

**“EVALUATION OF WEED MANAGEMENT PRACTICES
IN SUMMER MUNGBEAN (*Vigna radiata*) UNDER
ZERO TILLAGE CONDITION”**



**THESIS SUBMITTED TO THE
ICAR-NATIONAL DAIRY RESEARCH INSTITUTE, KARNAL
(DEEMED UNIVERSITY)
IN PARTIAL FULFILMENT OF THE REQUIREMENTS
FOR THE AWARD OF THE DEGREE OF
MASTER OF SCIENCE (AGRI.)
IN
AGRONOMY
BY
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B.Sc. (Hons.) Ag.
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ICAR-NATIONAL DAIRY RESEARCH INSTITUTE
(DEEMED UNIVERSITY)
KARNAL-132001 (HARYANA), INDIA**

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BY

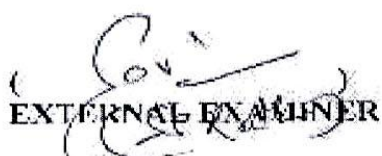
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Approved by:


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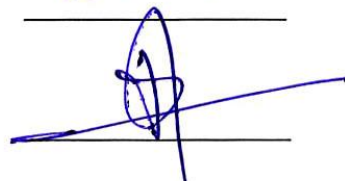


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CERTIFICATE

This is to certify that the thesis entitled, “**Evaluation of weed management practices in summer mungbean (*Vigna radiata*) under zero tillage condition**” submitted by **Mr. Kuldeep singh**. Towards the partial fulfillment of the award of the degree of Master of Science (Agri.) in Agronomy of the ICAR-National Dairy Research Institute (Deemed University), Karnal (Haryana), India, is a bonafide research work carried out by him under my supervision and no part of the thesis has been submitted for any other degree or diploma.

Dated: / / 2020


(Hardev Ram)
Major Advisor & Chairman

Jai Jawan Jai kisan
Jai Vigyan Jai Anusandhan



Dedicated To My Parents

And

Respected guide

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Date:


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ABBREVIATIONS

%	:	Percentage
₹	:	Indian Rupee
°C	:	Degree Celsius
ADF	:	Acid detergent fiber
ADL	:	Acid detergent lignin
ADS	:	Acid detergent solution
CHO	:	Total carbohydrate
cm	:	Centimeter
CP	:	Crude Protein
CSSRI	:	Central Soil Salinity Research Institute
CTAB	:	Cetyl trimethyl ammonium bromide
DM	:	Dry matter
DMB	:	Dry matter basis
dS/m	:	desi-Simens per meter
EC	:	Electrical conductivity
EE	:	Ether extract
Fb	:	Followed by
g	:	Gram
ha	:	Hectare
hr	:	Hour
HW	:	Hand weeding
IARI	:	Indian Agricultural Research Institute
K	:	Potassium
Kg	:	Kilogram
L	:	Litre
mg	:	Milligram
mhos/cm	:	Millimhos per centimeter
Min	:	Minute
ml	:	Milliliter
mm	:	Millimetre

MOP	:	Muriate of potash
N	:	Nitrogen
NDF	:	Neutral detergent fiber
NDRI	:	National Dairy Research Institute,
NDS	:	Neutral detergent solution
OM	:	Organic Matter
P	:	Phosphorus
PE	:	Pre emergence
POE	:	Post emergence
q	:	Quintal
SSP	:	Single super phosphate
WCE	:	Weed control efficiency
WCI	:	Weed control index
WI	:	Weed index

शून्य जुताई के अन्तर्गत ग्रीष्मकालीन मूंग (विगना रेडीएटा) में खरपतवार प्रबंधन सारांश

एक प्रक्षेत्र परीक्षण, भाकृअनुप-राष्ट्रीय डेरी अनुसंधान संस्थान, करनाल (हरियाणा) में सस्य विज्ञान अनुभाग के अनुसंधान फार्म पर ग्रीष्म ऋतु 2019 में "शून्य जुताई के अन्तर्गत ग्रीष्मकालीन मूंग (विगना रेडीएटा) में खरपतवार प्रबंधन" पर किया गया। यह परीक्षण यादृच्छिक खण्ड अभिकल्पना में 8 उपचारों को 3 पुनर्वावर्तियों के साथ लगाया गया, उपयोग किए गए उपचार निम्नानुसार थे :- टी₁ = खरपतवार युक्त, टी₂= खरपतवार रहित, टी₃= पेण्डीमेथालीन 0.75 किग्रा. सक्रिय घटक/हे. अंकुरण के पहले, टी₄= पेण्डीमेथालीन 0.75 किग्रा. सक्रिय घटक/हे. अंकुरण के पहले + एक हस्त निराई, बुवाई के 20 दिन बाद, टी₅= इमेजाथायपर 75 ग्राम सक्रिय घटक/हे. बुवाई के 20 दिन बाद, टी₆= शकेड (प्रॉपाकियोजाफाप + इमेजाथायपर) 2 लि./हे. बुवाई के 20 दिन बाद, टी₇= पेण्डीमेथालीन 0.75 किग्रा. सक्रिय घटक/हे. अंकुरण के पहले + इमेजाथायपर 75 ग्राम सक्रिय घटक/हे. बुवाई के 20 दिन बाद तथा टी₈= पेण्डीमेथालीन 0.75 किग्रा. सक्रिय घटक/हे. अंकुरण के पहले + क्यूजोलॉफोप 50 ग्राम सक्रिय घटक/हे. बुवाई के 20 दिन बाद। परीक्षण के प्रक्षेत्र की मिट्टी का गठन मृत्तिका दोमट था, जो कि उपलब्ध नत्रजन (164 किग्रा./हे.) एवं जैविक कार्बन (0.53%) में कम, उपलब्ध फास्फोरस (19.5 किग्रा./हे.) एवं पोटैश (227.7 किग्रा./हे.) में मध्यम तथा पी. एच. (7.32)। प्रयोग के परीणाम दर्शाते हैं कि बुवाई के 30 दिन बाद टी₂ उपचार में सबसे कम खरपतवार घनत्व (1.86), शुष्क भार (0.62 ग्राम) तथा ज्यादा खरपतवार नियंत्रण क्षमता (96.29 %) प्राप्त हुई। इसके बाद टी₄ उपचार में कम खरपतवार घनत्व (3.71), शुष्क भार (3.78 ग्राम) तथा ज्यादा खरपतवार नियंत्रण क्षमता (83.53 %) प्राप्त हुई। कटाई के समय टी₂ उपचार में सबसे कम खरपतवार घनत्व (2.91) शुष्क भार (1.89 ग्राम) तथा ज्यादा खरपतवार नियंत्रण क्षमता (98.49 %) प्राप्त हुई इसके बाद टी₆ उपचार में कम खरपतवार घनत्व (4.49), शुष्क भार (5.82 ग्राम) तथा ज्यादा खरपतवार नियंत्रण क्षमता (84.27 प्रतिषत) प्राप्त हुई। परीक्षण के परीणामानुसार, बुवाई के 30 दिन बाद व कटाई के समय टी₂ उपचार में सबसे ज्यादा पौधे की ऊंचाई, पत्तियों की संख्या/पौधा तथा पौधे की शाखाएं प्राप्त हुई इसके बाद टी₄ उपचार में प्राप्त हुई। सबसे ज्यादा पत्ति क्षेत्र सूचकांक टी₂ उपचार में पाया गया इसके बाद टी₄ उपचार में पाया गया। बुवाई के 40 दिन बाद सबसे ज्यादा गांठे तथा गांठों का शुष्क भार टी₂ में पाया गया जो कि टी₄ तथा टी₆ उपचार के बराबर था। सबसे ज्यादा उपज गुण जैसे कि फलियों की संख्या, बीजों की संख्या तथा 1000 बीजों का भार टी₂ उपचार में प्राप्त हुआ जो कि टी₄ उपचार के बराबर थी। सार्थक रूप से सबसे ज्यादा बीज उपज (10.10 कि./हे.) टी₂ उपचार में प्राप्त हुई जो कि टी₄ उपचार (9.49 कि./हे.) तथा टी₆ उपचार (9.47 कि./हे.) के बराबर थी। सार्थक रूप से सबसे ज्यादा हरे चारे की उपज टी₂ उपचार (63.30 कि./हे.) में प्राप्त हुई जो कि टी₆ उपचार (55.67 कि./हे.) के बराबर था। बीज तथा हरे चारे की उपज टी₂ तथा टी₆ उपचार में टी₁ उपचार से क्रमशः 127.99 तथा 113.36 तथा 59.32 तथा 40.12 % क्रमानुसार ज्यादा थी। सार्थक रूप से सबसे ज्यादा कुल पोषक तत्व अवशोषण टी₄ उपचार में हुआ जो कि टी₆ उपचार के बराबर था। सार्थक रूप से मृदा में सबसे ज्यादा नत्रजन टी₂ उपचार में पायी गयी। सार्थक रूप से सबसे ज्यादा चारा गुणवत्ता कारक जैसे कि सूखा पदार्थ (28.83 %) तथा कूड प्रोटीन (14.36 प्रतिषत) टी₂ उपचार में पाया गया। अन्य चारा गुणवत्ता कारक सार्थक रूप से प्रभावित नहीं हुए। सार्थक रूप से सबसे ज्यादा बीज गुणवत्ता कारक टी₂ उपचार एवं इसके बाद टी₄ उपचार में पाए गए। आर्थिक दृष्टि से सर्वाधिक शुद्ध प्रतिफल (रु55,079/हे.) तथा सबसे अधिक लाभ : लागत टी₆ उपचार (2.75) में प्राप्त हुआ। बीज की उपज, चारा की गुणवत्ता तथा आर्थिक दृष्टि से सबसे उत्तम टी₆ उपचार- शकेड (प्रॉपाकियोजाफाप + इमेजाथायपर) 2 लि./हे. बुवाई के 20 दिन बाद पाया गया। जिसको कि ग्रीष्म मूंग के लिए उत्तम उपचार माना गया।

Abstract

A field experiment was conducted on “**Evaluation of weed management practices in summer mungbean (*Vigna radiata*) under zero tillage condition**” during summer season 2019-20 at Agronomy Research Farm, ICAR-NDRI, Karnal, Haryana. The experiment was laid out in Randomized Block Design consisting of 8 treatments and 3 replication viz., T₁- Weedy check, T₂ – Weed free, T₃ – Pendimethalin (PE) @ 0.75 kg/ha, T₄ –Pendimethalin fb HW at 20 DAS, T₅ –Imezathyper (POE) @ 75 g/ha at 20 DAS, T₆ – Shaked (Propaquizafop + Imezathyper) (2 L/ha) as POE, T₇ – Pendimethalin @ 0.75 kg/ha fb Imezathyper @ 75 g/ha at 20 DAS and T₈ – Pendimethalin @ 0.75 kg/ha fb Quizolofop ethyl @ 50 g/ha at 20 DAS . The soil at experiment site was clay loam in texture and having neutral pH (7.32), medium in OC (0.53%) and low in available N (164 kg/ha), medium in available P (19.5 kg/ha) and K (227.7 kg/ha). The results revealed that at 30 DAS, T₂ treatment was recorded lowest weed population (1.86), weed dry weight (0.62g) and highest weed control efficiency (96.29%) followed by T₄ (3.71, 3.78g and 83.53%, respectively) and T₆. At harvest, T₂ treatment was recorded lowest weed population (2.91), weed dry weight (1.89g) and highest weed control efficiency (98.49%) followed by T₆ (4.49, 5.82g and 84.27%, respectively). At 30 DAS and harvest growth parameters such as plant height, no. of leaves/plant and no. of branches/plant were recorded significantly highest under T₂ followed by T₄. The maximum LAI was recorded with T₂ which was at par with T₄ and T₆. Same trends were also observed in yield attributes. Significantly higher seed yield (10.10 q/ha) was recorded under T₂ which was at par with T₄ (9.49 q/ha) and T₆ (9.47 q/ha). Significantly higher fodder yield (63.30 q/ha) was also recorded under T₂ followed by T₆ (55.67 q/ha) over rest of treatments. Seed and green fodder yield was increased by 127.99 and 113.76 and 59.32 and 40.12%, respectively higher under T₂ and T₆ treatments over T₁. Significantly, higher total nutrient (NPK) uptake was recorded under T₂ (83.25, 14.41 and 61.71 kg/ha) which was at par with T₆ (82.66 kg/ha). Fodder quality parameters such as dry matter (28.83%) and crude protein (14.36%) content was significantly higher under T₂ followed by T₄. Same trends were also observed in seed quality parameters. T₆ treatment recorded highest net returns (Rs 55,079/ha) and B: C (2.75) over rest of treatments followed by T₂. Based on finding we concluded that POE application of Shaked (Propaquizafop + Imezathyper) at 20 DAS was performing superior in weed control, seed and fodder quality, seed yield and higher net returns from per rupee investment may recommended for weed management and higher yield of summer mungbean.

CHAPTER -1

Introduction

Agriculture is backbone of Indian economy and contributes about 17.0 % of GDP, 16.5% of GVA and about 70 % of the population is dependent on agriculture and allied activities for their livelihood (Anonymous, 2019a). India is having 60.45% (159.7 mha) agriculture land which supports nearly 11.6% of the world's livestock and 17.8% human population. It is estimated that India will experience an overall surplus in food grain production, range from 4 to 8 MT in 2020. However, still the net deficit of 35.6 and 10.95% of green and dry fodder, respectively (Anonymous, 2019b). The present feed and fodder resources of the country only fulfill the 48% of the requirement. In India, the area under fodder crops is stagnated (about 4%) from last two-three decades (Anonymous, 2019c).

Preservation of soil health is prime need for sustainable crop production and balanced utilization of natural resources without affecting their quality. Farmers preferred conventional tillage (CT), which adversely affect soil health by repeated harrowing, ploughing and cultural operations. Although, CT helps in fine seed bed preparation, suppressing the weeds, hastening the nutrient mineralization, but these practices increased soil erosion, salinization and soil compaction and reduce nutrient content and soil organic matter and breaks macro-aggregates into the micro-aggregates (Ram *et al.*, 2017; Das *et al.*, 2014 and Kuotsu *et al.*, 2014). The conservation agriculture (CA) based technology was developed and tested in different climates and crops and it was adopted in more than 125 mha area in globally (Friedrich. T., 2012). It had confirmed that Zero tillage (ZT) is an efficient strategy for management of land and water resources for producing more yield and reduced cost (Kumari *et al.*, 2018). ZT can reduce the cost of tillage operations and lower down the cost of production (20-25%). In addition to this it eliminates the need for number of tillage operations, reduced planting time and saves fuel and labour cost and it has the potential to give higher productivity too (Ram *et al.*, 2017). Besides soil health improvements, less disturbance of soil under ZT reduce the weed seed germination, however, ZT had been reported to increase weed density (Singh *et al.*, 2015) and increase weed dry biomass (Singh *et al.*, 2014).

Pulses are playing an important role in Indian economy as well as socio-economic condition. Pulses are rich resource of proteins (20-25%) and establish to be major source of protein because most of Indian population are vegetarian and contributes to about 14 % of

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total protein of a usual diet of India. Pulses occupy a leading place in every cropping system and grow as main crop, cover crop, catch crop, inter crop and green manure crop. Pulses being fix atmospheric nitrogen into soil and leads to improve soil fertility and saving chemical fertilizers requirement. Besides, pulses can supply additional fodder to animals (Lambrides *et al.*, 2006).

In India, total area under pulses is 29.81 M ha with the total production of 23.40 MT and productivity of 8.06 q/ha (Anonymous, 2019a). As per recommendation of Indian Council of Medical Research (ICMR) the minimum requirement of pulse is 70g /capita/day but still the availability is only 35.8g /person/day (Chopra, K., 2014).

Mungbean (*Vigna radiata*) is an important short duration legume crop in India; it is also known as golden gram. It is quite versatile crop can be grown for seed, green manure, and forage as mixed or sole crop. Cultivation of mungbean also enhanced soil physical, biological and chemical properties as well as soil fertility status also improved through biological nitrogen fixation with symbiotic association with rhizobium from the atmosphere (Peoples *et al.*, 1995). Among cultivated pulses, mungbean is a leading pulse crop with an area of 3.64 M ha and an annual production of 1.95 MT with productivity of 8.72 q/ha. It is cultivated mainly in Rajasthan, Andhra Pradesh, Maharashtra, Tamilnadu, Madhya Pradesh, Gujarat, Haryana and Bihar. In Haryana, total production of mungbean is 0.024 MT from an area of 0.029 M ha with productivity of 8.24 q/ha (Anonymous, 2019a).

It serves as very important source of protein, vitamins and minerals predominantly in developing countries. Mungbean contains about 51.6% carbohydrate, 26 to 27% protein, 4 to 5% minerals and 3 to 4% vitamins (Kaul, 1982). Mungbean, like other fodder crops such as berseem and alfalfa is highly palatable legume attracted by the livestock and even more nutritious in nature. Mungbean fodder can also use as green forage for livestock, its fodder contains on an average about 17.5% crude protein (CP), 22.5% crude fiber (CF), 28.4% neutral detergent fiber (NDF), 3.0% ether extract (EE) and 11.4% ash (Feedipedia, 2018).

It has wider adaptability and is grown in different seasons under varied agro climatic conditions in the country. Mungbean can be a sequential partner of different cropping system during summer (April–June) under assured irrigation facility. Inclusion of mungbean in cereal based cropping system particularly under conservation agricultural practices can be future drivers of agricultural transform in the north-western Indo-Gangetic Plains of India (Gathala *et al.*, 2013).

Weeds are one of the most important causes to reduce yield of mungbean during summer and rainy season. Being a short duration crop, it faces heavy weed competition right from the early growth stages (Pandey *et al.*, 1999). Mungbean yield may be reduce up to 50-90 % due to uncontrolled weeds depending upon cultivars, soil moisture level, soil types, and other environmental conditions (Kumar *et al.*, 2006). Research workers have also noticed different levels of yield losses ranging from 30 to 90% (Sandhu *et al.*, 1980; Singh *et al.*, 1984; Singh., 1987 and PARC, 1988). The yield loss depends upon types of weed flora, period of crop-weed competition and its intensity (Choudhary *et al.*, 2016). Weed management is a prime factor for increasing the productivity of mungbean, weeds competing with crop for available resources like moisture, nutrients, space and air during initial growth period (Ali *et al.*, 2011). Hence, there is a need to find out the successful weed management strategies to comprehend higher growth and yield. Mechanical practices like hand weeding (HW) and inter culturing are doing well but unavailability and higher cost of labour and incessant rains throughout the initial crop growing season normally bound the weeding operations has leads to the utilize of herbicides (Nath *et al.*, 2016). The progressive transformation of agriculture concerning intensive use of herbicides is gaining status in recent years due to easy, lower cost and timeliness and success in controlling weeds (Butter *et al.*, 2008). Therefore, chemical weeding beneath such situation turn out to be indispensable and can be the good alternating to HW. Chemical weed controls an excellent alternative to manual as well as mechanical weeding and supply weed-free environment during early growing stage up to 30-35 days (Dungarwal *et al.*, 2003, Das and Yaduraju, 2011, 2012).

