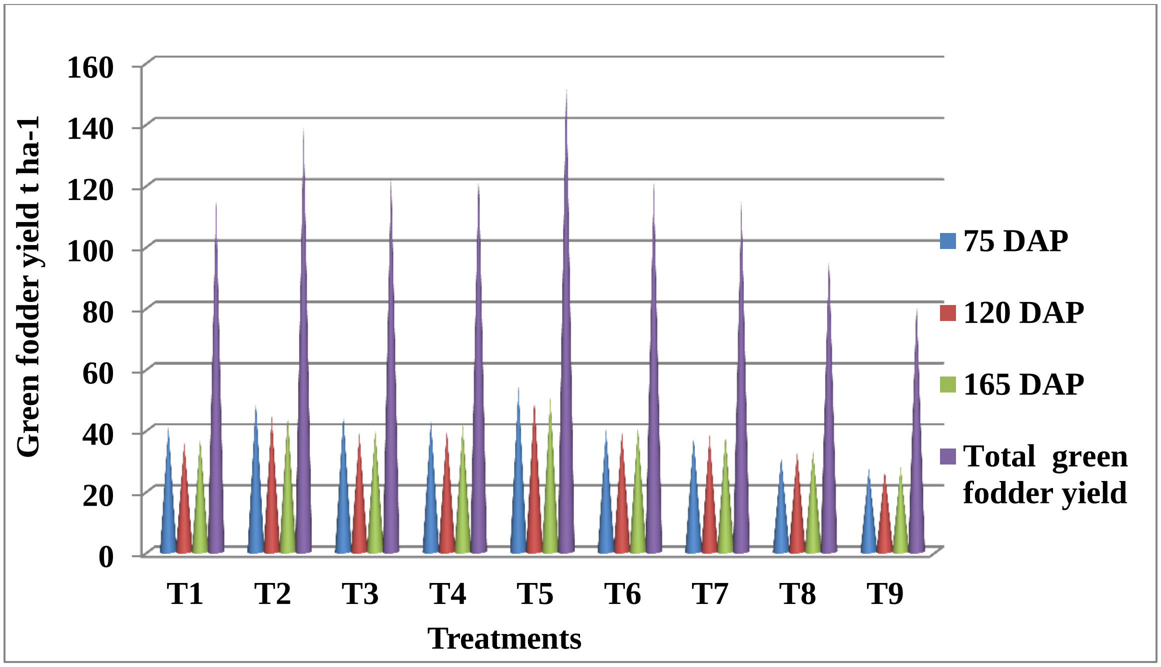

Fig 8. Effect of weed management practices on green fodder yield at each harvest.