Integrated weed management involved manual, cultural, biological and chemical weed control techniques are observed more effective to achieve effective control of weeds throughout crop growing period and reducing harmful effects of chemicals on soil health (Gelot *et al.*, 2018).

Therefore, keeping this information in view, the present study was undertaken to assess the effect of different weed management practices in summer mungbean under zero tillage condition to find out the higher productivity and profitability with following objectives:

1. To evaluate the efficiency of different herbicides
2. To assess the effect of different herbicides on fodder, seed yield and its quality
3. To work out the economics of different treatments.

CHAPTER -2

Review of Literature

Accepting of the earlier work completed and information of the present condition of research on concerned topic gives superior approaching and deals to carry out a more significant study. Thus, in this chapter an endeavor has been made to evaluation the work carried out on "EVALUATION OF WEED MANAGEMENT PRACTICES IN SUMMER MUNGBEAN (*Vigna radiata*) UNDER ZERO TILLAGE CONDITION" in India and abroad has been mentioned under following headings.

2.1 Weed flora present in mungbean field

2.2 Losses due to weeds

2.3 Crop-weed competition

2.4 Effects of herbicides

2.4.1 Crop growth

2.4.2 Weed growth

2.4.3 Yield attributes and yield

2.4.4 Quality

2.4.5 Nutrient uptake

2.4.6 Total microbial population

2.4.7 Economics

2.5 Zero tillage

2.6 Phytotoxicity

2.1 WEED FLORA PRESENT IN MUNGBEAN

Kumar and Hiremath (2018) reported that presence of following weeds in mungbean field. Among grassy weeds, *Chloris barbata*, *Cynodon dactylon*, *Dinbera retroflexa*, and *Echinochloa colona*, among broad leaf weeds, *Mollugo spp.* *Euphorbia hirta*, *Parthenium hysterophorus*, *Portulaca oleracea* and *Amaranthus viridis* and among sedge like *Cyperus rotundus* were common weeds present in mungbean.

Kumar *et al.* (2011) found that presence of weed flora in order of sedge, grasses and broad leaf weeds. The major weeds were *Cyperus rotundus*, *Cynodon dactylon*, *Trianthema monogyna*, *Portulaca quadrifolia*, *Digitaria sanguinalis* and *Setaria glana*.

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Kundu *et al.* (2006) at Mohanpur, West Bengal found that following major weeds were *Digitaria sanguinalis*, *Echinochloa crusgalli* and *Eleusine indica*. Sedge weed was *Cyperus rotundus* and broad leaf weeds were *Physalis minima*, *Alternanthera sessilis* and *Chenopodium album*.

Nath *et al.* (2016) state that five weed spp., two in narrow-leaved, viz *Echinochloa colona* and *Cyperus rotundus* and three broad leaf *Trianthema portulacastrum*, *Amranthus viridis* and *Digera arvensis* were present in mungbean field at IARI, New Delhi.

Sangakara (1999) conducted an experiment at Sri Lanka and found *Ageratum conyzoides*, *Commelina bengalensis*, *Euphoeia heterophylla*, *Cyperus rotundus* and *Echinochloa colonum* dominated weed flora in mungbean.

Tamang *et al.* (2015) at Mohanpur reported the presence of *Digitaria sanguinalis*, *Cynodon dactylon*, *Eleusine indica*, *Echinochloa colona* among grasses, *Cyperus* spp. among sedge, *Physalis minima*, *Euphorbia hirta* and *Chenopodium album* among broad leaf in mungbean.

2.2 LOSSES DUE TO WEEDS

The seed yield of mungbean was reduced by 35-45.6%, seed quality and nutritious value of seed also hinder by presence of weeds (Raman and Krishnamoorthy, 1999; Pandey and Mishra, 2003). Mungbean yield may be reduce up to 50-90 % due to presence of weeds depending upon cultivars, soil moisture level, soil type, and other environmental conditions (Kumar *et al.*, 2006). The range of yield loss was recorded by research worker from 30 to 90% (Sandhu *et al.*, 1980; Singh, 1987; Singh *et al.*, 1984; and PARC, 1988). The ability of weed to physically limit the normal upright growth of a crop was experiential. This might be due to higher weed invasion and high crop-weed competition for available resources like moisture, nutrients, space and air, this leads to lower crop growth and yield attributes and finally yield.

2.3 CROP WEEDS COMPETITION (CWC)

The grim time of CWC was between 20 to 40 DAS in rainy season mungbean under rain fed conditions (Sheoran *et al.*, 2003). The mainly critical period of competition in mungbean crop was during the 30 days (Raghvani *et al.*, 1985). The period during the first 30 DAS for monsoon planted mungbean and 15-30 DAS for a summer planted mungbean (Singh *et al.*, 1982). Weed free during 7-15 DAS gave significantly higher yield (Mandal *et al.*, 2008).

2.4 EFFECTS OF HERBICIDES

2.4.1 CROP GROWTH

Chhodavadia *et al.* (2013) performed an experiment at Junagarh and observed that highest plant height (39.32cm) and a greater number of branches/plant (6.73) by two HW and two intercultural operation at 20 and 40 DAS which was at par with Oxyfluorfen fb one HW at 30 DAS (37.26 and 6.37, respectively). Weedy check recorded lowest plant height and minimum no. of branches/plant. HW helps to minimize weed infestation and weed competition with crop plant with respect to moisture, nutrient and light ultimately gives more crop growth. Same time Oxyfluorfen kept minimum weed population during serious time of crop- weed competition and helps to enhance crop growth.

Gelot *et al.* (2018) conducted a experiment at Sardarkrush nagar, Gujarat and recorded that application of Pendimethalin as PE fb Imezathyper @ 75 g/ha at 20 DAS, recorded highest plant height (53.67cm) and dry matter/plant (24.82g) of mungbean which was on par with Pendimethalin as PE fb HW at 30 DAS (53.20cm and 23.78g, respectively). These due to minimize competition of weeds with mungbean for available resource like space, moisture and nutrients with application of efficient weed control methods.

Kaur *et al.* (2009) performed a trial at PAU, Ludhiana and noticed that plant height (cm) and no. of nodules/plant in mungbean at 25 DAS was highest with application of Pendimethalin @ 0.45 kg/ha (10.2 and 25.7, respectively) followed by Fluchloralin @ 0.625 kg/ha. Shortest plant height was recorded under application of Chlorimuron due to its toxic effects on crop. Pendimethalin and Fluchloralin show maximum no. of nodules and also observed favorable effect on the number of nodules. Application of Pendimethalin show minimum dry weight of nodules, due to size of nodule was influenced by its application.

Khairnar *et al.* (2013) at Akola, Maharashtra were found that highest plant height (77.9cm) and root nodules/plant (40.5) by application of Pendimethalin fb Imezathyper followed by two HW at 20 and 40 DAS. Pre emergence application of Pendimethalin was found to control weed population during initial crop growth stage and Imezathyper on later stage, this combination kept field free from weeds and gave higher plant height and crop growth. HW resulted higher nodules number/plant due to sufficient aeration in soil for nodules development.

Khan *et al.* (2006) performed a research at Aligarh Muslim university, Uttar Pradesh and observed that the increase the no. of nodules/plant by application of Sulfosulfuron @ 200ppm followed by Atrazine @ 200ppm.

Kumar *et al.* (2012) reported that at 25 DAS maximum no. and dry weight of nodules/plant (30.6 and 0.042g, respectively) within POE use of Imezathyper @ 60 g/ha followed by Imezathyper @ 40 g/ha (27.8 and 0.037, respectively). At 40 DAS maximum nodules number/plant and nodules dry weight (28.8 and 0.038 g/plant, respectively) was resulted from combine use of Pendimethalin @ 1.20 kg/ha fb Imezathyper @ 100 g/ha followed by Pendimethalin @ 1.25 kg/ha fb Imezathyper @ 60g/ha (26.7 and 0.023, respectively). Minimum nodules number at both stages was recorded in weedy check due to higher crop-weed competition and also effect on plant growth. Application of Imezathyper significantly improved nodulation in mungbean.

Kumar *et al.* (2015) performed an experiment at RARI, Durgapura (Rajasthan) and noticed that the highest plant height (cm) and branches/plant observed under two HW at 20 and 40 DAS (31.13 and 8.33, respectively) which was on par with manual weeding at 25-30 DAS (41.10 and 7.66, respectively). This might be due to lower competition for CO₂, nutrients, space and moisture, thus the plant growth positively affected.

Raman and Krishnamoorthy (1999) carry out an experiment at Annamalai University, Annamalainagar and observed that, the twice HW found the highest number and weight of nodules (31.5 and 4.98 g/plant, respectively) followed by Pendimethalin @ 1.0 kg with one HW (21 and 3.84 respectively). This might be due to improve aeration of rhizosphere in disturbing soil condition.

Tamang *et al.* (2015) performed an experiment at Mohanpur and recorded that maximum leaf area index (4.03) under application of Pendimethalin @ 2 kg/ha followed by two HW at 20 and 40 DAS. Highest dry mass of aerial plant parts (333.56 g/m²) by application of HW at 20 and 40 DAS which was on par with Pendimethalin @ 2 kg/ha. This due to minimum weed infestation and competition with crop plant ultimately leads to enhanced crop growth.

2.4.2 WEED GROWTH

Ali *et al.* (2011) carried out a research in Odisha and found that use of Imazethapyr 100 g/ha at 15 DAS were recorded lowest weed population, dry weight of weeds and maximum seed yield of mungbean which was on par with Quizalfop-ethyl @ 100 g/ha applied at 20 DAS was equally effective.

Choudhary *et al.* (2014) performed an trial at Gujarat and found that use of Pendimethalin @ 1 kg/ha recorded lowest weed population at 25, 50 DAS and at harvest of

crop, which resulted in minimum weed dry weight, maximum WCE and minimum weed index followed by HW at 20 and 30 DAS.

Chhodavadia *et al.* (2013) conducted an trail at Junagarh and found that the lowest dry weight of weed in mungbean was exist under two HW and two inter-culturing at 20 and 40 DAS and maximum dry weight of weeds by Pendimethalin @ 0.9 kg/ha. Quizolofop-ethyl (WCE 39.70%) was most helpful in controlling weeds followed by Fenoxaprop ethyl (WCE 34.50%).

Kumar *et al.* (2012) carried out an research at Kanpur and found that significantly reduction in weed population and weed biomass under application of Imazethapyr and the herbicide efficiency was increased up to the 80 g/ha. The maximum weed control efficiency observed with Pendimethalin @ 1.25 kg/ha fb Imezathyper @ 100 g/ha (68.6 %) followed by Pendimethalin @ 1.25 kg/ha fb manual weeding at 30 DAS (63.5%). This might be because of efficiently reduction in weed population by these herbicides.

Kataria *et al.* (2018) performed an experiment at SKRAU, Bikaner and found that use of Pendimethalin @ 0.75 kg/ha as PE fb (Imezathyper + Imazamox) @ 40 g/ha at 30 DAS and (Imazethapyr + Imazamox) @ 60 g/ha at 20 DAS fb HW at 40 DAS in mungbean, were found to be on par with each other and recorded significantly least number of weeds and weed dry matter. Pendimethalin @ 0.75 kg/ha followed by (Imazethapyr + Imazamox) @ 40 g/ha at 30 DAS was found next superior treatment after weed free in respect of all weed parameters.

Kumar *et al.* (2015) performed an experiment at RARI, Durgapura (Rajasthan) recorded that minimum weed count/m² and weed infestation (%) under two HW at 20 and 40 DAS (4.86 and 14.64, respectively) which was on par with manual weeding at 30 DAS (5.53 and 16.02, respectively). Among chemical treatment minimum weed count/m² and weed infestation (%) under application of Pendimethalin fb manual weeding at 30 DAS (6.00 and 17.31, respectively). The extraordinary reduction in weed population at different stages might be due to efficient weed control in particular treatments either manual or chemical or both in mungbean.

Kundu *et al.* (2009) carried out a trial at Mohanpur, West Bengal and found that Quizolofop ethyl @ 50 g/ha at 21 DAE fb one HW at 28 days after emergence (DAE) showed the lowest population of grasses, sedges and broadleaved weeds at both the stages. This was on par with the Quizolofop ethyl @ 50 g/ha at 14 DAE fb HW at 21 DAE. This might be due to efficient weed control by these herbicides.

Review of Literature

Khairnar *et al.* (2013) at Akola, Maharashtra were found that the highest total weed dry matter production (25.18 g/m^2) at 30 DAS was recorded in weedy check plots. Whereas, the minimum total weed biomass was recorded with two HW (1.34 g/m^2) which was closely followed by application of Imazethapyr @ 80 g/ha at 20-25 DAS (5.64 g/m^2) and Imazethapyr @ 75 g/ha (7.16 gm/m^2) in mungbean. This might be due to wide spectrum activity of Imezathyper particular on both grasses and broad leaf weeds.

Kumar and Hiremath (2018) conducted a research at UAS, Bangalore and noticed that maximum weed control efficiency (89.5%) by application of Imezathyper @ 750 ml/ha + adjuvants followed by Imezathyper @ 625 ml/ha. Same time maximum seed yield (9.25 q/ha) was observed with use of Imezathyper @ 750 ml/ha followed by Imezathyper @ 625 ml/ha.

Malik *et al.* (2003) reported that the huge reduction in dry weight and density of weeds was due to two HW 25 and 45 DAS in mungbean. Application of Pendimethalin @ 1.5 kg/ha with one HW recorded maximum grain yield. HW, control all type of weeds leads to low weeds dry weight and density.

Raman and Krishnamoorthy (1999) recorded that minimum number and weed dry weight (g/m^2) were recorded by use of Pendimethalin @ 1.0 kg/ha fb one HW at 20 DAS (14.2 and 42.1 respectively) with higher weed control efficiency (70.53 %) followed by Fluchloralin @ 1kg/ha fb HW on 20 DAS (20.4, 48.3 and 57.67, respectively). This might be because of combined effects of herbicides and HW effectively checking the weed growth.

Nayak *et al.* (2000) reported that minimum weed population, dry matter and highest weed control by HW treatment followed by Pendimethalin @ 1.25 kg/ha. Grain yield was maximum by HW followed by Pendimethalin @ 1kg/ha. This might be due to effective weed control during serious crop weed competition by chemical and manual weeding.

Panwar *et al.* (1999) conduct an experiment at Shamli, Uttar Pradesh reported that lowest dry matter, weed population and greatest grain yield was recorded by application of Fluchloralin 0.75 kg/ha.

Patel *et al.* (2011) performed an experiment at Junagarh, Gujarat and noticed that PE use of Pendimethalin @ 0.5 kg/ha fb HW at 30 DAS prove to be competent in reducing weed dry weight with more than 70% of WCI and recorded maximum seed yield. The extraordinary reduction in weed population at different stages might be due to efficient weed control in particular treatments either manual or chemical or both.

Shruthi *et al.* (2015) found that the application of Pendimethalin @ 1 l/ha followed by Imezathyper 75 g/ha at 20 DAS significantly reduced weed growth, uptake of nutrients by weed and recorded the higher nutrient uptake by crop.

Yadav *et al.* (2014) conducted a research at HAU, Hisar on effect of planting methods and weed management of mungbean and reported that HW at 15 and 30 DAS minimizing density and dry weight of weed effectively.

Tamang *et al.* (2015) performed an experiment at Mohanpur and observed that minimum no. of broad leaf weed/m² was recorded with Pendimethalin @ 2 kg/ha, no. of grasses/m² with application of Fenoxaprop-ethyl @ 50 g/ha and minimum no. of sedge with application of two HW at 20 and 40 DAS. Pendimethalin significantly control grasses and broad leaf weeds and Fenoxaprop-ethyl control mostly grasses weed.

2.4.3 YIELD ATTRIBUTES AND YIELD

A experiment performed at Akola and recorded that highest pods/plant (25.5) and seed yield (12.4 q/ha) were found with application of Imezathyper @ 0.1 kg/ha at 25 DAS and maximum test weight (38.5g) under application of HW twice at 20 and 40 DAS followed by Imezathyper @ 0.075 kg/ha at 25 DAS. This because of wide spectrum activity of Imezathyper particular on established of both grasses and broad leaf weeds (Khairnar *et al.*, 2013)

Billore *et al.* (2001) state that greatest yield of soybean obtain with application of Imezathyper @ 100 g/ha followed by Imezathyper 75 g/ha fb Fenoxaprop-p ethyl @ 50 g/ha this might be due to broad- spectrum weed control by these herbicides kept field free from weeds during entire crop growth period.

Chhodavadia *et al.* (2013) performed a trial at Junagarh and reported that maximum no. of pods/plant, no. of grain/pod, test weight (g) and seed yield (q/ha) were found under two HW and two interculturing at 20 and 40 DAS (15.40, 7.03, 35.96 and 9.70, respectively) after weed free. Weedy check recorded minimum yield and yield attributes. This because of more weed infestation and crop weed competition for available resources in weedy check treatment this leads to lower yield.

Dash *et al.* (2015) conducted an experiment in Odisha, they were found that PE application of Pendimethalin gave the highest grain yield of mungbean (5.80 q/ha). Pendimethalin control weeds during peak period of crop weed competition and helps to healthier crop stand, initial growth and development ultimate leads to higher yield.

Review of Literature

Gelot *et al.* (2018) carried out an trial at Sardarkrush nagar, Gujarat and found maximum no. of pods/plant (22.68), test weight (36.91g) and seed yield (10.70 q/ha) with use of Pendimethalin @ 0.75 kg/ha fb Imezathyper @ 75 g/ha at 20 DAS fb HW at 25 DAS which was at par with Pendimethalin as PE fb HW at 25 DAS. This may be due to minimize struggle of weeds with mungbean for available resource like space, moisture and nutrients with application of efficient weed control treatments.

Kade *et al.* (2014) performed a research at Akola and notified that greatest grain yield of mungbean under application of Quizolofop-ethyl @ 75 g/ha at 20 DAS followed by use of Imezathyper @ 100 g/ha at 20 DAS due to maximum weed control efficiency and minimum weed index.

Kaur *et al.* (2009) performed a trial at PAU, Ludhiana and recorded that maximum no. of pods/plant (23.0) and no. of seeds/pod (9.2) with the use of Pendimethalin 0.75 kg/ha. Highest yield (15.1 q/ha) of mungbean in two hand hoeing at (25 and 40 DAS) is followed by Pendimethalin @ 0.75 kg/ha (14.47 q/ha). Combination of manual weeding and chemical application observed better weed control and good number of nodulations. The higher yield was because minimum weed infestation by these weed control treatments.

Khan *et al.* (2006) carried out a research at Aligarh muslim university, Uttar Pradesh and they found that maximum increase in yield of mungbean by application of Sulfosulfuron @ 200 ppm, while Atrazine @ 200 and 400 ppm decreased seed yield by 25 and 40%, respectively. Sulfosulfuron mostly prefer herbicides over Atrazine for better weed control in mungbean cultivation.

Komal *et al.* (2015) at SKRAU, Bikaner found that highest seed yield of mungbean as 12.20 q/ha by use of Pendimethalin @ 0.75 kg/ha fb HW at 30 DAS Followed by Pendimethalin 0.75kg/ha fb Imezathyper fb Imazamox 40 g/ha 20 DAS fb HW 40 DAS (11.9 q/ha). This may be due to more number of pods/plant and seeds/pod and minimum weed density and weed dry weight observed in same sequence in above treatments.

Kumar *et al.* (2015) conducted a research at RARI, Durgapura (Rajasthan) and observed that highest pods/plant, seed/pod, test weight (g) and grain yield (q/ha) were recorded under two HW at 20 and 40 DAS (19.33, 9.66, 38.49 and 6.8, respectively) which was on par with manual weeding at 25 DAS (18.66, 9.33, 37.96 and 6.5, respectively). This might be due to reduction in weed growth and population at different stages and lower competition by weeds with crop for moisture and nutrients.

Kundu *et al.* (2007) performed an experiment at Mohanpur, West Bengal and observed that application of Quizolofop ethyl @ 50 g/ha at 21 DAE fb HW at 28 DAE in mungbean, recorded highest no. of pods/plant (23.63), no. of seeds/plant (10.70), seed yield (13.27 q/ha) and harvest index (17.85 %) followed by Quizolofop ethyl @ 50 g/ha at 14 DAE fb HW at 21 DAE and Quizolofop ethyl @ 50 g/ha at 7 DAE fb HW at 14 DAE. Minimum weed infestation and competition with crop plant recorded in these treatments gives higher yield and yield attributes.

Mirjha *et al.* (2009) performed a field trial at Varanasi and noticed that highest grain yield of mungbean obtained from two HW at 20 and 40 DAS followed by application of Fenoxaprop fb Chlorimuron as POE. Maximum yield was recorded in HW due to maximum WCI and minimum WI.

Patel *et al.* (2003) conducted an trial at AAU, Anand and reported that maximum yield of gram found by application of Oxadiargyl @ 0.75 kg/ha followed by Pendimethalin @ 0.75 kg/ha because of efficient weed control and recorded lowest weed index.

Patel *et al.* (2014) performed experiment at pulse research station, Gujarat and observed that highest seed yield of mungbean (13.88 q/ha) under two manual weeding at 20 and 35-40 DAS followed by Pendimethalin fb Imezathyper + manual weeding at 25-30 DAS (12.67 q/ha) due to highest weed control efficiency (68.08 and 67.35 %, respectively).

Prabha *et al.* (2002) noticed that highest grain yield of soybean by application of Clomazone-Pendimethalin @ 2 kg/ha. This might be because of highest plant height, more number of branches, more seeds/pod and nutrient uptake because of less crop weed competition.

Punia *et al.* (2010) performed an experiment at HAU, Hisar and recorded highest seed yield of mungbean by POE-emergence use of Imezathyper at 50 and 70 g/ha and (Imezathyper + Imazamox) @ 60 g/ha. This sequential application of herbicide recorded highest weed control efficacy and weed control index ultimately leads to higher yield.

Raman and Krishnamoorthy (1999) performed an experiment at Annamalai University, Annamalainagar found that use of Pendimethalin at 1.0 kg/ha fb one HW at 20 DAS was the mainly successful method of weed control and resulted in the highest grain yield (9.21 q/ha), followed by Fluchloralin at 1.0 kg/ha fb one HW at 20 DAS (8.43 q/ha). Weedy check recorded lowest seed yield by 35% compared to twice HW (Weed free). The minimum weed population and highest WCE resulted in higher grain yield in these treatments.

Review of Literature

Seed yield of green gram was highest (21.08 q/ha) in the weed free and decreased by 23.5 and 45.8% with 160 plants/m² of *Echinochloa crusgulli* and *Cyperus esculentus* respectively (Punia *et al.*, 2004).

Shamina and Hossain (2010) performed an experiment at Bangladesh and found that application of Pendimethalin @ 2 ml/l of water recorded higher seed yield 1226 kg/ha and higher test weight 47.60g.

Shruthi *et al.* (2015) carried out an trial at Dharwad and found that the sequential treatment, PE use of Pendimethalin @ 1 L/ha followed by Imezathyper 75 g/ha at 20 DAS gave significantly higher seed yield (11.10 q/ha) after weed free treatment. The sequential application of herbicide kept field free from weeds leads to significantly higher yield over weedy check.

Singh *et al.* (1996) reported that grain yield of mungbean was increased when initial weed free period was extended by cultural method up to 45 DAS. This might because of less crop-weed competition, better weed control efficiency.

Singh *et al.* (2008) conduct an experiment at PAU, Ludhiana and reported that highest yield of mungbean in Imazethapyr @ 100 g/ha (15.13 q/ha) followed by Imazethapyr @ 75 g/ha (15.02 q/ha). Imezathyper had broad- spectrum activity on weeds thus control all types of weed and kept field free from weeds.

Singh *et al.* (2015) conducted a research at ARS, Bikaner and found that highest seed yield of mungbean with application of Pendimethalin 0.9 kg/ha fb Imazethapyr @ 75 g/ha was (9.07 q/ha) followed by Pendimethalin 0.9 kg/ha fb Imazethayer @ 70 g/ha. Pendimethalin 0.9 kg/ha fb Imazethapyr @ 75 g/ha recorded lowest weed count/m², highest pod/plant and seed/pod.

Singh *et al.* (2006) performed an experiment at Amritsar and recorded that highest plant height, no. of branches, test weight and finally maximum grain yield of soybean showed by Pendimethalin @ 1.0 kg/ha fb one hand hoeing at 35 DAS. Pendimethalin controls weed growth during initial crop growing period and HW helps to minimize weed population during later stages which ultimately leads to higher yield and yield attributes.

Tamang *et al.* (2015) carried out an experiment at Mohanpur and reported that one HW and (Pendimethalin fb Imazethapyr) @ 1.00 kg/ha effectively control weeds in mungbean. Highest seed yield of mungbean recorded by HW at 20 and 40 DAS followed by Pendimethalin @ 1 kg/ha because of efficient weed control by combination of manual

weeding and chemical mean. HW, control all types of weeds and reduce weed population and gives higher crop yield.

Yadav *et al.* (2012) performed an experiment at Hisar were found that application of Fluchloralin @ 1kg a.i./ha and alachlor @ 1 kg a.i./ha effectively controlled the major weeds (*Echinochloa colonum* and *Trianthema monogyna*) and gave to a higher seed yield over the weedy check. Prometryne controlled the weeds but had an adverse effect on crop growth, leads to lower seed yield.

2.4.4 EFFECTS ON QUALITY

Chhodavadia *et al.* (2013) performed experiment at Gujarat and reported that two HW at 20 and 40 DAS significantly enhance protein content (22.5 %) followed by Oxyfluorfen @ 0.180 kg/ha fb 1HW at 30 DAS (21.87 %).

Khan *et al.* (2006) carried out a field trial at Aligarh muslim university, Uttar Pradesh and recorded that the average highest Chlorophyll content of 1.2 mg/g was obtained with application of Sulfosulfuron @ 200 ppm.

Lal *et al.* (2014) performed an experiment on mungbean at BHU, Varanasi and found that highest dehydrogenase activity under use of Quizolofop-ethyl 50% EC @ 1 L/ha followed by Imezathyper @ 50 g/ha.

Prasad *et al.* (1989) conducted a field trial at Pantnagar and noticed that Fluchloralin and Pendimethalin at 1kg/ha improve grain quality and yield as compare to weedy control. This might be due to efficient weed control and reduce competition with crop for available resources by weed ultimately lead to improve grain quality and yield.

Singh *et al.* (2015) performed an experiment at ARS, Bikaner and found that highest total chlorophyll content with use of Pendimethalin @ 1kg/ha followed by Pendimethalin fb Imazethapyr and highest protein content with Pendimethalin fb Imazethapyr followed by Pendimethalin as PE.

2.4.5 EFFECT ON NUTRIENT UPTAKE

Chhodavadia *et al.* (2013) performed an experiment during summer season at Gujarat and noticed that maximum uptake of nutrients by crop observed in weed free as 23.0, 40.05 and 7.8 kg/ha of N, P and K, respectively. However, maximum nutrient uptake by weeds was observed in weedy check plot *i.e.* 31.0, 28.7 and 1.9 kg/ha N, P and K, respectively. This

might be due to excellent crop growth and yield in weed free treatment ultimately leads to higher nutrient uptake.

Komal *et al.* (2015) conducted an experiment at Bikaner, Rajasthan and recorded that minimum nutrient uptake by crop i.e. 45 N, 6.05 P and 46 kg K/ha, whereas highest uptake by weeds 61.9 N, 12.1 P and 51 kg K/ha, respectively were observed in weedy check.

Studied conducted at Ludhiana, Punjab and find that maximum nutrients removed by weeds in weedy check i.e. 68.78, 19.29 and 77.15 kg/ha, N, P and K, respectively and the minimum by Pendimethalin @ 0.75 kg/ha i.e. 8.7, 17 and 11.57 kg/ha of N, P and K, respectively. Weedy check recorded highest weed growth thus recorded maximum uptake of nutrients by weeds and same time lowest nutrients uptake by crop due to poor growth and lower grain and straw yield (Kaur *et al.*, 2010).

2.4.6 TOTAL MICROBIAL POPULATION

Khairnar *et al.* (2013) performed an experiment at Akola and noticed that toxic effect of chemicals appears instantly after the use when their residue in the soil is highest. At 30 DAS and harvest highest population of bacteria, fungi and actinomycetes (24.8×10^7 cfu/g soil, 24.2×10^4 cfu/g soil and 20.1×10^6 cfu/g soil) and (40.0×10^7 /g soil, 36.5×10^4 /g soil and cfu 28.3×10^6 /g soil, respectively) were observed in weed free followed by HW twice at 20 and 40 DAS. Among herbicides, maximum microbial population observed with use of Pendimethalin 1.0 kg/ha which was at par with Pendimethalin fb Imezathyper at 30 DAS and harvest. It indicates that highest total microbial population was recorded with cultural operations and minimum use of herbicides.

2.4.7 ECONOMICS

Chhodavadia *et al.* (2013) conducted an experiment at Junagarh recorded highest net return (Rs 18350) under application of two HW at 25 and 40 DAS followed by Oxyfluorfen fb 1 HW at 30 DAS (Rs. 18004). The highest net return under HW might be due to excellent weed control at low investment and higher yield.

Dash *et al.* (2015) reported that among weed control practices, Pendimethalin 1.0 kg/ha recorded the highest gross return of Rs 31375. Quizolofop-p-ethyl fb hoeing and weedy check proved significantly inferior to Pendimethalin with reduced gross return by 13.7, 15.2 and 60.5% respectively. This might be due low weed competition between weed and crop under Pendimethalin, this leads to higher yield and maximum gross return.

Khairnar *et al.* (2013) performed an experiment at Akola and found that among the weed control treatments, Imazethapyr @ 1.0 kg/ha (Rs 30,370/ha) and Imazethapyr @ 75 g/ha (Rs 28,776/ha) gave the maximum monetary returns, due to outstanding management of grassy and broad-leaf weeds without any unfavorable influence on crop growth.

Komal *et al.* (2015) at SKRAU, Bikaner found that highest net return (Rs 48011 /ha) and B: C ratio (2.98) by use of Pendimethalin @ 0.75kg/ha fb Imezathyper @ 40 g/ha at 20 DAS followed by Pendimethalin @ 0.75 kg/ha fb 1 HW at 30 DAS (Rs 47990 /ha) and B: C ratio (2.94). HW recorded lowest B: C ratio due to the cost of cultivation was increased due to the higher need of labor and their higher wages.

Kumar, (2007) performed a field experiment on mungbean at Odisha and found that application of Imazethapyr @ 100 g/ha at 20 DAS followed by one HW at 40 DAS gave significantly higher monetary returns (Rs 872/ha/day) and B: C ratio (2.18).

Kumar *et al.* (2011) carried out a trial at Kanpur and found that the net return was maximum by application of Imazethapyr @ 100 g/ha (Rs.24, 889 /ha) the marginal rate of return was higher in Imazethapyr @ 80 g/ha.

Kundu *et al.* (2006) performed an experiment at Mohanpur, West Bengal observed maximum B: C ratio (2.26) by application of Quizolofop ethyl @ 50g/ha at 21 DAE fb HW at 28 DAE followed by Quizolofop ethyl @ 50 g/ha at 14 DAE fb HW at 21 DAE (2.03).

Patel *et al.* (2014) performed a trial at Pulse research station, Gujarat and recorded that maximum net return (Rs. 32750) by application of two manual HW at 20 and 35-40 DAS followed by Pendimethalin fb Imezathyper fb manual weeding at 25-30 DAS (Rs. 27317) and Pendimethalin @1kg/ha as PE fb Quizolofop-ethyl @ 50 g/ha POE at 15-20 DAS (Rs. 26061).

Singh *et al.* (2008) conduct an trial at PAU, Ludhiana and noticed that use of Imezathyper 100 g/ha recorded the maximum gross return of Rs. 41342 followed by Imezathyper 75 g/ha of Rs. 40632 and Imezathyper 75 g/ha recorded the maximum B: C ratio (3:60) followed by Imezathyper 100 g/ha B:C ratio (3.55).

Singh *et al.* (2015) performed an experiment at ARS, Bikaner and reported that Pendimethalin fb Imezathyper (80g) recorded the maximum gross return of Rs. 31350 with B: C ratio (2.7) followed by Pendimethalin fb Imezathyper (90g) of Rs. 31259 with B: C ratio (2.67).

Tamang *et al.* (2015) performed an experiment at Mohanpur and noticed that highest B: C ratio with application of Pendimethalin fb Imazethapyr @ 1.00 kg/ha as followed by Imazethyper @ 40 g/ha.

2.5 EFFECT OF ZERO TILLAGE

Amanullah *et al.* (2012) at Pakistan found that reduced tillage (15 cm) had resulted in highest number of pod/ plant (32), number of seed/ pod (9), test weight (53.52 g) and grain yield (810 kg/ha) of mungbean over deep tillage (30 cm) under irrigated conditions. Dry bean germination was delayed in one to six days with zero tillage compared with conventional tillage and similar yield obtain with zero and conventional tillage (Blackshaw *et al.*, 2006). The greater number of nodules /plant in gram under conventional tillage system over zero tillage most probably due to disturbed soil condition and more aeration under tillage leads to more nodules number /plant (Jan *et al.*, 2012).

Dodwadiya *et al.* (2012) performed an experiment at Delhi and recorded that zero tillage was more profitable in summer, while conventional tillage was best practices in rainy season. In Zero tillage, there was somewhat higher BD recorded than conventional tillage. It is due to lower porosity in surface soil because ploughing is done. Suryavanshi *et al.* (2016) found that soil organic carbon significantly increases by zero tillage under mungbean cultivation beside that zero-tillage enhanced better carbon content and nitrogen availability in soil, and cultivation of mungbean more profitable under zero tillage system with residue. Ploughing promote oxidation of organic C in soils by disturbing of soils. Studies reported 30–60 % of C reduction due to cultivation (Maana and Singh, 2000; Lal, 2000). A net increase in SOC content was recorded with crop residues under both zero. This was clearly associated with a huge amount of crop residues and root biomass C in residue added plots, which significantly enhanced the yield of crops (Mandal *et al.*, 2008). Under zero tillage, a significant lowering of pH observed at the upper soil 0-7.5 cm on silt loam soil (Dick *et al.*, 1980).

The weed oppressive effects of residue have resulted in superior lessening of weeds in zero tillage with crop residue (Christoffoleti *et al.*, 2007). The zero tillage had been reported to increase weed density (Singh *et al.*, 2015) and increase weed dry biomass (Singh *et al.*, 2014). In instance of weeds, weed biomass was reported to be significantly higher in zero tillage plot (0.39 t/ha) than in conventional tillage plot (0.27 t/ha) (Bhatt *et al.*, 2015). The maximum reduction in dry weight of weeds was obtained under raised bed planting as compared to conventional and zero tillage system. The highest weed control efficiency and

seed/ plant recorded under raised bed planting than zero tillage (Yadav *et al.*, 2014). Zero tillage with residue and green seeker (ZT fb R+ 75% N+ GS) recorded minimum weed dry weight (56.4 g/m²) and highest weed control efficiency (52.7 %) and weed control index (63.1 %) followed by CT+R+100 % N (108.9 g/m²). This probably due to suppress weed seeding emergence and allow the crop to gain advantage over weeds and reduction the need for control by residue retention on soil surface (Nath *et al.*, 2012).

2.6 Phytotoxicity

Naidu *et al.* (2012) while studying bio efficacy and economics of herbicides agaisnd weeds in blackgram found that application of Imezathyper as POE @ 150 g/ha caused crop injury to amount of 40 percent resulting in sensible stunt growth of seedling and discoloration of rising leaves with biased defeat of crop stand. The phytotoxic effect of Imazethypr on blackgram was also observed by Gosia (2005).

Punia *et al.* (2012) performed an experiment at HAU, Hisar and found that 23 to 35% injury to mungbean initial stages in terms of stunted crop growth and yellowing of leaves up to 7 DAS which mitigated to 5-8 % up to 45 DAS, without any yield reduction.

Singh *et al.* (2014) in mungbean found no adverse effect of POE application of Imazethpyr @ 50, 75 and 100 g/ha in terms of yellowing, injury or change in morphology. Osten (1996) also reported that application of Imezathyper as POE @ 96 g/ha was safe to *Vigna* spp.

Mishra *et al.* (2004) recorded that use of Imezathyper @ 100 g/ha was found phytotoxic to gram. However, these herbicidal injuries recovered later on. Sangeetha *et al.* (2012) recorded that higher dose of Imezathyper @ 200 g/ha found slight injurious to soybean.