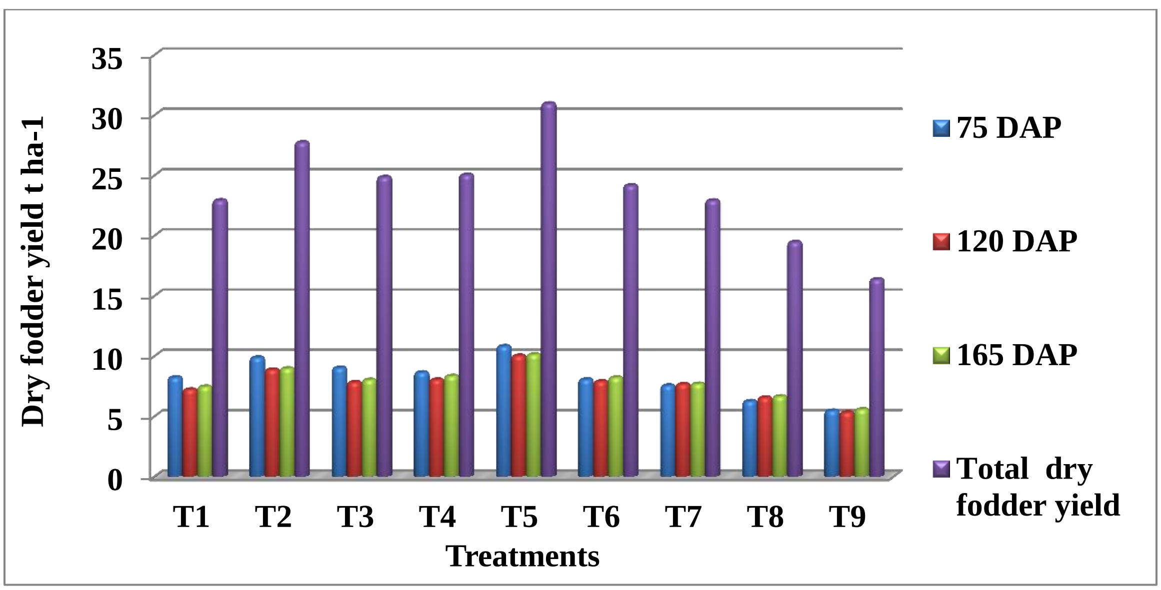

Fig 9. Effect of weed management practices on dry fodder yield at each harvest

The weedy check recorded the highest weed index due to luxurious weed growth and reduced crop yield. An increase of 47.14 per cent green fodder yield and 47.15 per cent dry fodder yield was recorded in the treatment T_5 (oxadiargyl 90 g ha^{-1} on 3-5 DAP *fb* hand weeding on 25 - 30 DAP) over T_9 (weedy check). In fodder maize a maximum yield loss of 49.5 per cent was reported in weedy check by Sanodiya *et al.* (2013).

5.2.3 QUALITY CHARACTERS

The crude protein content (Fig. 11) was higher in T_2 (oxadiargyl 90 g ha^{-1}on 3-5 DAP *fb* carfentrazone ethyl 20 g ha^{-1}on 25-30 DAP) which was on par with T_5 (oxadiargyl 90 g ha^{-1} on 3-5 DAP *fb* hand weeding on 25 - 30 DAP). This might be due to low crop weed competition and contribution of growth factors to accumulate more nitrogen by crop. Nitrogen is directly involved in increasing amino acid formation. These findings are in close agreement with Ram *et al.* (2005).

The crude fibre content (Fig. 11) was lower in T_2 (oxadiargyl 90 g ha^{-1}on 3-5 DAP *fb* carfentrazone ethyl 20 g ha^{-1}on 25-30 DAP) which was on par with T_5 (Oxadiargyl 90 g ha^{-1} on 3-5 DAP *fb* hand weeding on 25 - 30 DAP). This might be due to the increased uptake of nitrogen in these treatments which is the constituent of amino acids and protein and decreased pectin, cellulose and hemicellulose which are the major constituent of fibre. Similar findings were reported by Babu *et al.* (1995) and Quwat (2013). The highest crude fibre was observed in weedy check. This increase in crude fibre could be due to high weed density that competes with the crop for water and reduces the crop moisture content (Gill, 2016).

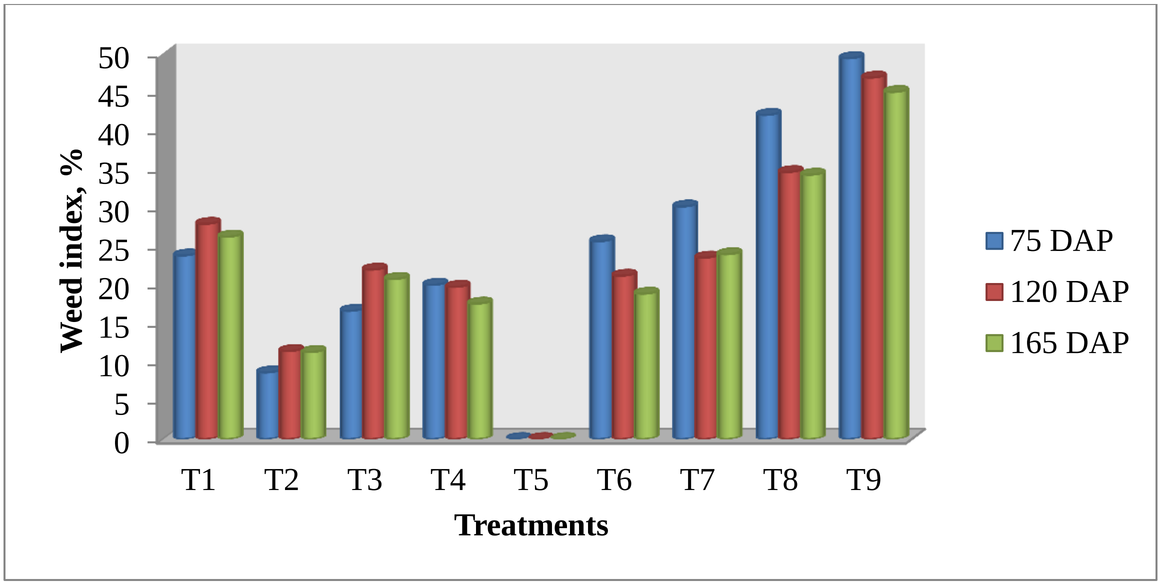

Fig 10. Effect of weed management practices on weed index.

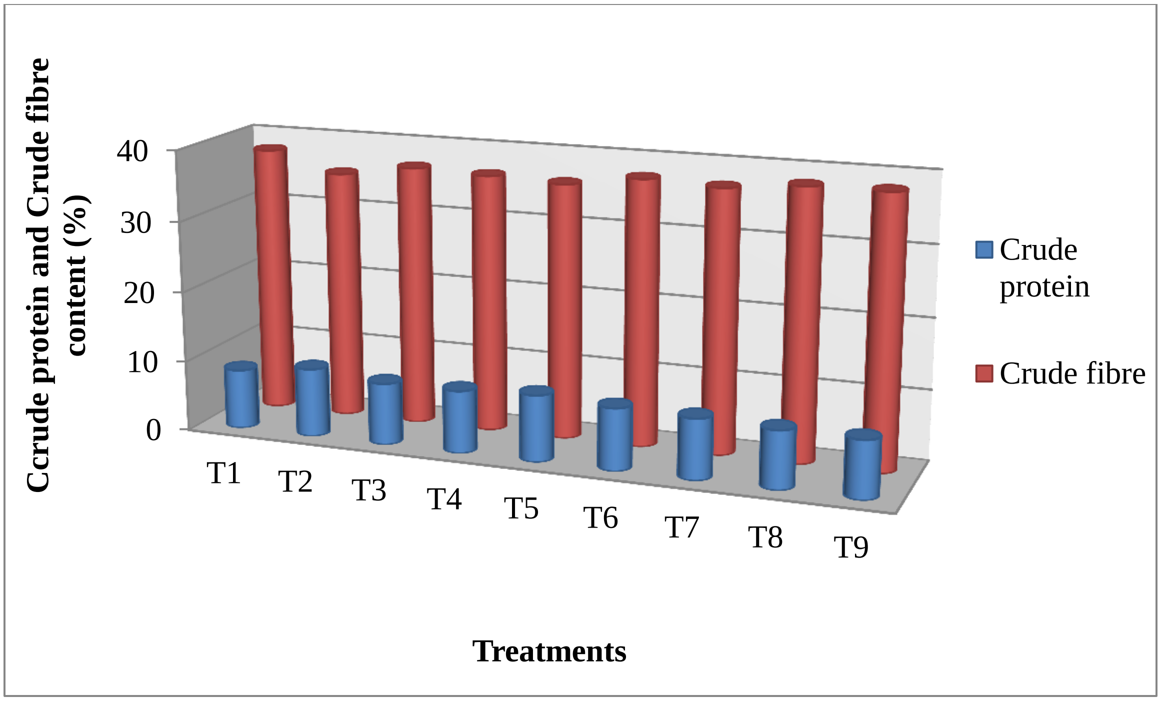

Fig 11. Effect of weed management practices on crude protein content and crude fibre content

5.2.4 PHYSIOLOGICAL PARAMETERS

The treatment T_5 (oxadiargyl 90.g ha^{-1} on 3-5 DAP.*fb* hand.weeding on 25 - 30 DAP) recorded significantly higher CGR during 25- 50 DAP and 50-75 DAP time intervals. The treatment registered 5.9 per cent increase in CGR. This increase might be due to improvement of crop growth factors and finally more dry matter accumulation of individual plants due to reduced crop weed competition for space, light, water, nutrients and carbon di oxide. The lowest CGR was observed in T_9 (weedy check) which might be due to increased weed growth that increased the weed crop competition for light, space, water, carbon di oxide and nutrients which reduced the plant growth and ultimately reduced crop yield. Similar results were reported by Patidar and Mali (2004). Weed management practices had no significant effect on RGR at both the time intervals (25-50 DAP and 50-75 DAP respectively).

The highest chlorophyll content observed in T_5 (oxadiargyl 90 g ha^{-1} on 3-5 DAP *fb* hand weeding on 25 - 30 DAP) at different growth stages might be due to better utilization of radiant energy leading to higher photosynthesis and finally more accumulation of dry matter by the plants. These findings were similar to those by Dixit *et al.*(2005) and Singh (2007).