CHAPTER –3

Materials & Methods

A field experiment entitled on “**Evaluation of weed management practices in summer mungbean (*Vigna radiata*) under zero tillage condition**” was conducted during summer season of 2019-20 at Agronomy research farm, ICAR-National Dairy Research Institute, Karnal (Haryana). The details of weather conditions, materials used and methods adopted during the course of investigation are presented and described in this chapter.

3.1 EXPERIMENTAL DESCRIPTION

3.1.1 Location of experimental site

The experiment was conducted at research farm of Agronomy Section, ICAR-National Dairy Research Institute, Karnal, Haryana located at 29°45’ North latitude and 76°58’ East longitude and at an altitude of 245 m above mean sea level. The research station is located in North Western zone of Haryana.

3.1.2 Climate and weather conditions

Climatologically Karnal district enjoys a subtropical climate and is subjected to extremes of weather conditions i.e. extremely hot summer and cold winter. During summer maximum temperature goes up to 45°C and in winter minimum temperature reaches near freezing point. This region falls in sub-tropical and semi-arid type of climate. Normally the period for the onset of monsoon in this domain is third week of June and it lasts up to the end of September.

The mean annual rainfall is about 707 mm of which major portion (about 574 mm) is received during the monsoon season (July to September) and rest during winter and spring seasons. The mean annual ET of this region is 1600mm. The weekly mean meteorological data on the climate parameters for the experimental season from April to June recorded from meteorological observatory at ICAR-Central Soil Salinity Research Institute; Karnal is furnished in Table 3.1 and depicted in Fig.3.1.

The highest rainfall of 1.89 mm was recorded in 25th (18th-24th June) standard week and there was no rainfall received in 15th, 16th, 19rd, 22th and 26rd standard weeks during the crop period. The highest relative humidity 80.29 % was recorded in 25th standard week (18th-24th June) and lowest relative humidity 22.57 % in 18th standard week (30th April -6rd May).

Table 3.1: Mean weekly meteorological data during crop season of the year 2019.

Standard Week	Date of Standard week	Temperature (°C)		RH (%)		Rainfall (mm/week)	Evaporation	Sunshine hrs Per day
		Max.	Min.	Max.	Min.			
15	9 th – 15 th April	35.60	19.01	76.00	27.43	0.00	6.97	8.94
16	16 th - 22 th April	33.00	18.57	74.71	36.43	0.00	6.13	8.03
17	23 th -29 th April	39.19	21.20	63.29	22.71	0.97	7.91	9.14
18	30 th April -6 rd May	38.81	20.20	49.29	22.57	1.31	10.24	9.73
19	7 th -13 th May	40.54	21.06	52.57	23.00	0.00	9.91	10.11
20	14 th -20 th May	35.20	21.79	77.14	41.00	1.06	6.73	8.00
21	21 th -27 th May	38.09	22.63	58.86	25.00	0.57	9.74	9.46
22	28 th May - 3 rd June	41.46	25.71	50.14	29.86	0.00	10.76	11.33
23	4 nd -10 th June	39.54	25.99	61.29	35.43	0.36	9.29	9.90
24	11 th -17 th June	40.51	25.97	58.00	36.14	0.37	10.63	10.14
25	18 th -24 th June	36.14	24.63	80.29	53.57	1.89	7.41	8.86
26	25 rd June - 01 th July	37.57	27.61	72	43.42	0	8.27	9.28

The evaporation rate was highest in 22rd standard week (28th May -3rd June) during the crop period. The maximum temperature (41.46°C) was recorded in 22th standard week (28th May - 3rd June) and minimum (18.57°C) in 16rd standard week (16th - 22th April).

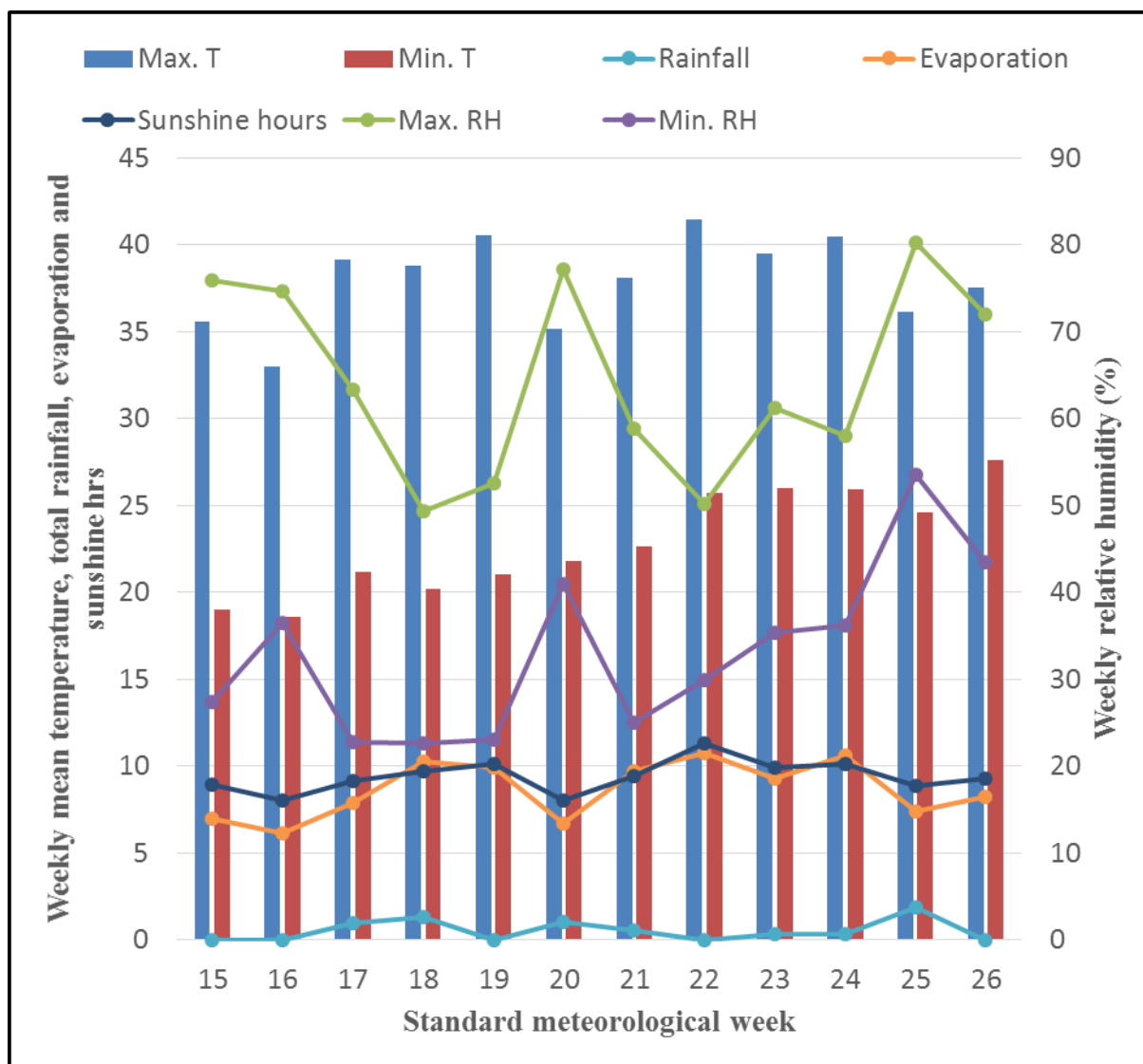


Figure 3.1 Weekly weather data during crop season

3.1.3 Physical and chemical properties of soil of the experimental site

The texture of soil was clay loamy in nature. Soil samples were randomly collected from different spots in experimental field from 0-15 cm depth just before preparing the field for sowing. A composite sample was prepared and analyzed for the chemical and physical properties of the soil. The results of the analysis along with methods used for determination are presented in table 3.2. The data in the table 3.2 indicate that the soil of the experimental field was neutral in nature (7.32), low in available N (164.00 kg/ha), medium in OC (0.53%), available P (19.50 kg/ha) and available K (227.70 kg/ha).

Table 3.2: Soil Properties of experimental site

Particular	Value	Method employed
1. Physical properties		
A. Particle size distribution (%)		
Sand	43.4	International pipette method (Piper, 1966)
Silt	23.1	
Clay	33.4	
B. Textural class	Sandy clay loam	
2. Chemical properties		
Organic carbon (%)	0.53	Walkley and Black' s Wet Oxidation Method (Walkley and Black, 1934)
Available N (kg/ha)	164.00	Alkaline Permanganate Method (Subbiah and Asija, 1956)
Available P ₂ O ₅ (kg/ha)	19.50	Olsen' s Method (Olsen <i>et al.</i> , 1954)
Available K ₂ O (kg/ha)	227.70	Flame Photometer method (Jackson, 1967)
Soil reaction (pH)	7.32	pH Meter (piper, 1966)
Electrical conductivity (dS/m)	0.33	EC bridge (Jackson, 1967)
3. Microbiological properties		
Bacterial Count (CFU/g soil)	11.23×10^6	Serial dilution method Gordon <i>et al.</i> (1973)
Fungal Count (CFU/g soil)	0.76×10^4	Serial dilution method Martin (1950)
Actinomycetes Count (CFU/g soil)	5.78×10^5	Serial dilution method Ken-knight and Muncie (1939)

3.1.4 Previous cropping history

Cropping pattern followed on a particular field will affect the performance of succeeding crop of that field. The three years period details of preceding cropping history of the experimental field were given in table 3.3

Table 3.3 cropping history of the experiment plot

Year	Kharif	Rabi/summer
2017-18	Maize	Mustard
2018-19	Maize	Pearl millet
2019-20	Mustard (Rabi)	Experimental crop (Summer)

3.2 Experimental details

The details of the experiment with regard to different herbicides, design and plot size are given below (Table 3.4).

3.2.1 Design and layout

The experiment was laid out in Randomized Complete Block Design with three replications. Gross plot size of 5×4 m² and net plot size 4.8×3.8 m².

Table 3.4: Details layout of experimental field.

S. No	Particular	
1.	Experimental Design	Complete Randomized Block Design
2.	Crop	Mungbean
3.	Variety	MH-421
4.	Seed rate	20 kg/ha
5.	Spacing	30 x 10 cm (RxP)
6.	RDF	20:30:40 kg/ ha, N: P ₂ O ₅ : K ₂ O
7.	Treatments	8
8.	Replications	3
9.	No. of plots	24
10.	Gross plot size	5 x 4m = 20 m ²
11.	Total area	480m ²
12.	Main irrigation channels	1.5 M

3.2.2 Treatment details

All together there were eight treatments and the details of which are given below:

Sr. No.	Treatments	Dose (g/ha)	Application time
1	Weed check	-	-
2	Weed free	-	-
3	Pendimethalin	750	PE
4	Pendimethalin + 1 HW at 20 DAS	750	PE
5	Imezathyper	75	20 DAS
6	Shaked (Propaquizafop + Imezathyper)	2L	20 DAS
7	Pendimethalin (PE) fb Imezathyper	750 and 75	PE and 20 DAS
8	Pendimethalin fb Quizolofop ethyl (POE)	750 and 50	PE and 20 DAS

DAS- Days after sowing, fb- Followed by, PE- pre-emergence, HW- Hand weeding, POE- Post emergence

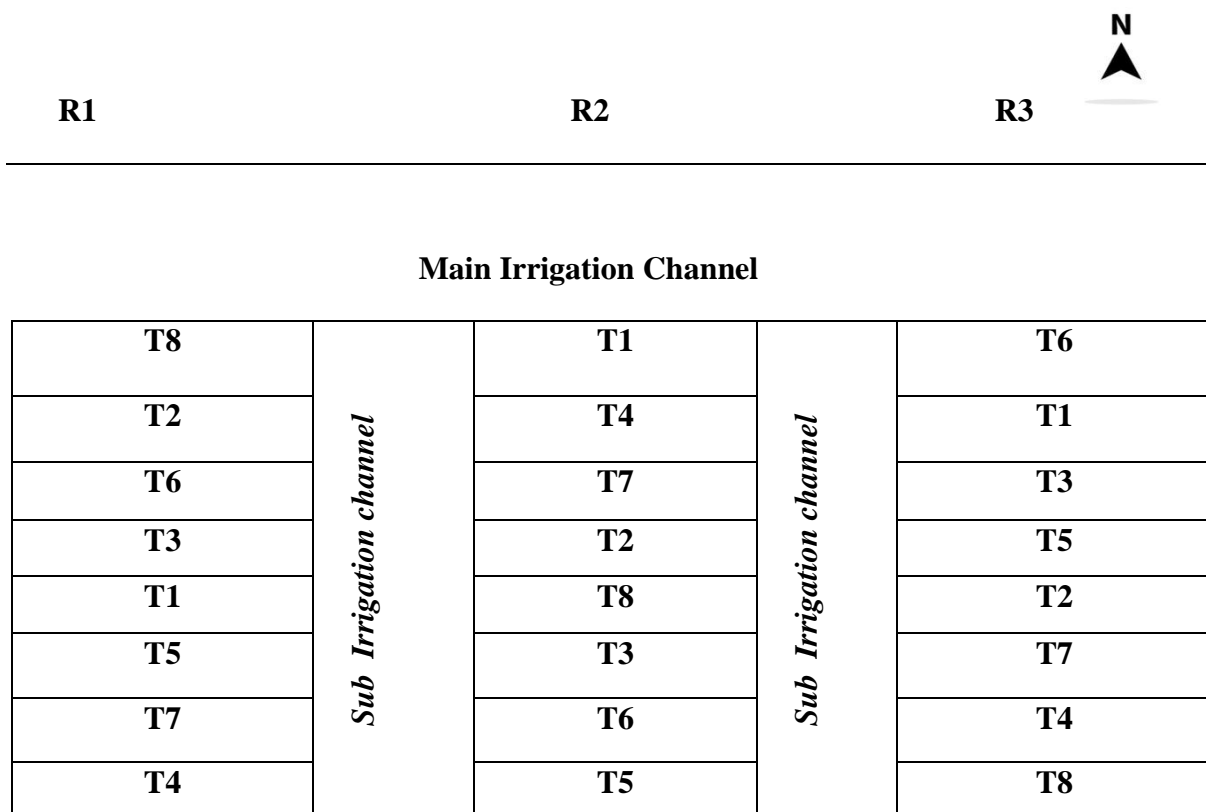


Figure 3.5 Layout plan of experimental field



Plate 1: Land preparation



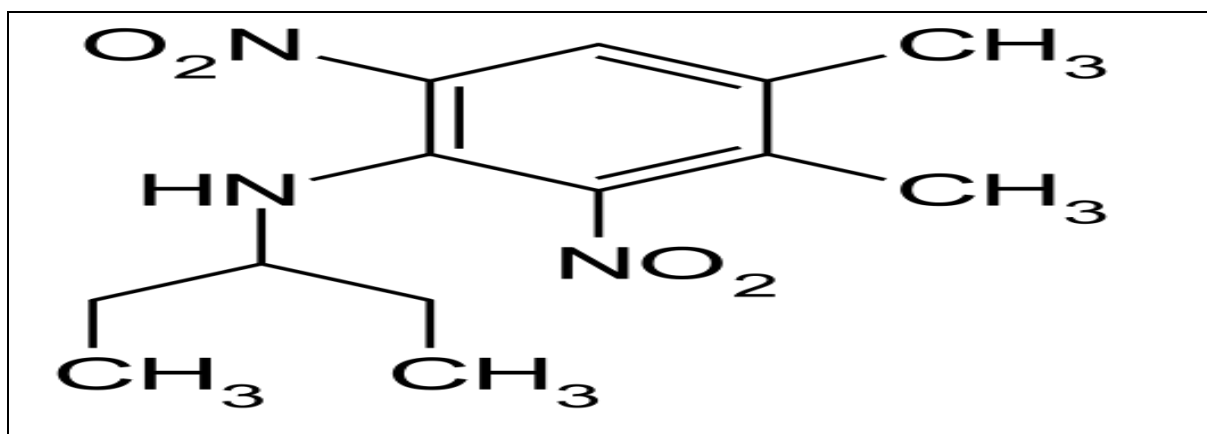
Plate 2: Spraying of pre-emergence herbicides

3.2.3 Descriptions of herbicides used

A. Pendimethalin

Common name	: Pendimethalin
Trade name	: Stomp
IUPAC name	: 3, 4- Dimethyl-2,6-dinitro-N-pentan-3-yl-aniline
Molecular formula	: C ₁₃ H ₁₉ N ₃ O ₄
Chemical family	: Dinitroaniline
Active ingredient	: 30 EC
Dose	: 750 g/ha
Application time	: Pre-emergence
Selectivity	: Selective

Structure of herbicide:



Mode of action:

Pendimethalin absorbed by germinating weeds inhibits cell-division in the meristemic tissues, disrupt the microtubule and inhibits synthesis of food by seedlings which results in chlorosis and inhibition of elongation of leaves therefore resulting in death of most of the weeds within few days of their emergence.

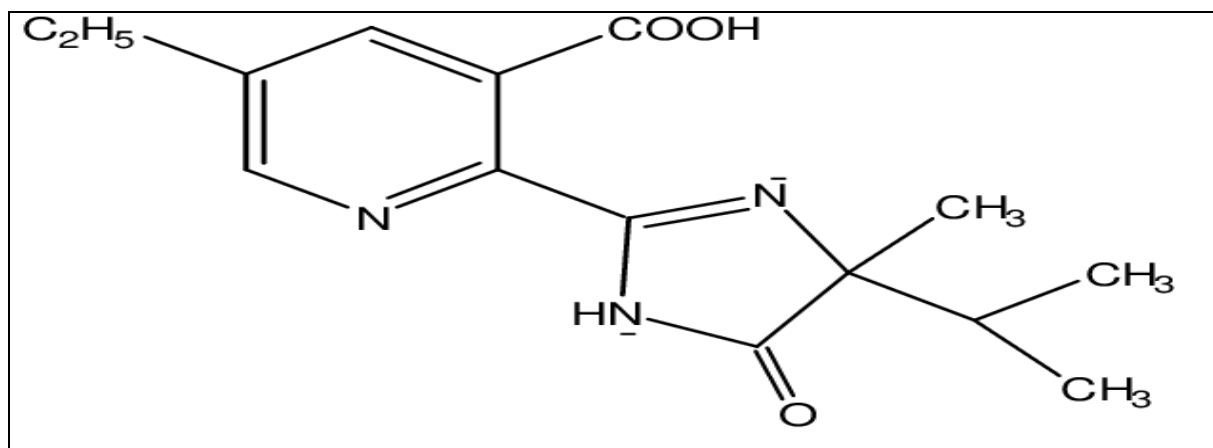
Uses: It controls most of the grassy weeds and certain broad leaf weeds. It is a selective soil applied herbicide, predominantly used for pre-emergence treatments.