5.2.5 NUTRIENT ANALYSIS

The highest organic carbon content of the soil was recorded in T_7 (biomulching) which might be due to the addition of more organic matter content to the soil. The weed management strategies had no significant effects on soil EC.

After the experiment higher nitrogen was observed in weedy check which was on par with T_8 (farmers practice). This might be due to comparatively lower nitrogen uptake. The lowest available nitrogen content of soil was observed in T_5 (oxadiargyl 90 g ha^{-1} on 3-5 DAP *fb* hand weeding on 25 - 30 DAP). This might be due to the extraction of nitrogen by plants for profuse plant growth and efficient translocation towards sink component. After the experiment, available phosphorus content was higher in T_4 (oxadiargyl 60 g ha^{-1} on 3-5 DAP *fb* and weeding on 25 - 30 DAP) which was on par with T_5 (oxadiargyl 90 g ha^{-1} on 3-5 DAP *fb* hand weeding on 25 - 30 DAP) and T_1 (Oxadiargyl 60 g ha^{-1} on 3-5 DAP *fb* carfentrazone ethyl 20 g ha^{-1} on 25-30 DAP). The lowest available phosphorus content of soil was observed in T_8 (farmers practice). The reduction in phosphorus content might be due to the excessive use by the crop for root growth , which ultimately resulted in increased green fodder yield. The potassium content was significantly lowest in T_5 (oxadiargyl 90 g ha^{-1} on 3-5 DAP *fb* hand weeding on 25 -30 DAP) which might be due to the extraction of potassium by plants for effective photosynthesis, protein synthesis which ultimately resulted in improved yield and quality of plant.

Significantly higher nitrogen, phosphorus and potassium uptake were observed in T_5(oxadiargyl 90 g ha^{-1} on 3-5 DAP *fb* hand weeding on 25 - 30 DAP). The increased uptake of nutrients could be due to reduced crop weed competition for nutrients which resulting in improved root growth, high photosynthesis rates, better use of carbohydrates in the more protoplasm synthesis which ultimately resulted in increased plant growth and thus increased plant height, leaf area, number of tillers, leaf stem ratio and tussock diameter under this treatment over other treatments. Significantly lower nitrogen uptake was observed in weedy check. Similar findings were reported by Sunitha *et al.* (2010) and Arvadiya *et al.* (2012).

5.2.6 ECONOMICS OF CULTIVATION

The total cost of cultivation was higher in T_3 (oxadiargyl 120 g ha^{-1} on 3-5 DAP *fb* carfentrazone ethyl 20 g ha^{-1} on 25-30 DAP) mainly because of the higher dose and cost of the herbicides used.

Among weed control treatments, T_5 (oxadiargyl 90 g ha^{-1} on 3-5 DAP *fb* hand weeding on 25 - 30 DAP) recorded the highest net returns (Fig. 12) and the lowest was reported in T_9 (weedy check). This might be due to the effect of treatment which decreased weed crop competition resulting in fodder yield. Choudary *et al.* (2017) also reported similar findings.

Weed management practices had significant effect on B:C ratio (Fig. 13). Higher B:C ratio (1.66) was obtained in T_5 (oxadiargyl 90 g ha^{-1} on 3-5 DAP *fb* hand weeding on 25 - 30 DAP) due to the highest fodder yield which ultimately resulted in the highest net returns. Similar findings were reported by Sharma and Singh(2010). The B:C ratio was lower in weedy check (0.88) in which the net returns was lower due to the reduction in green fodder yield due to heavy weed infestation. Similar results were reported by Walia *et al.* (2007), Sunitha *et al.* (2010) and Arvadiya *et al.* (2012).

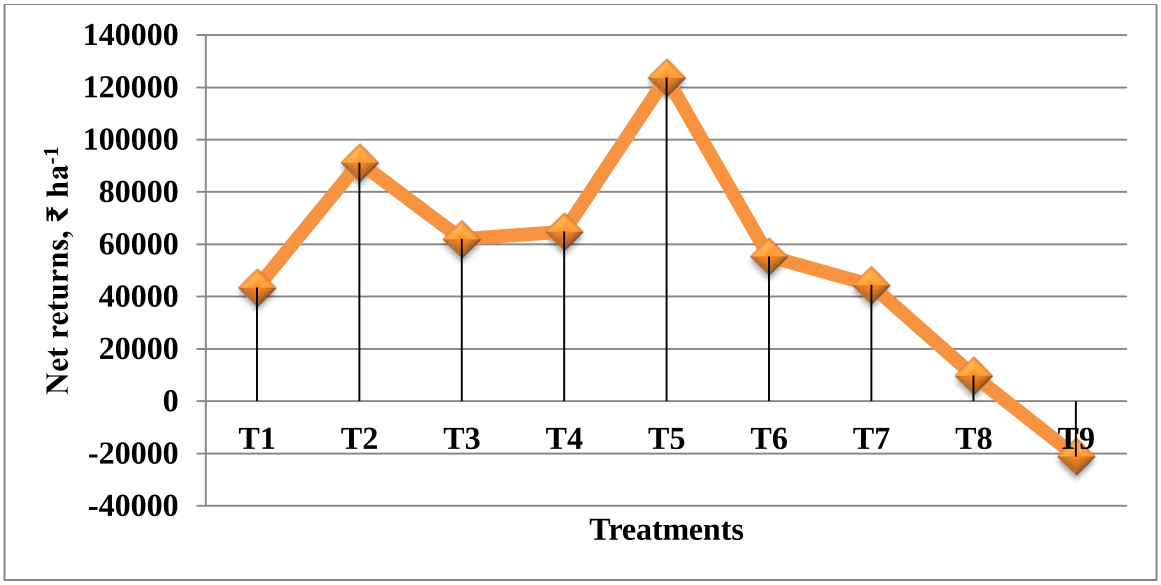

Fig 12. Effect of weed management practices on net returns

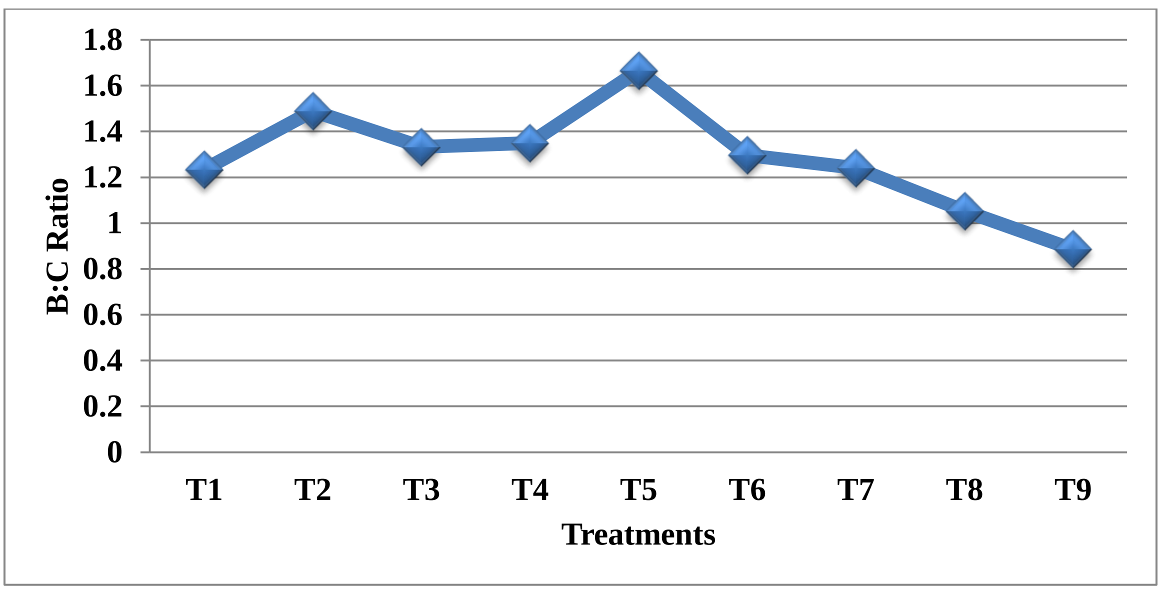

Fig 13. Effect of weed management practices on B:C ratio

SUMMARY

6. SUMMARY

An experiment entitled "Weed management in Bajra Napier hybrid (*Pennisetum glaucum x Pennisetum purpureum*)"was undertaken in the Instructional Farm, College of Agriculture, Vellayani during 2018-2020 to standardise an economic weed management strategy for Bajra Napier Hybrid.