B. Imezathyper

Common name	: Imezathyper
Trade name	: Pursuit
IUPAC name	: 5-ethyle-2-[(RS)-4-isopropyl-4-methyl-5-oxo-2-imidazolin-2-yl] nicotinic acid

Molecular formula : C₁₅H₁₉N₃O₃
 Chemical family : Imidazolinones
 Active ingredient : 10% SL
 Dose : 75 g/ha
 Application time : Post-emergence
 Selectivity : Selective

Chemical structure :



Mode of action:

The mode of action of imazethapyr is the inhibition of acetolactate synthase (ALS) (Shaner *et al.*, 1984), the first common enzyme in the biosynthesis of the branched-chain amino acids valine, leucine, and isoleucine (Saari and Mauvais, 1996).

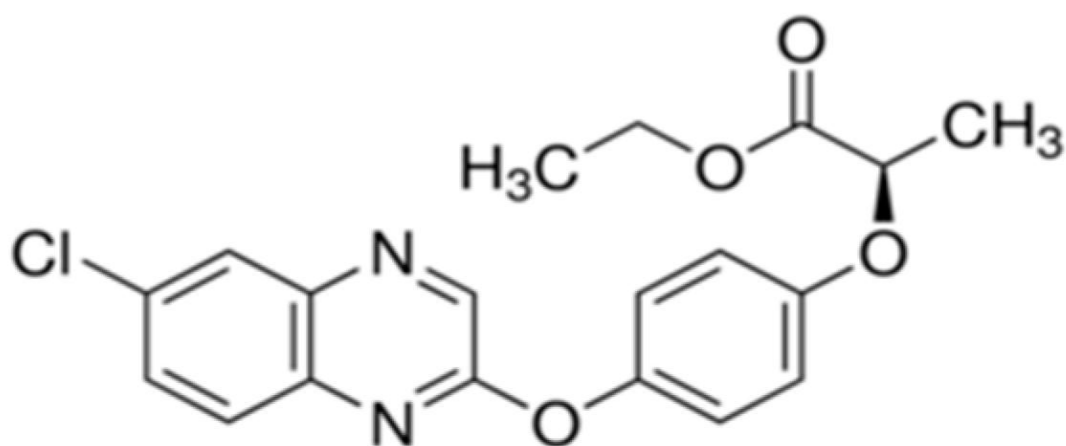
Uses: Imezathyper is an herbicide is used to stop post emergence broadleaf and grassy weeds in crops such as soybean, mungbean, cluster bean and other pulses etc.

C. Quizolofop ethyl

Common name : Quizolofop ethyl
 Trade name : Targa super
 IUPAC name : 2-{4-[(6-chloroquinoxalin-2-yl)oxy] phenoxy}propanoate
 Molecular formula : C₁₉H₁₇ClN₂O₄
 Chemical family : Phenoxy propionates
 Active ingredient : 5% EC
 Dose : 50 g/ha
 Application time : Post-emergence
 Selectivity : Selective

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Chemical structure:



Mode of action: Quizolofop is a systemic herbicide, absorbed from the leaf surface, with translocation throughout the plant, moving in both the xylem and phloem, and accumulating in the meristematic tissue.

Uses: Quizolofop-P-ethyl is a selective, post-emergence phenoxy herbicide. It is used to control annual and perennial grass weeds in potatoes, soybeans, sugar beets, peanuts vegetables, cotton, flax and Mungbean.

D. (Propaquizafop + Imezathiper)

Common name	: (Propaquizafop + Imezathiper)
Trade name	: Shaked
IUPAC name	: Propaquizafop- 2-isopropylideneaminoxyethyl (R)-2-, propionate
Molecular formula	: Propaquizafop- C ₂₂ H ₂₂ ClN ₃ O ₅
Active ingredient	: 2.5% + 3.7%
Dose	: 2L/ha
Application time	: Post-emergence
Selectivity	: Selective

Shaked is an early post emergence herbicide with broad spectrum activity on grasses and broad leaf weeds.

Mode of action: Shaked combine two active ingredients with two different mode of action. It hinders amino acid synthesis (protein synthesis) and also fatty acid synthesis. This leads to disruption of the DNA synthesis and cell growth and ultimately the weeds get killed.

Formulation: Shaked has a unique formulation combining two different actives with inbuilt adjuvant for ease of use application.

3.3 Details of cultural operations

Details of cultural operations for raising Mungbean crop is described below:-

3.3.1 Land Preparation

No soil disturbance was done in plots. Avoided all preparatory tillage operations and sowing was done after 2-3 days of Paraquat application by using zero till seed-drill. Paraquat kept field free from weeds during sowing and later on.

3.3.2 Fertilizer application

The recommended dose of Nitrogen (20 kg/ha), phosphorus (30 kg/ha) and potassium (40 kg/ha) adopted as per standard package of practice of seed crops in different treatments. The crop was supplied with full amount of nitrogen, phosphorus and potassium were applied in the form of urea, DAP and MOP respectively as basal application.

3.3.3 Seed treatment and Sowing

The required quantity of seeds (20 kg/ha) was treated with rhizobium culture and phosphorus solubilising bacterial (PSB) before sowing @ 20 g/kg of seed. The seeds were sown in row drawn 30cm apart. Plant to plant spacing was maintained at 10cm with 5cm deep.

3.3.4 Application of herbicide

The herbicide pendimethalin @ 0.75 kg/ha was applied as pre emergence through uniform spray at one DAS and Imezathyper @ 75 g/ha, Shaked @ 2 L/ha and Quizolofop-ethyl @ 50 g/ha as post emergence at 20 DAS. One HW was done at 20 DAS for eliminating early weed crop competition.

3.3.5 Plant protection measures

The crop was sprayed with Imidacloprid 17.8 SL @ 0.4 ml/liter water as per need based requirement to save the crop from various insect and pest attacks.

3.3.6 Irrigation

Mungbean water loving crop especially in summer season. One pre-sowing irrigation (Palewa) was given and crop was irrigated at 4, 20, 32 and 56 DAS in all the treatment.

3.3.7 Harvesting/cutting management

Harvesting was done plot wise when the 80 % of the pods turned into black color. First picking done at 70 DAS and second picking at 75 DAS, than crop cut for fodder purpose.

Table 3.6: Details of the field operations during experimentation

S. No	Operations	Date	Remarks
1.	No tillage	09/04/2019	No soil disturbance was done in plots.
2.	Layout experiment	09/04/2019	All bunds, main irrigation channels and sub irrigation channels were formed
3.	Pre-sowing irrigation	11/04/2019	Pre-sowing irrigation was given to obtained proper soil moisture for sowing of the crops.
4.	Seed treatment by Rhizobium and PSB	12/04/2019	With Rhizobium culture and phosphorus solubilising bacterial (PSB) one day before (@ 20gm per kg of seed).
5.	Soil sampling	13/04/2019	For the purpose of checking out initial fertility status of the soil, soil sampling was done and after that recommended dose of FYM was applied into selected plots per the treatment.
6.	Basal Fertilizer application	13/04/2019	Full amount of Nitrogen, Phosphorus and Potassium were applied in the form of urea, DAP and MOP respectively as basal application
7.	Date of sowing	13/04/2019	Crops were sown and planting as per standard package of practice and recommended method
8.	Herbicide application	08/04/2019 15/04/2019 03/05/2019	1. In zero tillage treatment paraquat was applied @ 0.5 a.i kg/ha. 2. Spraying of Pre emergence herbicides was sprayed with recommended dose as per treatment 3. Spraying of post emergence herbicides.
9.	Irrigation	17/04/2019 07/05/2019	One pre sowing irrigation (Palewa) was given and crop was irrigated four times in

		21/05/2019 10/06/2019	all the treatment.
10.	Plant observations	05/05/2019 22/06/2019	Biometric observation like plant height, no of branches, no of pods, no of nodule was taken at 30DAS and at harvest.
11.	Harvesting	22/06/2019 27/06/2019	At 70 DAS first picking At 75 DAS final picking At 75 DAS harvested for fodder
12.	Sun drying	22 and 27/06/2019	
13.	Threshing	30/06/2019	

3.4 Collection of experimental data

3.4.1 Sampling technique

Random sampling techniques (Gomez and Gomez, 1984) were adopted for recording growth and yield attributes of mungbean. Weed and crop samples were collected from each individual plot during the period of investigation for studying various crop and weed characters. Weed samples were collected placing a quadrat of 0.25 m² randomly in each plot. The observations were taken at 30 and harvest for crop and weeds. Five plants from each plot were tagged randomly to record crop growth and yield contributing characters

3.4.2 Observation on mungbean

3.4.2.1 Plant Height (cm)

The plant height was measured from five randomly tagged plants from ground to tip of the longest leaf, average of five plants were worked out to get the mean plant height.

3.4.2.2 Number of leaves/ plant

Number of leaves /plant was recorded by counting the fully opened leaves of same five tagged plants and average was work out at both stage of observation.

3.4.2.3 Number of branches/ plant

Number of branches/ plant was recorded by counting the branches of same five tagged plants and average was work out at both stage of observation.

3.4.2.4 Number of pods/ plant

Number of pods/plant was recorded by counting the pods of same five tagged plants and average was work out at both stage of observation.

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3.4.2.5 Number of seeds/ pod

Number of seeds/ pod was recorded by counting the pods of same five tagged plants and average was work out.

3.4.2.6 Leaf area index

The leaf area index is the total area per unit ground area. The same was calculated by using the following formula.

$$\text{LAI} = \frac{\text{Total leaf area per plant (cm}^2\text{)}}{\text{Total land area occupied by the plant (cm}^2\text{)}}$$

3.4.2.7 Number and weight of nodules/plant

The number of effective nodule and their fresh weight from the uprooted plant were recorded at 40DAS and average was worked out to get the nodule number and weight/ plant.

3.4.2.8 Root biomass/plant

Root biomass of selected uprooted plant was recorded at 40 DAS and average was worked out.

3.4.2.9 Injury score (Phytotoxicity due to herbicides)

Injury effects of the herbicides caused, if any, to crop was visually assessed at 5 and 25 DAS by observing a simple rating scale of 0 to 10 (equal to 0 to 100%) this given in table (Rao, 1983).

Table 3.7: Qualitative description of treatment effects on crop in the visual scoring scale of 0 to 10

Effect	Rating	Description on crop
none	0	No injury, normal
Slight	1	Slight stunting injury
	2	Some stand loss, stunting or discolouration
	3	Injury more pronounced but not persistent
Moderate	4	Moderate injury, recovery possible
	5	Injury more persistent, recovery doubtful
	6	Near severe injury, no recovery possible
Severe	7	Severe injury, stand loss
	8	Almost destroyed, a few plant surviving
	9	Very few plants alive
Complete	10	Complete destruction



Plate: 3 Herbicide injuries on crop

3.4.3 Observations on weeds:

3.4.3.1 Weed flora:

The important weed flora of the experimental plot during the period of experimentation was recorded.

3.4.3.2 Weed population count (number/m²)

An area of 0.25 m² was selected randomly by throwing a quadrat of size 50 cm X 50 cm. Total numbers of weeds present in randomly fixed 0.25 m² area in each plot was counted at 30 DAS and harvest. Weed density was expressed in numbers/m² and transformed as wide variations existed among the treatments.

3.4.3.3 Weed species count (dicot and monocot)

Species wise density was recorded which present in randomly fixed 0.25 m² area in each plot at 30 DAS and harvest and expressed in numbers/m² and transformed as wide variation existed among the treatments.

3.4.3.4 Weed dry weight (g)

Dry weight of weeds was recorded at 30 DAS and harvest. The weeds were uprooted from the destructive sampling area of 0.25m² and were oven dried to a constant weight at 70. Dry weight recorded from sampled area from each plot was expressed as g/m².

3.4.3.5 Weed control efficiency (WCE)

Weed control efficiency denotes the magnitude of weed reduction due to the weed control treatment. Weed control efficiency was calculated on weed population basis at 30 DAS and harvest by adopting formula, given by Mani *et al.* (1973).

$$\text{WCE (\%)} = \frac{\text{Weed population in weedy check} - \text{weed population in treatment}}{\text{Weed population in weedy check}} \times 100$$

3.4.3.6 Weed control index (WCI)

Weed control index was calculated on weed dry weight basis at 30 DAS and harvest by adopting formula (Mishra and Tosh, 1979).

$$\text{WCI (\%)} = \frac{\text{Weed dry weight in weedy check (g)} - \text{weed dry weight in treatment (g)}}{\text{Weed dry weight in weedy check (g)}} \times 100$$

3.4.3.7 Weed index

Weed index indicates the extent of reduction in yield (q/ha) due to crop weed competition. It was worked out for different treatments by adopting the formula given by Gill and Kumar (1969).

$$\text{WI (\%)} = \frac{\text{Yield from weed free} - \text{Yield of a particular treatment}}{\text{Yield from weed free}} \times 100$$

3.4.4 Yield attributes

To eliminate border effect two rows on both sides and 0.5 m length at each end of the plot was harvested as non-experimental and discarded. The net plot area was harvested separately from each plot to record the final seed, green fodder yield and dry matter yield was calculated by multiplying with dry matter percentage.

3.4.4.1 Seed yield

The grain was picked up from net plot area at 70 and 75 DAS of the crop treatment wise and the weight of grains were recorded and converted into one hectare area separately.

3.4.4.2 Green fodder yield

The crop from net plot area was harvested at maturity stage of the crop treatment wise and the fresh weight of fodder was recorded and converted into one hectare area separately.

3.4.4.3 Dry matter yield (DMY)

The fresh weight of the samples were recorded and dried in hot air oven at 75 °C for 48-72 hours to constant weight to record the dry weight and dry matter percentage was determined. The net plot wise green forage yield was multiplied by respective dry matter percentage to get dry weight in kg per plot and was expressed in t/ha.

$$\text{DMY (t/ha)} = \frac{\text{Green fodder yield (t/ha)} \times \text{Dry matter content (\%)}}{100}$$

100



Plate: 4 Seed picking of mungbean (Harvesting)

3.5 Quality Parameters

3.5.1 Fodder quality

a. Preparation of Substrates

The all fodder crops samples were dried and grounded separately (Wiley mill) to pass through one mm screen for analysis of quality parameters. The ground samples were stored in polycarbonate bottles until analyzed.

3.4.5.1 Chemical analysis of Mungbean.

a. Estimation of dry matter content (%)

A known quantity of fresh fodder sample (about 10-50 g) was taken in a pre-weighed aluminium tray. The aluminium tray was placed in hot air oven at 60-70 °C for 24 hr. (AOAC, 2005). The loss in moisture content after drying was estimated and dry matter (DM) was calculated by following formula.

$$\text{DM (\%)} = \frac{(\text{Wt. of aluminum tray + samples after drying}) - (\text{Wt. of aluminum tray})}{\text{Wt. of fresh sample}}$$

B. Estimation of total ash content (%)

A known quantity of sample (3 g) was taken in pre-weighed silica crucible. After charring the sample on heater (till the smoke disappeared), the crucible was kept in muffle furnace for ignition at 550°C for 2-3 hours. The crucible was removed on cooling and kept in a desiccator and weighed again to find out weight of ash (AOAC, 2005). The ash content was calculated by following formula.

$$\text{Total ash (\%)} = \frac{(\text{Wt of crucible + ash after cooling}) - (\text{Wt of crucible})}{\text{Wt of dried sample (g)}} \times 100$$

C. Estimation of Organic Matter content (OM)

OM (%) was determined by subtracting the total ash content from 100.

$$\text{OM (\%)} = 100 - \text{Total ash (\%)}$$

D. Determination of crude protein (CP) content (%)

Total nitrogen was analysed by micro Kjeldahl method. A known quantity of sample (about 0.5-1.0 g) was taken in Kelplus-Kelvac/digestion tubes and digested with 20-30 ml concentrated H₂SO₄ and 2-3 g of digestion mixture till the solution became colourless. After digestion, the contents were cooled and volume was made to 100 ml. 10 ml of aliquot was distilled in Kjeldahl distillation apparatus (KEL PLUS-Classic DX Nitrogen Analyzer) after adding 10-15 ml of 40% NaOH solution. About 60-75 ml of distillate (light green colour) was collected into an Erlenmeyer flask containing 10 ml of 2% boric acid indicator solution.

The distillate was then titrated against standard N/100 H₂SO₄ solution and the end point was recorded when the colour changed to slight pink. Volume of N/100 H₂SO₄ solution used in titration was recorded (AOAC, 2005).

The crude protein (%) of sample was calculated by multiplying the N content with the factor 6.25. This was based on the principle that all the proteins contain 16% nitrogen.

$$N (\%) = \frac{(0.14 \times 0.01 \times \text{volume of } 0.01N \text{ H}_2\text{SO}_4 \text{ used} \times \text{volume made (ml)})}{\text{Aliquot taken (ml)} \times \text{Wt of sample (g)}} \times 100$$

$$\text{Crude protein (\%)} = N (\%) \times 6.25$$

E. Estimation of ether extracts (EE) content

A known quantity of ground sample (about 3 g) was taken in a cellulose thimble and extracted for 16 hours with petroleum ether in Soxhlet's extraction apparatus attached to a pre-weighed oil flask. The oil flask was removed and after evaporating the excess of ether, it was dried overnight in a hot air oven (100±5°C). The flask was cooled in a desiccator and weighed to a constant weight. The difference between two weights gave the amount of ether extract in the sample (AOAC 2005, method 920.39).

Calculation:

$$EE (\%) = \frac{(\text{Wt of oil flask with ether extract} - \text{Wt of empty oil flask})}{\text{Wt of dried sample (g)}} \times 100$$

F. Estimation of cell wall Constituents

The fraction of cell wall constituents such as ADF and hemi cellulose was estimated (Van Soest *et al.* 1991) while NDF content was estimated as per McQueen and Nicholson (1979).

G. Estimation of neutral detergent fiber (NDF)

A known quantity of air dried, ground samples (1 g) was taken in a 500 ml spout less beaker and add 100 ml NDS and 0.5g sodium sulphite were added and the contents of spout less beaker were refluxed for an hour after the initial onset of boiling. Then, the contents of beaker were filtered through pre-weighed 50 ml sintered glass crucible (G-I) using oil-free vacuum pump. The contents were washed repeatedly 2-3 times with hot boiling water and then acetone to remove all salts. The sintered crucible containing residue was dried in hot air oven (100 ± 5°C) overnight, cooled and weighed to a constant value. The crucible was kept for ashing in a muffle furnace at 550 °C for 2-3 hr and crucible along with ash was weighed again (Van Soest *et al.* 1991).