The experiment was laid out in randomized block design (RBD) with 9 treatments in three replications during July 2019 to January 2020. The treatments were T_1: oxadiargyl 60 g ha^{-1} on 3-5 DAP *fb* carfentrazone ethyl 20 g ha^{-1} on 25-30 DAP, T_2: oxadiargyl 90 g ha^{-1}on 3-5 DAP *fb* carfentrazone ethyl 20 g ha^{-1}on 25-30 DAP, T_3: oxadiargyl 120 g ha^{-1} on 3-5 DAP *fb* carfentrazone ethyl 20 g ha^{-1} on 25-30 DAP, T_4: oxadiargyl 60 g ha^{-1} on 3-5 DAP *fb* hand weeding on 25 - 30 DAP, T_5: oxadiargyl 90 g ha^{-1} on 3-5 DAP *fb* hand weeding on 25 - 30 DAP, T_6: oxadiargyl 120 g ha^{-1} on 3-5 DAP *fb* hand weeding on 25 - 30 DAP, T_7 : biomulching, T_8 : farmers practice (hand weeding at 20 and 40 DAP) and T_9: weedy check. The variety used for the study was Suguna, released from AICRP on Forage Crops and Utilization, College of Agriculture, Vellayani, Kerala Agricultural University.

The salient findings of the experiment are summarized below

The dominant weeds associated with the crop in the experimental site comprised of *Digitaria sanguinalis, Eleusine indica, Digitaria ciliaris, Dactyloctenium aegyptium*, *Chenopodium album*, *Eclipta prostrata, Amaranthus viridis*, *Phyllanthus niruri* and *Cyperus rotundus.* From the periodic observations it was observed that weed count, relative density and dry weight of grass weeds, broad leaved weeds and sedges were more at 25 DAP and reduced thereafter. Among the weed management practices, T_5 recorded the lowest weed count, relative density, dry weight and the highest weed control efficiency at 25 and 50 DAP.

Plant height was significantly influenced by weed management practices At first harvest (75 DAP), second harvest (120 DAP) and third harvest (165 DAP), treatment T_5 (oxadiargyl 90 g ha^{-1} on 3-5 DAP *fb* hand weeding on 25 - 30 DAP) recorded the highest plant height which was on par T_2 (oxadiargyl 90 g ha^{-1}on 3-5 DAP *fb* carfentrazone ethyl 20 g ha^{-1}on 25-30 DAP). At all three harvests, weedy check recorded lower plant height

The treatment T_5 recorded the highest leaf area, number of tillers per plant and tussock diameter per hill in the first, second and third harvests. And the least was recorded in weedy check (T_9) in all the three harvests (75, 120 and 165 DAP respectively). During first and second cut, the highest leaf stem ratio was obtained in T_5 which was on par with T_2. In the third cut, the highest leaf stem ratio was obtained in T_5 on par with T_2 and T_3. At all the three cuts the lowest leaf to stem ratio was recorded in T_9.

The highest leaf chlorophyll content during first harvest was observed in T_9 which was on par with T_8 and the lowest was observed in T_2. In the second harvest highest leaf chlorophyll content was observed in T_8 which was on par with T_7 and the lowest was observed in T_2. During the third harvest highest leaf chlorophyll content was observed in T_7 which was on par with T_8 and T_9 and the lowest was observed in T_3.

Crop growth rate (CGR) was also significantly influenced by weed management practices and the treatment T_5 recorded the highest CGR at both the time intervals (25-50 DAP and 50- 75 DAP). The treatment registered 5.9 per cent increase in CGR. The lowest CGR was observed in T_9. However, RGR was not significantly influenced by weed management practices at both the time intervals.

The highest N, P and K uptake was recorded in T_5. The highest green fodder yield (154.84 t ha^{-1}), dry fodder yield (30.96 t ha^{-1}) and the lowest weed index was recorded in T_5. An increase of about 47.14 per cent in green fodder yield and an increase of about 47.15 per cent in dry fodder yield was recorded in the treatment T_5 over T_9.

The highest crude protein content (9.7%) was recorded in T_2 which was on par with T_5 (9.4%) and the lowest crude protein content was recorded in T_9 (8.14%). The lowest crude fibre content was recorded in T_2 (oxadiargyl 90 g ha^{-1}on 3-5 DAP *fb* carfentrazone ethyl 20 g ha^{-1}on 25-30 DAP-35.2 %) which was on par with T_5 (oxadiargyl 90 g ha^{-1} on 3-5 DAP *fb* hand weeding on 25 - 30 DAP- 36.03 %). The highest crude fibre content (38.11 %) was recorded in T_9 (weedy check).

Available soil nutrient status was also significantly influenced by weed management treatments. The treatment T_7 recorded the highest soil organic carbon content, T_9 recorded the highest soil available nitrogen and potassium and T_4 recorded the highest soil available phosphorus.

The weed management strategies had significant effect on the net returns and B:C ratio. The highest net returns of ₹ 123758.5 ha^{-1} was obtained in T_5. Significantly higher B:C ratio (1.66) was obtained in T_5 and significantly lower B:C ratio (0.88) was obtained in T_9.

Hence considering the growth, physiological and yield parameters, weed control efficiency, weed index, net return and B: C ratio, the treatment T_5 (oxadiargyl @ 90 g ha^{-1} on 3-5 DAP *fb* hand weeding on 25-30 DAP) could be adjudged as the economic weed management practice in Bajra Napier hybrid.

FUTURE LINE OF WORK

The efficacy of the best treatment identified in this study may be tested in other popular perennial fodder grasses like guinea grass, both under open and shade situations.

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WEED MANAGEMENT IN BAJRA NAPIER HYBRID
(*Pennisetum glaucum x Pennisetum purpureum*)

by

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ABSTRACT

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ABSTRACT

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The study entitled "Weed management in Bajra Napier hybrid (*Pennisetum glaucum x Pennisetum purpureum*)" was carried out during 2018-2020, at College of Agriculture, Vellayani, Thiruvananthapuram, Kerala with an objective to standardise an economic weed management strategy for Bajra Napier Hybrid.

The experiment was laid out in randomized block design (RBD) with 9 treatments in three replications during July 2019 to January 2020. The treatments were T_1: oxadiargyl 60 g ha^{-1} on 3-5 DAP *fb* carfentrazone ethyl 20 g ha^{-1} on 25-30 DAP, T_2: oxadiargyl 90 g ha^{-1}on 3-5 DAP *fb* carfentrazone ethyl 20 g ha^{-1}on 25-30 DAP, T_3: oxadiargyl 120 g ha^{-1} on 3-5 DAP *fb* carfentrazone ethyl 20 g ha^{-1} on 25-30 DAP, T_4: oxadiargyl 60 g ha^{-1} on 3-5 DAP *fb* hand weeding on 25 - 30 DAP, T_5: oxadiargyl 90 g ha^{-1} on 3-5 DAP *fb* hand weeding on 25 - 30 DAP, T_6: oxadiargyl 120 g ha^{-1} on 3-5 DAP *fb* hand weeding on 25 - 30 DAP, T_7 : biomulching, T_8 : farmers practice (hand weeding at 20 and 40 DAP and T_9: weedy check. The variety used for the study was Suguna, released from Kerala Agricultural University.

Among the weed management practices, T_5 recorded the lowest weed count, relative density, dry weight and the highest weed control efficiency at 25 and 50 DAP. Plant height was significantly influenced by weed management practices. At first harvest (75 DAP), second harvest (120 DAP) and third harvest (165 DAP), treatment T_5 (oxadiargyl 90 g ha^{-1} on 3-5 DAP *fb* hand weeding on 25 - 30 DAP) recorded the highest plant height which was on par with T_2 (oxadiargyl 90 g ha^{-1}on 3-5 DAP *fb* carfentrazone ethyl 20 g ha^{-1}on 25-30 DAP).

The treatment T_5 recorded the highest leaf area, number of tillers per plant and tussock diameter per hill at all the three harvests (75, 120 and 165 DAP). Leaf stem ratio was found higher in T_5 during first, second and third harvests. The treatments T_9, T_8 and T_7 recorded the highest leaf chlorophyll content at first, second and third harvest. Crop growth rate (CGR) was also significantly influenced by weed management practices and the treatment T_5 recorded the highest CGR at both the time intervals (25-50 DAP and 50-

75 DAP). However, RGR was not significantly influenced by weed management practices at both the time intervals.

The highest N, P and K uptake was recorded in T_5. The highest green fodder yield (154.84 t ha^{-1}), dry fodder yield (30.96 t ha^{-1}), net return (Rs. 123758.5 ha^{-1}) and B:C ratio (1.66) and the lowest weed index was recorded in T_5 (oxadiargyl 90 g ha^{-1} on 3-5 DAP *fb* hand weeding on 25 - 30 DAP).