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The NDF was calculated as follows:

$$\text{NDF (\%)} = \frac{(\text{Wt of crucible + Residues}) - (\text{Wt of empty crucible})}{\text{Wt of dried sample (g)}} \times 100$$

H. Cell soluble

Cell soluble calculated by subtracting the NDF % from 100 as follows

$$\text{Cell soluble (\%)} = 100 - \text{NDF (\%)}$$

I. Estimation of Acid detergent fiber (ADF)

A known quantity of air dried, ground samples (1 g) was taken in a 500 ml spout less beaker and add 100 ml acid detergent solution and the contents were refluxed for exactly 1 hour. After refluxing, the residue was filtered through pre-weighed sintered glass crucible (Grade-I) using vacuum pump, washed with hot water 2-3 times followed by acetone to remove all salts. The crucible containing residue was dried in hot air oven ($100 \pm 5^\circ\text{C}$) overnight and weight taken next day when it cools down (AOAC, 2005, method 973.18). The ADF was calculated as follows.

$$\text{ADF (\%)} = \frac{(\text{Wt of crucible + Residues}) - (\text{Wt of empty crucible})}{\text{Wt of dried sample (g)}} \times 100$$

J. Estimation of Hemi cellulose content

Hemi cellulose was calculated by subtracting the Acid detergent fiber % from neutral detergent fiber %.

$$\text{Hemi cellulose content (\%)} = \text{NDF (\%)} - \text{ADF (\%)}$$

K. Estimation of Acid Detergent Lignin (ADL)

ADF containing crucible was filled with 72% H_2SO_4 (15°C) with continuous stirring to break the lumps and stir at hourly intervals as acid drains away. After three hours, filter off and washed with hot water to remove acid residues. Dry the crucible at 100°C for 8 hours and weight. Keep the crucible in muffle furnace at $500\text{-}550^\circ\text{C}$ for 8 hr and then weigh it after cooling. The ADL was calculated as follows:

$$\text{ADL (\%)} = \frac{(\text{Wt of crucible + Lignosilica}) - (\text{Wt of crucible+ ash})}{\text{Wt of dried sample (g)}} \times 100$$

3.5.2 Seed quality parameters

Seed samples were collected from seed lot of each treatment and stored in cloth bags. Hundred seeds were taken for seed quality parameters viz:- germination (%), Seedling length (cm) and seedling dry weight (g).

a. Thousand seed weight

1000 seed weight from seed sample of seed of seed lot of each plot were taken randomly and weighed separately.

b. Germination percentage

The seeds were placed for standard germination at 25 °C for 8 days in rolled towel paper (B.P. Method) (ISTA Method, 1985).

B.P. Method (Between paper)

Seeds were placed for germination between the two layers of germination papers. The papers used were of good quality and free from toxin substances. Papers (46×29 cm) was soaked in water for 4 hours to moisten it and to remove water soluble toxic substances. Seeds were carefully placed between two layers of paper towel which will then rolled carefully ensuring no excess pressure placed on seeds. Then it was wrapped in sheet of butter paper to reduce surface evaporation and placed in germination chamber in an upright position. Germination percentage was recorded according to ISTA, 1985.

$$\text{Germination percentage} = \frac{\text{No. of seeds germinated}}{\text{Total no.of seeds}} \times 100$$

C. Seedling length

Five seedlings were taken randomly from germinated seedlings of each plot and their length was measured with the help of centimetre scale and average was expressed as seedling length in centimetre (cm).

c. Seedling dry weight

Five seedlings were taken randomly from germinated seedlings of each lot, and dried in a hot air oven at 70 °C till constant weight was obtained and average was expressed as dry weight g/seedling.

d. Seedling vigour index

The seedling vigour expressed after 8 days setting the experiment. Seedling Vigour Index was determined by the formula given by Murugesen *et al.* (1989).

$$\text{Seedling Vigour Index 1} = \text{Germination \%} \times \text{Seedling length (cm)}$$

$$\text{Seedling Vigour Index 2} = \text{Germination \%} \times \text{Seedling dry weight (mg)}$$

3.5.4 Estimation of Nutrients contents in plant tissue of weed, seed and green fodder

The plant samples were collected at harvesting and oven dried (70°C) then grinded in a Wiley mill to pass through 2 mm sieve. The sieved samples were used for the estimation of nutrients contents in plant tissue.

3.5.4.1 Determination of Nitrogen content in plant sample (Kjeldahl method)

Nitrogen content in plants was estimated by Kjeldahl method and expressed in percentage on dry weight basis (detail of procedure is given in CP content analysis).

$$N (\%) = \frac{(0.14 \times 0.01 \times \text{volume of } 0.01N \text{ H}_2\text{SO}_4 \text{ used} \times \text{volume made (ml)})}{\text{Aliquot taken (ml)} \times \text{Wt of sample (g)}} \times 100$$

3.5.4.2 Determination of phosphorus content in plant sample:

Take a 5 ml aliquot of di-acid plant digest into a 50 ml volumetric flask. Add 10 ml of vanadate-molybdate solution and dilute to 50 ml with water. Then mix well and read the colour intensity at 420 nm in spectrophotometer. Run a blank without phosphorus solution simultaneously. Finally P content was calculated by using the standard curve.

$$P (\text{ppm}) = \frac{\text{Conc. reading from standard curve} \times \text{volume made (ml)} \times \text{dilution facto} \times 100}{\text{Wt of dried sample (g)}}$$

3.5.4.3 Determination of potassium (K) content in plant sample

Potassium content in the digest of plant sample was determined by using flame photometer. Depending of the concentration of K in the plant sample, the digest can be used either directly or after dilution for flame photometric determination.

$$K (\text{ppm}) = \frac{\text{Flame photometer reading} \times \text{volume made (ml)} \times \text{dilution factor} \times 100}{\text{Wt of dried sample (g)}}$$

3.5.4 Nutrient Uptake by weed

Nutrient uptake by weed are obtained by multiplying weed dry weight (q/ha) and nutrient content (%).

$$\text{Nutrient uptake (kg/ha)} = \frac{\text{Nutrient concentration in weed (\%)} \times \text{Dry weight (kg/ha)}}{100}$$

3.5.5 Nutrient Uptake by Crop

Nutrient uptake by crop are obtained by multiplying dry matter yield kg/ha and nutrient content (%).

$$\text{Nutrient uptake (kg/ha)} = \frac{\text{Nutrient concentration in plant (\%)} \times \text{Dry matter (kg/ha)}}{100}$$

3.5.5 Soil fertility parameters

3.5.5.1. pH

A known quantity (25gm) of dried, grinded and sieved (2mm) soil sample was taken in 100ml plastic beaker and added 50 ml distilled water (The ratio of soil and water 1:2, respectively). After half an hour when solution was stirred for with the help of glass rod than calibrate pH meter by using buffer solution with pH 7.0 than after calibration electrode was dipped in soil water solution and the reading was noted down from pH meter.

3.5.5.2 Electric conductivity (EC)

For measuring EC, 25gm dried, grinded and sieved (2mm) soil sample was taken in 100ml plastic beaker and add 50 ml distilled water (The ratio of soil and water 1:2, respectively). When soil water solution was stirred for half an hour, leave the solution for some time till soil settled down and clear water solution appear. Digital EC meter was calibrated using distilled water, the reading was zero as distilled water is free from all type of soluble salts. After calibration electrode of EC meter was dipped in clear water solution and note down reading from EC meter.

3.5.5.3. Organic carbon (Walkley and Black, 1935)

A known quantity (1gm) of the dried, grinded and sieved (2mm) soil sample was taken in 500ml conical flask (Erlenmeyer flask) also run a blank sample without soil. After that 10 ml of 1N potassium dichromate (1N $K_2Cr_2O_7$) was added to it followed by 20ml of concentrated H_2SO_4 by tilting the flask and it left to stand for 30 minutes after a little shaking. After completion of oxidation process 200 ml distilled water was added to it to stop the reaction. After that 10 ml of ortho-phosphoric acid followed by 1ml di-phenyl amine indicator was added to it. The Solution was back titrated with 0.5 N ferrous-ammonium sulphate until the color changes from blue violet to green and note the volume (reading) of ferrous-ammonium sulphate used in titration. The soil organic carbon content calculated by following formula.

$$\text{Organic carbon (\%)} = \frac{10 (\text{Blank reading} - \text{Sample reading}) \times 0.003}{\text{Blank reading} \times \text{Wt. of sample taken (g)}} \times 100$$

3.5.5.4 Determination of available Nitrogen

A known quantity of (8 gm) dried, grinded and sieved (2mm) soil sample was taken in Kjeldahl distillation tube and same time run a blank sample without soil and added to it 40 ml of each solution potassium permanganate (0.32% $KMnO_4$) and sodium hydroxide (2.5% NaOH). Thereafter, 20 ml Boric acid (2%) was taken in a 250 ml conical flask for trapping the ammonia. Set the Kjeldahl distillation tube for distillation in distillation assembly/system

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together also set conical flask that have boric acid for trapping the ammonia. Set time in distillation assembly/system about 8-10 minutes and run it for 9 minutes. The ammonia release from sample and absorbed in conical flask that have boric acid. The pink colour of boric acid solution turns to green colour. Now the content in conical flask is titrated with 0.01N standard sulphuric acid till colour change from green to pink than the volume of sulphuric acid was noted down (reading) that was used in titration. The soil nitrogen content calculated by following formula.

$$\text{Available N (kg/ha)} = \frac{(\text{Sample reading} - \text{Blank reading}) \times 0.014 \times \text{volume of H}_2\text{SO}_4 \times 2.24 \times 1000000}{\text{weight of oven dried soil sample taken (g)}}$$

3.5.5.5. Determination of Available Phosphorous

A known amount of (2.5 g) dried, grinded and sieved (2mm) soil sample placed in 100 ml conical flask. Added 1g Darco G-60 activated charcoal and 50 ml of 0.5N NaHCO₃ (pH 8.5) solution also run a blank sample without soil. Shake the flask for 30 minutes on a mechanical shaker and then filter through Whatman no. 42 filter paper and collect the filtrate. Then taken 5 ml of the aliquot in 25 ml of volumetric flask. Added 2 drops of p-nitrophenol indicator. It develops yellow colour. Add drop wise 5N H₂SO₄ till yellow colour disappears. Keep it overnight preferably to complete bubble out of CO₂ make this free of dissolved gases. Then added 10 ml of distilled water and 5 ml of ascorbic acid solution make the volume to 25 ml. Blue colour so developed can be measured at 882 nm after calibrating the spectrophotometer with standard curve. The soil phosphorus content calculated by following formula.

$$\text{Available phosphorus (kg/ha)} = \frac{\text{Reading} \times \text{volume of extracting reagent} \times \text{volume made} \times 2.24}{\text{Volume of aliquot taken} \times \text{wt. of soil (g)}}$$

3.5.5.6 Determination of Available Potassium

A known amount of (2.5g) dried, grinded and sieved (2mm) soil sample placed in 100 ml conical flask and added 25 ml of 1N Ammonium acetate solution into it. Shake the content on mechanical shaker for five minutes and then filter it through Whatman No.1 filter paper and collect the filtrate, then by using this filtrate measure potassium concentration on flame photometer after calibration of instrument. The soil potassium content calculated by following formula.

$$\text{Available K (kg/ha)} = \frac{\text{Reading of flame photometer} \times \text{volume of extracting reagent used} \times 2.24}{\text{Wt. of soil sample taken (g)}}$$

3.5.5.7 Determination of soil micronutrient

A known amount of (2.5g) dried, grinded and sieved (2mm) soil sample placed in 100 ml conical flask and added 30 ml of DTPA extracting solution was added to it. The flasks were transferred on mechanical shaker for two hours for shaking. After shaking the solution was filtered by Whatman no. 42 filter paper. After filtration the filtrate was used for micronutrients estimation on AAS after calibrating the AAS with standard curve.

$$\text{Available micronutrients (ppm)} = \frac{\text{Reading of AAS (ppm)} \times \text{volume of extracting solution used}}{\text{Wt. of soil sample taken (g)}}$$

3.5.5.8 Quantitative and qualitative estimation of soil microbes

Quantitative estimation of soil microbes

To estimate the number of soil microflora, counts were calculated on the basis of serial 10-fold dilution technique, using the pour plate methods and replicate of 10 gm soil samples, and an appropriate dilution as described by Johnson and Curl (1972). 10 g of air-dried soil was taken and sieved properly to discard all foreign particles and added to 100 ml of sterilized distilled water to make a dilution of 10^{-1} , from this dilution 10 ml of the aliquot was transferred to 90 ml of sterilized distilled water to make dilution 10^{-2} . Likewise, the soil sample were serially diluted (6-fold series). Aliquots of 1 ml from dilution 10^{-5} were spread on nutrient agar, for total bacterial counts and from 10^{-4} on Rose Bengal agar for fungi and Kenknights medium for actinomycetes. Each dilution was spread onto five replicates. The number of colonies forming on each medium was counted at 48-72 hrs for bacteria and after 120 hrs for fungi and actinomycetes, after incubation at $32 \pm 2^\circ\text{C}$ for bacteria and $25 \pm 2^\circ\text{C}$ for fungi and actinomycetes. Colony forming unit per g of soil (cfu/g) was calculated using the equation of Johnson and Case (2007).

$$\text{No. of colonies (CFU/g)} = \frac{\text{Number of colonies} \times \text{dilution factor}}{\text{Volume plated (ml)}}$$

3.6 Workout the Economics of treatments

The cost of cultivation was worked out treatment-wise. The prices of the inputs that were prevailing at the time of their use and selling price for grain and green fodder as approved by the ICAR-NDRI, Karnal were taken into account.

a. Gross returns (Rs/ha)

The gross monetary returns in rupee per ha were worked out by considering the price of grain and fodder at the time of harvest prevailing in the market.

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b. Net returns (Rs/ha)

The net profit per ha was calculated by deducting the cost of cultivation per ha from the gross returns/ha.

Net returns (Rs/ha) = Gross returns (Rs/ha) - Total cost of cultivation (C3) (Rs/ha)

c. Benefit cost ratio

$$\text{B: C ratio} = \frac{\text{Net return (Rs/ha)}}{\text{Cost of cultivation (Rs/ha)}}$$

3.7 Statistical Analyses of Data

Data recorded on growth parameters, yield parameters, weed parameters, soil fertility parameters and fodder quality parameters were subjected to analysis of variance given by Gomez and Gomez (1984). The results have been discussed at probability of five per cent. The “F” and “T” test were done at five per cent probability level. Critical difference was calculated when “F” test value indicated the significance. Since data recorded on weed density and weed dry weight do not follow normal distribution, so the data were transformed by using square root $\sqrt{x+0.5}$ transformation as suggested by Gomez and Gomez (1984). The transformed data were statistically analysed.

Table 3.9: The skeleton of the analysis of variance

Source of variation	DF	SS	MSS	F cal	F tab	SEm±	CD 5%
Replication(r)	(r-1)=2						
Treatment (t)	(t-1)=7						
Error	(r-1)(t-1)=14						
Total	Rt-1=23						

Where,

R = Number of replication T = Number of treatment
D.F = Degree of freedom S.S = Sum of square
M.S.S = Mean sum of square S.Em± = Standard error of mean

Standard error of mean (SEM) and critical difference (CD) were found out by using following formula.

$$\text{SEm} = \sqrt{\text{EMS}/r}$$

Where,

EMS = Error mean square
R = Number of replication
CD (0.05) = SE (m) × t (error) d.f

Where,

t (error) d.f = t value at error degree of freedom at 5% level of probability.

CHAPTER -4

Results and Discussion

Outcome of the field experiment entitled “**Evaluation of weed management practices in summer mungbean (*Vigna radiata*) under zero tillage condition**” was conducted during summer 2019-20 have been discussed in this part with the help of appropriate tables and figures. These have been mentioned under following headings.

- 4.1 Weed studies**
- 4.2 Crop studies**
 - 4.2.1 Growth**
 - 4.2.2 Yield attributes**
 - 4.2.3 Yield**
 - 4.2.4 Phytotoxicity on crop**
 - 4.2.5 Nutrient content and uptake studies**
- 4.3 Soil quality parameters**
- 4.4 Fodder quality parameters**
- 4.5 Seed quality parameters**
- 4.6 Economics**

4.1 WEED STUDIES

Study on weeds viz., weed species, total weed population, weed dry weight, weed control efficiency and weed control index were observed at 30 DAS and harvest and weed index at harvest of crop as affected by different weed control practices.

4.1.1 Weed flora of the experiment field

The field trial was attentively monitored during crop growth stages to look the presence of different weed species at the particular stage. It was observed that three type of weeds were present in experimental field i.e. monocot (narrow leaved), dicot (broad leaved) and sedge weeds. A total of 11 species of weeds including 4 grasses, 2 sedges and 5 broadleaf weeds were observed (Table 4.1 and figure 4.1). Among the grassy weeds *Cynodon dactylon* and *Panicum repens* were the most prominent weeds. The broadleaf weed *Amaranthus viridic*, *Digera arvensis*, *Trianthema portulacastrum* and *Portulaca oleracea* were prominent. *Cyperus rotundus* was the prominent sedge. Similar botanic compositions of weeds were also reported by Poornima *et al.* (2016) and Kumar *et al.* (2011).