The highest crude protein content (9.7%) and the lowest crude fibre content (35.2%) was recorded in T_2 (oxadiargyl 90 g ha^{-1}on 3-5 DAP *fb* carfentrazone ethyl 20 g ha^{-1}on 25-30 DAP). Available soil nutrient status was also significantly influenced by weed management treatments. The treatment T_7 recorded the highest soil organic carbon content, T_9 recorded the highest soil available nitrogen and potassium and T_4 recorded the highest soil available phosphorus.

Hence considering the growth, physiological and yield parameters, weed control efficiency, weed index, net return and B: C ratio, the treatment T_5 (oxadiargyl @ 90 g ha^{-1} on 3-5 DAP *fb* hand weeding on 25-30 DAP) could be adjudged as the economic weed management practice in Bajra Napier hybrid.

സംഗ്രഹം

സങ്കര നേപ്പിയർ തീറ്റപ്പുല്ലിന്റെ കള നിയന്ത്രണം എന്ന വിഷയത്തെ സംബന്ധിച്ച ഒരു പഠനം 2018 - 2020 കാലയളവിൽ വെള്ളായണി കാർഷിക കോളേജിലെ അഗ്രോണോമി വിഭാഗത്തിൽ വെച്ച് നടത്തുകയുണ്ടായി. ഗുണപരമായ കള നിയന്ത്രണ രീതി കണ്ടെത്തുക എന്നതായിരുന്നു ഈ പരീക്ഷണത്തിന്റെ പ്രധാന ലക്ഷ്യം. സങ്കര നേപ്പിയർ ഇനം സുഗുണയാണ് പരീക്ഷണത്തിന് ഉപയോഗിച്ചത്. റാൻഡമൈസ്ഡ് ബ്ലോക്ക് ഡിസൈൻ എന്ന പരീക്ഷണ രീതിയിൽ ഒമ്പതു കളനിയന്ത്രണ രീതികൾ മൂന്നു തവണ ആവർത്തിച്ചു.

പ്രസ്തുത പഠനത്തിന്റെ പ്രധാന കണ്ടെത്തലുകൾ ഇവയാണ്. ഓക്സഡയാർജിൽ കളനാശിനി ഹെക്ടറിന് 90 ഗ്രാം എന്ന തോതിൽ തണ്ടു നട്ട് 3 - 5 ദിവസത്തിന് ശേഷം പ്രയോഗിക്കുകയും , 25 - 30 ദിവസത്തിന് ശേഷം കൈ കൊണ്ട് കളകളെ പറിച്ചുമാറ്റുകയും ചെയ്തത് വഴി സങ്കര നേപ്പിയറിന്റെ ആദ്യ വളർച്ചാ ഘട്ടങ്ങളിലെ ഒട്ടുമിക്ക കളകളെയും ഫലപ്രദമായി നിയന്ത്രിക്കാമെന്ന് പരീക്ഷണ ഫലം തെളിയിക്കുകയുണ്ടായി. കൂടാതെ പുല്ലിന്റെ വളർച്ചയും, വിളവും, പോഷണ മൂലകങ്ങളുടെ ആഗിരണവും മറ്റു കള നിയന്ത്രണ രീതികളെക്കാൾ മുന്നിട്ടു നിൽക്കുന്നതായി കണ്ടു.

എന്നാൽ കാലിത്തീറ്റ ഗുണമേന്മാ ഘടകമായ മാംസ്യം, ഓക്സഡയാർജിൽ കളനാശിനി ഹെക്ടറിന് 90 ഗ്രാം എന്ന തോതിൽ തണ്ടു നട്ട് 3 - 5 ദിവസത്തിന് ശേഷം പ്രയോഗിക്കുകയും, 25 - 30 ദിവസത്തിന് ശേഷം കാർഫെൻട്രാസൊൻ ഈതൈൽ കളനാശിനി ഹെക്ടറിന് 20 ഗ്രാം എന്ന തോതിൽ ഉപയോഗിക്കുകയും ചെയ്തപ്പോൾ കൂടുതലായി കാണപ്പെട്ടു.

APPENDIX

APPENDIX 1

Weather parameters during the cropping period, July 2019 – January 2020

PERIOD	Maximum temperature (°C)	Minimum temperature (°C)	Relative Humidity (%)	Rainfall (mm)
July	30.9	24.9	91.46	182.7
August	30.8	24.2	92	321
September	31	24.4	91.65	279
October	30.8	24.1	92.8	404
November	25.6	24.5	91.5	91.2
December	25.3	23.8	92.2	201
January	25.5	23.3	91.4	55
Average/ Total	28.55	24.17	91.85	1535.5