Table 4.1: Important weed flora in the experiment field

S. No.	Botanical name	Common name	Family
Grasses			
1.	<i>Cynodon dactylon</i>	Bermunda grass, devils grass	Poaceae
2.	<i>Digitaria ciliaris</i>	Crab grass	Poaceae
3.	<i>Panicum repens</i>	Quick grass	Poaceae
4.	<i>Brachiria mutica</i>	Buffalo grass	Poaceae
Sedges			
1.	<i>Cyperus iria</i>	Umbrella sedge	Cyperaceae
2.	<i>Cyperus rotundus</i>	Purple nut sedge	Cyperaceae
Broadleaf			
1.	<i>Amaranthus viridis</i>	Amaranthus	Amaranthaceae
2.	<i>Digera arvensis</i>	Lasuva, false amaranthus	Amaranthaceae
3.	<i>Trianthema portulacastrum</i>	Sathi, black pigweed	Aizoaceae
4.	<i>Euphorbia hirta</i>	Bara dudi, common spurge	Euphorbiaceae
5.	<i>Portulaca oleracea</i>	Lunia	Portulacaceae

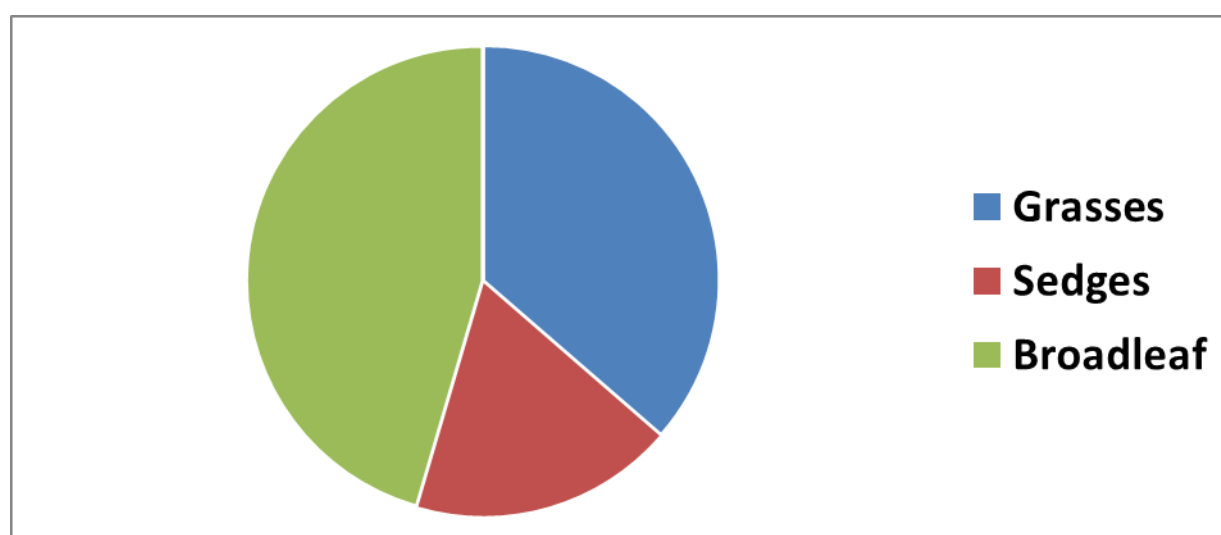


Figure 4.1: Occurrences of weed species (no. basis) in mungbean as influenced by weed control treatments

4.1.2 WEED DENSITY

Weed density is one of the prime factors affecting the efficiency of crop where it grows. Weeds compete for moisture, space, nutrients, light and shade with the crop. Moreover, weeds have adversely affected on the productivity, yield and quality of the main crop.

4.1.2.1 GRASSY WEEDS

The population of grassy weeds was observed at 30 DAS and harvest was mentioned in table 4.2. At 30 DAS weed free treatment was recorded the lowest grass weed population throughout the crop growth period followed by (Propaquizafop + Imezathyper) at 20 DAS. At Harvest, after weed free, (Propaquizafop + Imezathyper) at 20 DAS was recorded lowest grassy weeds (1.89) which were at par with Pendimethalin (PE) fb Quizolofop ethyl at 20 DAS (2.31). It indicates that application of pendimethalin followed by one HW at 20 DAS results in lower weed growth. Pendimethalin, Imezathyper, Pendimethalin fb Quizolofop ethyl and Pendimethalin fb Imezathyper also recorded significantly low grass weed population at all stages of crop growth as compared to weedy check.

Application of Propaquizafop + Imezathyper and Pendimethalin (PE) fb Quizolofop ethyl herbicides mostly control grasses weed. Pendimethalin having broad spectrum activity on weeds, control all type of weed during initial growing period of crop and later on Quizolofop ethyl control most of grassy weeds. Similar result was also recorded by Kundu *et al.* (2016).

4.1.2.2 SEDGE WEEDS

Total population of sedge weeds recorded at 30 DAS and harvest were mentioned in table 4.2 significantly influenced by various weed control treatments. At 30 DAS, significantly lowest sedge weeds population was recorded under weed free treatment (1.12) followed by Pendimethalin (PE) fb HW at 20 DAS (2.55). At harvest, significantly lowest sedge weeds population was recorded under weed free treatment (1.82) followed by Pendimethalin fb Imezathyper at 20 DAS (3.21). Unweeded control recorded maximum sedge weeds population at all stages of crop growth.

HW was effectively control sedge weed over chemical control because of successfully destroying the rhizome of sedge. The rhizome of sedge not suppressed by herbicides but same time by HW uprooted the whole weed plant entirely done. Ultimately this leads to complete control of sedge weed and kept minimum sedge population throughout growing

period. The extraordinary reduction in sedge weed population at different stages might be due to efficient weed control in particular treatments either manual or chemical or both. These results were harmonies with findings of Kaur *et al.* (2009).

Table 4.2: Effects of different weed control practices on grassy weed population and sedges (Per m²) at different crop growth stages

Treatments	No. of grasses		No. of sedge	
	30 DAS	Harvest	30 DAS	Harvest
Weed check	5.28 (27.33)	7.93 (62.63)	5.40 (28.67)	7.37 (54.00)
Weed free	1.22 (1.00)	1.48 (2.00)	1.12 (0.83)	1.82 (3.00)
Pendimethalin (PE)	4.13 (16.67)	5.54 (30.67)	3.66 (13.00)	5.73 (32.67)
Pendimethalin (PE) fb one HW 20 DAS	2.40 (5.33)	3.05 (9.00)	2.55 (6.00)	4.23 (17.55)
Imezathyper (POE) at 20 DAS	3.81 (14.00)	4.40 (19.00)	3.34 (10.67)	4.90 (23.67)
(Propaquizafop + Imezathyper) as POE at 20 DAS	1.89 (3.10)	2.31 (5.00)	3.58 (12.28)	3.77 (14.00)
Pendimethalin (PE) fb Imezathyper (POE) at 20 DAS	3.54 (12.00)	3.79 (14.00)	2.91 (8.00)	3.21 (10.00)
Pendimethalin (PE) fb Quizolofop ethyl at 20 DAS	2.31 (4.97)	2.52 (6.00)	4.71 (21.67)	4.31 (18.28)
SEm(±)	0.16	0.20	0.13	0.15
CD (p=0.05)	0.48	0.60	0.39	0.45

Original standards are given in parenthesis, which were transformed to $\sqrt{x+0.5}$

4.1.2.3 BROAD LEAVED WEEDS

Total broadleaf weeds count taken at 30 DAS and harvest of crop were mentioned table 4.3. Pendimethalin fb one HW at 20 DAS, Pendimethalin as PE, Imezathyper as POE, (Propaquizafop + Imezathyper) as POE, pendimethalin fb Imezathyper and Pendimethalin fb Quizolofop ethyl, were significantly reduced the broadleaved weed population at all the stages of crop growth. At 30 DAS minimum populations of broadleaf weeds were recorded

by weed free which was at par on Pendimethalin as PE fb one HW at 20 DAS. At harvest lowest dicot weed population was recorded under weed free followed by (Propaquizafop + Imezathyper) as POE at 20 DAS. Weedy check was recorded significantly highest dicot weeds at all the stages of crop growth.

Weed free recorded minimum broad leaf weeds throughout growing period because of repeated HW at different stages of crop growth, kept field free from broad leaved weeds. Same time excellent reductions in dicot weed population by combination of chemical and manual weeding and broad-spectrum activity of Imezathyper.

Table 4.3: Effects of different weed management practices on broadleaf and total weed population (Per m²) at different crop growth stages

Treatments	No. of broadleaf weeds		Total weed population	
	30 DAS	Harvest	30 DAS	Harvest
Weed check	5.04 (25.00)	6.60 (43.04)	9.03 (81.00)	12.54 (156.82)
Weed free	1.27 (1.17)	1.86 (3.00)	1.86 (3.00)	2.91 (8.00)
Pendimethalin (PE)	3.67 (13.00)	6.23 (38.66)	6.57 (42.67)	10.32 (106.51)
Pendimethalin (PE) fb one HW 20 DAS	1.56 (2.00)	3.24 (10.00)	3.71 (13.33)	5.90 (34.43)
Imezathyper (POE) at 20 DAS	3.24 (10.00)	3.93 (15.00)	5.93 (34.67)	7.44 (55.00)
(Propaquizafop + Imezathyper) as POE at 20 DAS	2.73 (7.00)	2.91 (8.00)	4.78 (22.38)	4.49 (24.67)
Pendimethalin (PE) fb Imezathyper (POE) at 20 DAS	3.54 (12.07)	3.94 (15.00)	5.71 (32.07)	6.41 (40.67)
Pendimethalin (PE) fb Quizolofop ethyl at 20 DAS	4.77 (22.33)	4.69 (21.56)	7.03 (48.97)	7.09 (49.84)
SEm (±)	0.17	0.20	0.10	0.29
CD (p=0.05)	0.51	0.60	0.31	0.88

Original standards are given in parenthesis, which were transformed to $\sqrt{x+0.5}$

4.1.2.4 TOTAL WEED POPULATION

Weeds grow faster than crop plants. It was noticed that there was progressive increase in weed population from sowing to harvest. Pendimethalin as PE with one HW at 20 DAS was best treatment in lowering the total weed population significantly at all stage of crop growth. The weedy check was recorded the maximum total weed population at all stages mentioned in table 4.3.

At 30 DAS weed free was recorded minimum total weed population followed by Pendimethalin fb one HW at 20 DAS. At harvest minimum total weed population was recorded under weed free followed by (Propaquizafop + Imezathyper) as POE at 20 DAS. Kaur *et al.* (2009) and Kataria *et al.* (2018) also recorded similar results.

The extraordinary reduction in weed population at different stages might be due to efficient weed control in particular treatments either manual or chemical or both. Broad spectrum activity of Imezathyper particular on established plants of both grasses and broad leaf weeds helps to kept field free from all types of weed. Similar results recorded by Raman and Krishnamoorthy (1999).

After the impressive the all treatments, it was disclose that PE use of pendimethalin with one HW at 20 DAS was excellent weed control practices for minimizing all types of weed population. The application of Pendimethalin as PE, controlled weeds during early growth stage of crop and HW controlled weeds during later stage. The consequences are in harmony with the conclusion of Kumar *et al.* (2011) and Chhodavadia *et al.* (2013).

4.1.3 WEED DRY WEIGHT

It was noticed that there was continuous increase in total weed dry weight from sowing to harvest (Table 4.4). Weed free was recorded the lowest dry weight of weeds at 30 DAS and harvest of crop followed by Pendimethalin (PE) fb one HW 20 DAS. Pendimethalin (PE), Imezathyper (POE), Pendimethalin (PE) fb Quizolofop ethyl @ at 20 DAS and Pendimethalin fb Imezathyper also recorded significantly lower weed dry weight at 30 DAS and harvest of crop as compared to weedy check. Weedy check recorded huge weed dry weight at 30 DAS and harvest of crop.

This may well credited possibly to the severe competition for moisture, space, nutrients, light, shadiness and short life of weeds. This reflective increase in population and dry weight accumulation of weeds under weedy check might be qualified to continuous growth of weeds throughout the crop season attached with more competitive capability than crop that was approximately entirely smother due to accelerated growth of weeds.

This is because of successful control of weeds at critical time of crop weed competition. HW was recorded better weeds control due to uprooting of weeds and thus reducing the dry weight. The consequences were in harmony with Venkata *et al.* (2017) findings.

Table 4.4: Effects of different weed management treatments on weed dry weight (g/m²) at different crop growth stages

Treatments	Dry weight	
	30 DAS	Harvest
Weed check	6.47 (41.33)	10.74 (115.00)
Weed free	1.06 (0.62)	1.89 (3.07)
Pendimethalin (PE)	5.05 (25.07)	9.16 (83.42)
Pendimethalin (PE) fb one HW 20 DAS	3.78 (13.80)	5.30 (27.70)
Imezathyper (POE) at 20 DAS	4.83 (22.87)	7.04 (49.07)
(Propaquizafop + Imezathyper) as POE at 20 DAS	3.95 (15.07)	5.82 (33.90)
Pendimethalin (PE) fb Imezathyper (POE) at 20 DAS	4.13 (16.53)	6.36 (39.97)
Pendimethalin (PE) fb Quizolofop ethyl at 20 DAS	4.64 (21.43)	6.84 (46.47)
SEm (\pm)	0.16	0.26
CD (p=0.05)	0.49	0.79

Original standards are given in parenthesis, which were transformed to $\sqrt{x+0.5}$

4.1.4 WEED CONTROL EFFICIENCY (WCE), WEED CONTROL INDEX (WCI) AND WEED INDEX (WI)

The WCE, WCI and WI were worked out for various weed control practices was mentioned in table 4.5 figure 4.2 and 4.3. WCE varied with time in different treatments. At 30 DAS the maximum WCE of (83.53%) was observed with Pendimethalin fb one HW at 20 DAS after weed free. At harvest the maximum WCE of (84.47%) was observed with application of Propaquizafop + Imezathyper as POE at 20 DAS. Application of Pendimethalin as PE was recorded lowest WCE after weed check.

Pendimethalin as PE fb one HW at 20 DAS was recorded highest WCE might be because of pendimethalin records lowest weed population during initial growing period and HW records lowest weed population at critical crop-weed competition as compared to all other treatments. Similar results also recorded by Mahoptara *et al.* (2018).

Results and Discussion

At 30 DAS and harvest the maximum WCI of 66.61 and 75.91%, respectively was observed with Pendimethalin as PE fb one HW at 20 DAS after weed free. Like WCE, lowest WCI was recorded by application of Pendimethalin as PE fb one HW at 20 DAS. This might be due to lowest weed dry weight at 30 DAS and harvest as compared to other treatments. Kumar *et al.* (2012) were also found similar results.

Table 4.5: Effects of different weed management practices on Weed Control Efficiency, Weed Control Index and Weed Index (%) at different crop growth stage

Treatments	Weed control efficiency		Weed control index		Weed index
	30 DAS	Harvest	30DAS	Harvest	
Weed check	0	0	0	0	56.14
Weed free	96.29	94.89	98.5	97.33	0
Pendimethalin (PE)	47.32	32.07	39.35	27.46	42.18
Pendimethalin (PE) fb one HW 20 DAS	83.53	78.04	66.61	75.91	6.07
Imezathyper (POE) at 20 DAS	57.2	64.92	44.67	57.33	32.01
(Propaquizafop + Imezathyper) as POE at 20 DAS	72.36	84.27	63.54	70.52	6.27
Pendimethalin (PE) fb Imezathyper (POE) at 20 DAS	60.4	74.06	60	65.24	10.5
Pendimethalin (PE) fb Quizolofop ethyl at 20 DAS	39.54	68.21	48.14	59.59	16.67

Weed index worked out at harvest of crop was recorded lowest under weed free (0%) followed by Pendimethalin as PE with one HW at 20 DAS (6.07%), (Propaquizafop + Imezathyper) as POE at 20 DAS (6.27%), Pendimethalin (PE) fb Imezathyper (POE) at 20 DAS (10.50%). The highest WI recorded under weedy check (56.14%).

The lower value of weed index might be because of fact that additive effect of both manual and chemical methods, resulted in excellent weed control. PE herbicide application kept field free from weed during initial period of crop growth and HW and POE reduce CWC during later stages, thus ultimately leads to higher yield and lowest weed index. Similar results were recorded by Patel *et al.* (2016).

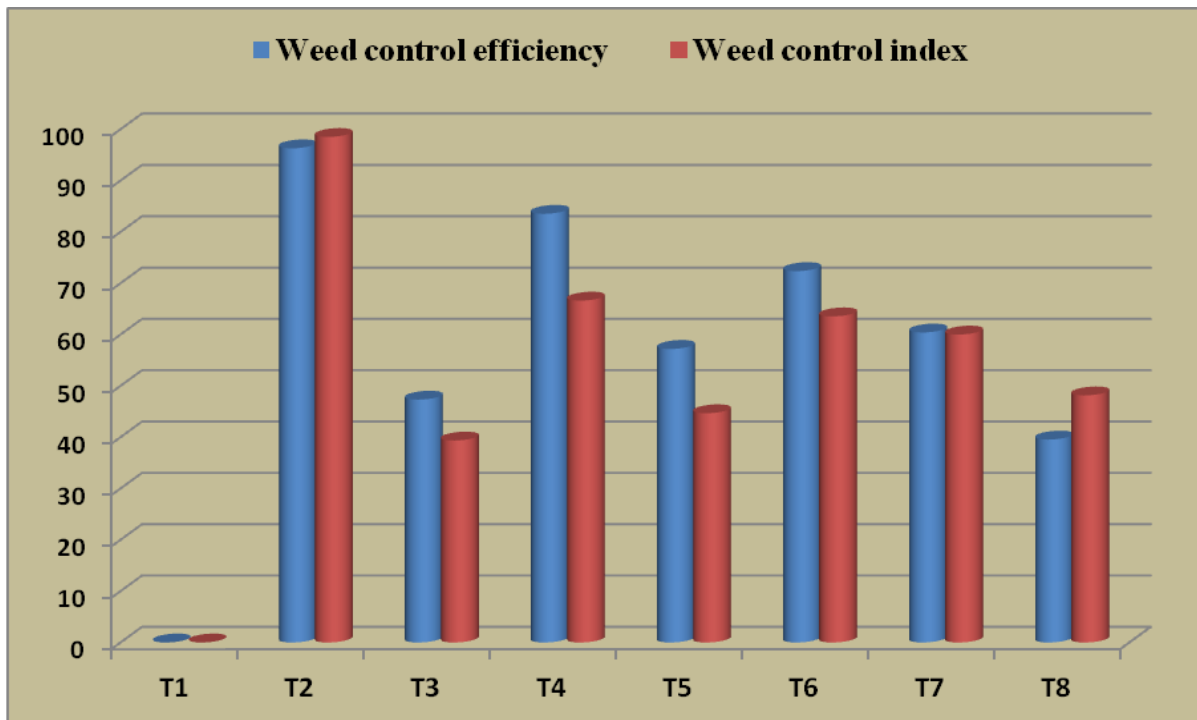


Figure 4.2: Weed Control efficiency and Weed control index (%) at 30 DAS in mungbean as affected by weed control treatments

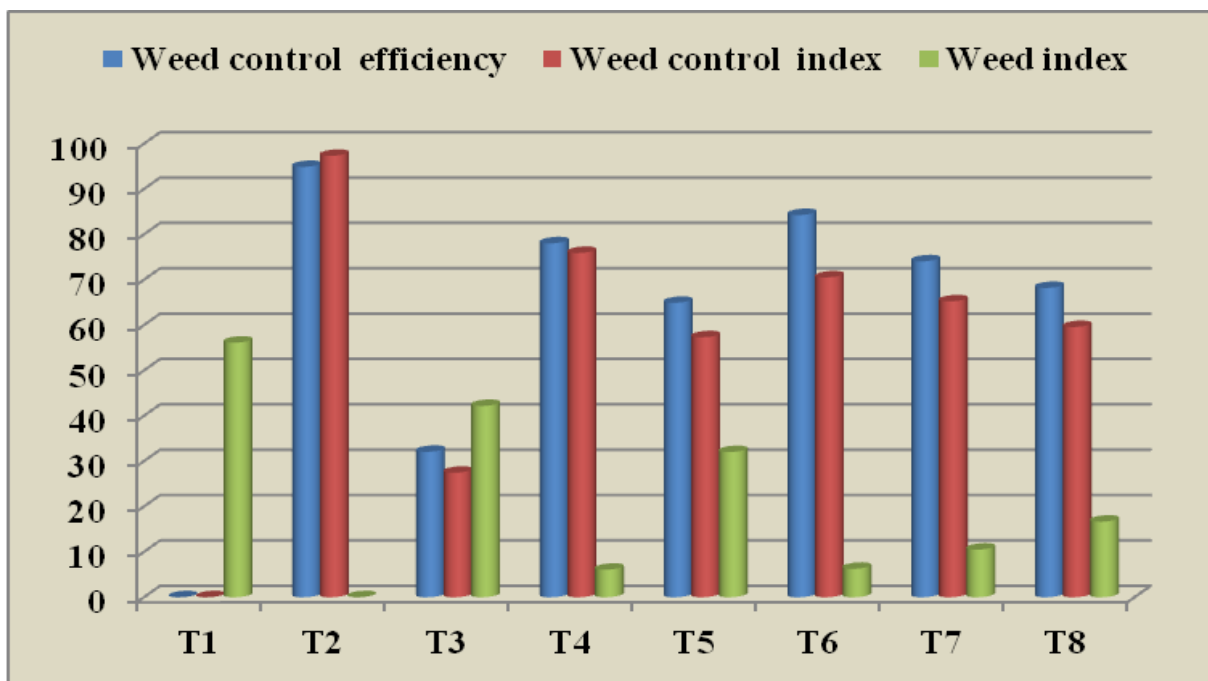


Figure 4.3: Weed Control efficiency, Weed control index and Weed index (%) at harvest in mungbean as affected by weed control treatments

4.2 CROP STUDIES

4.2.1 Growth parameters

4.2.1.1 Plant height

Plant height is forbidden by the genetic makeup of species and the environment to which the plants are subjected during the growth and development. The observations on plant height of mungbean were recorded at 30 DAS and harvest mentioned in Table 4.6. Plant height was significantly affected by various weed control practices at 30 DAS and harvest. It was noticed that plant height was increasing trend with ageing of the crop. At 30 DAS and harvest, Pendimethalin as PE fb one HW at 20 DAS was recorded taller plants which were at par with Propaquizafop + Imezathyper as POE. Weed free treatment was recorded greatest plant height at 30 DAS (32.7cm) and harvest (57.0cm).

Table 4.6: Effects of different weed management practices on plant height (cm) and no. of branches/plant at 30 DAS and Harvest

Treatments	Plant height		No. of branches/ plant	
	30 DAS	Harvest	30 DAS	Harvest
Weed check	16.07	32.17	1.97	2.49
Weed free	32.70	57.00	4.30	5.87
Pendimethalin (PE)	21.43	42.13	3.15	3.38
Pendimethalin (PE) fb one HW 20 DAS	28.40	53.80	3.74	5.02
Imezathyper (POE) at 20 DAS	21.60	42.93	3.42	3.53
(Propaquizafop + Imezathyper) as POE at 20 DAS	24.60	48.07	3.50	4.08
Pendimethalin (PE) fb Imezathyper (POE) at 20 DAS	23.00	45.67	3.47	3.75
Pendimethalin (PE) fb Quizolofop ethyl at 20 DAS	22.03	43.67	3.48	3.63
SEm (±)	1.39	2.81	0.17	0.26
CD (p=0.05)	4.20	8.51	0.52	0.79

In weedy check, it was recorded minimum plant height might be because of overcrowding of weeds during entire crop growth period. All other weed control treatments were recorded significantly taller plant over weedy check might be because of efficient weed control and reduce the CWC. Similar results were recorded by Komal *et al.* (2015).

4.2.1.2 Number of branches/plant

The observation on number of branches/plant was recorded at 30 DAS and harvest was mentioned in Table 4.6. Number of branches/plant was significant affected by various weed control treatments. At 30 DAS and harvest the highest number of branches/plant was found in weed free (4.30) which was at par with Pendimethalin as PE fb one HW at 20 DAS (3.74) and Propaquizafop + Imezathyper. Pendimethalin as PE, Pendimethalin (PE) fb Quizolofop ethyl, Imezathyper as POE, and Pendimethalin fb Imezathyper were recorded significantly more number of branches/plant at 30 DAS and harvest as compare to weedy check treatment.

Minimum number of branches/plant was recorded in weedy check treatment because of aggressive weed growth resulting in depletion of plant nutrients, so reducing plant growth and no. of branches. Similar results were recorded by Komal *et al.* (2015).

4.2.1.3 Number of leaves/plant

The total number of leaves/plant significantly affected by different weed control treatments at 30 DAS and harvest (Table 4.7). At 30 DAS and harvest maximum no. of leaves/plant (25.10 and 48.03, respectively) was recorded in weed free followed by Pendimethalin as PE fb one HW at 20 DAS (20.93 and 41.37, respectively). Weedy check observed significantly lowest number of leaves/plant at 30 DAS and harvest (13.93 and 20.87, respectively).

4.2.1.4 Root biomass /plant

The root biomass was significantly affected by various weed management practices at 40 DAS (Table 4.7 and Figure 4.5). At 40 DAS weed free was recorded maximum root biomass (0.56g) which was on par with Pendimethalin as PE fb one HW (0.50g). Other treatments recorded significantly higher root biomass over weedy check. Weedy check treatment recorded significantly lowest root biomass at 40 DAS.

Table 4.7: Effects of various weed management practices on no. of leaves and root biomass (g) at different crop growth stage

Treatments	No. of leaves/plant		Root biomass/plant
	30 DAS	Harvest	40 DAS
Weed check	13.93	20.87	0.31
Weed free	25.10	48.03	0.56
Pendimethalin (PE)	18.03	29.80	0.38
Pendimethalin (PE) fb one HW 20 DAS	20.93	41.37	0.50
Imezathyper (POE) at 20 DAS	18.13	31.73	0.40
(Propaquizafop + Imezathyper) as POE at 20 DAS	19.93	39.47	0.43
Pendimethalin (PE) fb Imezathyper (POE) at 20 DAS	18.73	35.00	0.42
Pendimethalin (PE) fb Quizolofop ethyl at 20 DAS	19.03	33.10	0.41
SEm (\pm)	1.06	2.12	0.03
CD (p=0.05)	3.20	6.43	0.08

HW was recorded more root growth due to HW good soil condition, making soil more porous leads to more root growth and root biomass over other treatments same time weed free face lower crop-weed competition, ultimately more root growth and root biomass. Weedy check recorded minimum root biomass because having more competition for space with crop leads to minimum growth of roots. Similar results were also recorded by Raman and Krishnamoorthy (1999).

4.2.1.5 Leaf Area Index (LAI)

LAI was significantly affected by different weed control treatments at harvest (Table 4.8). At Harvest, the highest LAI was recorded in weed free (4.11) which was at par with Pendimethalin as PE fb one HW at 20 DAS (3.57). The lowest LAI was observed under weedy check (2.30).

4.2.1.6 Number and dry weight of nodules/plant

The weed control practices were significantly affected the no. and dry weight of nodules /plant at 40 DAS (Table 4.8 and figure 4.4). The highest nodules number/plant at 40 DAS (27.03) was recorded in weed free which was at par with Pendimethalin as PE fb one HW at 20 DAS (24.15). Weedy check was observed significantly less nodules/plant (13.53) at 40 DAS. Weed free was recorded the maximum dry weight of nodules/plant (0.29g) at 40 DAS which was at par with Pendimethalin as PE fb one HW (0.26g) at 20 DAS. Weedy check was recorded significantly lowest dry weight of nodules/plant (0.13g) at 40 DAS.

Table 4.8: Effects of different weed management practices on LAI at harvest, no. and dry weight (g) of nodules/plant at 40 DAS

Treatments	LAI	No. of nodules/plant	Nodules dry weight
	Harvest	40 DAS	40 DAS
Weed check	2.30	13.53	0.13
Weed free	4.11	27.03	0.29
Pendimethalin (PE)	2.77	17.17	0.18
Pendimethalin (PE) fb one HW	3.57	24.15	0.26
Imezathyper (POE) at 20 DAS	2.87	17.70	0.19
(Propaquizafop + Imezathyper) as POE	3.40	22.87	0.22
Pendimethalin (PE) fb Imezathyper	2.95	20.20	0.21
Pendimethalin (PE) fb Quizolofop ethyl	2.92	18.23	0.20
SEm (\pm)	0.18	1.16	0.01
CD (p=0.05)	0.55	3.52	0.04

Weed free treatment was recorded (99.77%) higher nodules number over weedy check. However, application of Pendimethalin (PE) fb one HW 20 DAS, Propaquizafop fb Imezathyper) as POE at 20 DAS and Pendimethalin (PE) fb Imezathyper (POE) at 20 DAS were recorded lower nodules number plant as compare to weed free by 10.65, 15.39 and 25.26%, respectively.

Results and Discussion

Hand weed was recorded more nodules/plant. The increase in number of nodules under HW treatments due to improve aeration of rhizosphere and improve soil condition. These results were similar with findings of Khairnar *et al.* (2013) and Chhodovadia *et al.* (2011).

The weed free and other treatments viz., Pendimethalin fb one HW at 20 DAS, Pendimethalin fb Quizolofop ethyl at 20 DAS, (Propaquizafop + Imezathyper) as POE, Pendimethalin fb Imezathyper, Pendimethalin as PE and Imezathyper at POE were controlling various spp. of weeds at sensitive period of crop-weed competition ultimate leads to maximum plant height, no. of branches/plant, no. of leaves/plant, LAI, no. and dry weight of nodules as compared to weedy check. The results were similar with findings of Kundu *et al.* (2016), Singh *et al.* (2015) and Kaur *et al.* (2010).

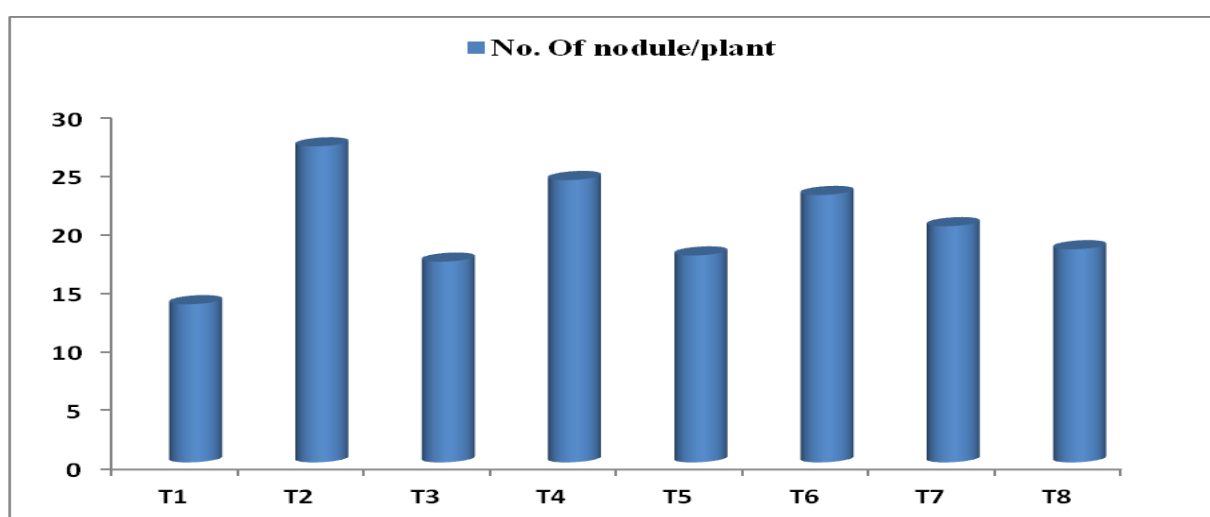


Fig 4.4: Effect of various weed management practices on no. of nodules/plant at 40DAS

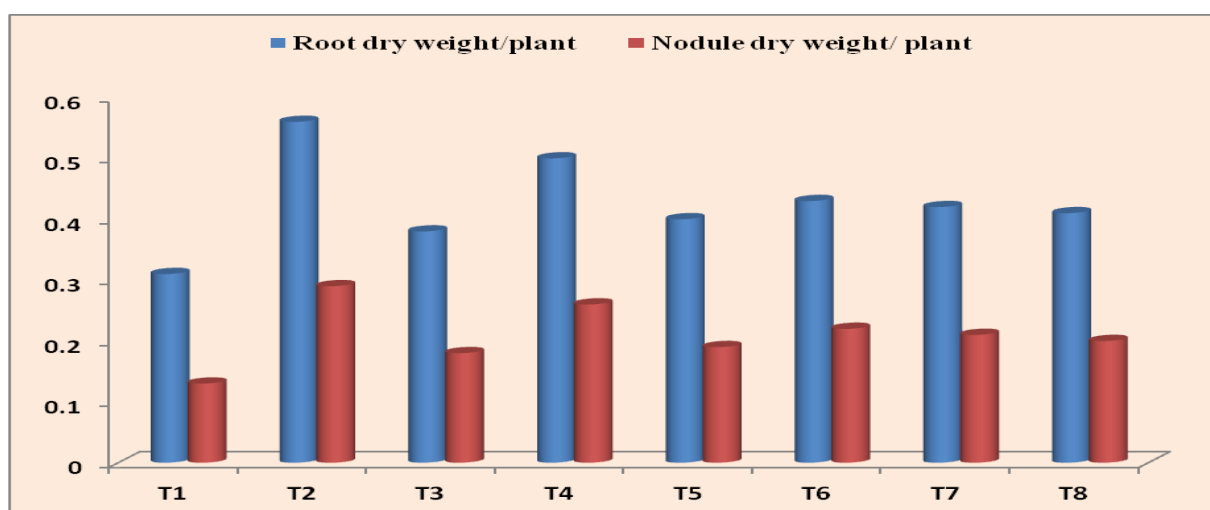


Fig 4.5: Effect of various weed management practices dry weight of nodules and root biomass/plant at 40 DAS

4.2.2 Yield attributes

4.2.2.1 Pod length (cm)

The data mentioned in Table 4.9 reflects that weed control practices were significantly influenced pod length in mungbean. Weed free treatment recorded longest pod length (7.85cm) which was at par with Pendimethalin as PE fb one HW at 20 DAS (7.29 cm). The other treatments were also significantly superior to the weedy check, which produced lowest pod length (4.47 cm).

4.2.2.2 Pods per plant

The pods /plant mentioned in table 4.9 reflect that the weed free treatment produced significantly highest seeds/plant (21.03) which was at par on Pendimethalin as PE fb one HW at 20 DAS (19.87) and (Propaquizafop + Imezathyper) as POE at 20 DAS (19.60) over weedy check treatment. The lowest pods /plant were recorded in weedy check (13.32).

Table 4.9 Effects of different weed management practices on pod length (cm), pod/plant, seeds/pod and test weight (g)

Treatments	Pod length	Pod /plant	Seeds /pod	Test weight
Weed check	4.47	13.32	5.87	34.57
Weed free	7.85	21.03	9.67	43.03
Pendimethalin (PE)	6.05	17.10	7.43	39.27
Pendimethalin (PE) fb one HW 20 DAS	7.29	19.87	8.67	41.94
Imezathyper (POE) at 20 DAS	6.13	17.03	7.67	38.10
(Propaquizafop + Imezathyper) as POE at 20 DAS	6.68	19.60	8.60	41.67
Pendimethalin (PE) fb Imezathyper (POE) at 20 DAS	6.33	17.90	8.17	40.54
Pendimethalin (PE) fb Quizolofop ethyl at 20 DAS	6.27	17.37	7.80	39.43
SEm (\pm)	0.40	1.02	0.44	1.60
CD (p=0.05)	1.21	3.10	1.34	4.84

4.2.2.3 Seeds per pod

The data indicates that seeds/pod was affected by different weed management treatments were mentioned in Table 4.9. Weed free treatment observed maximum number of seeds/pod (9.67) which was at par with Pendimethalin as PE fb one HW at 20 DAS (8.67) and (Propaquizafop + Imezathyper) at 20 DAS (8.60). However, rest of the treatments was significantly higher than weedy check which recorded the minimum seeds/pod (5.87).

4.2.2.4 Test weight (g)

The data indicates test weight was mentioned in Table 4.9. It is observed from data that significant difference in 1000 seed weight due to various weed control treatments. Although weed free gave the highest test weight (43.03) which was at par with Pendimethalin as PE fb one HW at 20 DAS (41.94), (Propaquizafop + Imezathyper) as POE (41.67) and Pendimethalin (PE) fb Imezathyper (POE) (40.57) and minimum by weedy check (34.57).

4.2.3 Yields

4.2.3.1 Seed yield

The analyzed data on seed yield of mungbean was mentioned in table 4.10 and figure 4.6 which showed that significant effect observed due to the weed management treatments. Weed free treatment was recorded higher seed yield (10.10 q/ha) which was at par with Pendimethalin as PE fb one HW at 20 DAS (9.49 q/ha), Shaked (Propaquizafop + Imezathyper) at 20 DAS (9.47 q/ha) and Pendimethalin (PE) fb Imezathyper (POE) at 20 DAS (9.04 q/ha) These treatments were recorded significantly supercilious to rest of the treatments. Next superior treatments in recording highest seed yield were (PE) fb Quizolofop ethyl at 20 DAS (8.42 q/ha) followed by Imezathyper as POE (6.87 q/ha) and Pendimethalin as PE (5.84 q/ha). Weed free treatment and Shaked (Propaquizafop + Imezathyper) as POE at 20 DAS recorded (127.99 and 104.74%, respectively) higher seed yield over weedy check. Pendimethalin (PE) fb one HW 20 DAS, Shaked (Propaquizafop + Imezathyper) as POE at 20 DAS, Pendimethalin (PE) fb Imezathyper (POE) at 20 DAS and Pendimethalin (PE) fb Quizolofop ethyl @ at 20 DAS were recorded lower seed yield as compare to weed free by 6.03, 6.23, 10.49 and 16.63% respectively.

4.2.3.2 Green fodder yield

The data mentioned in table 4.10 and figure 4.6 showed that the use of weed management treatment significantly influenced the green fodder yield. Weed free observed the highest green fodder yield (63.30 q/ha) followed by (Propaquizafop + Imezathyper) at 20

DAS (55.67 q/ha) which was at par with Pendimethalin as PE fb one HW at 20 DAS (55.57 q/ha) Pendimethalin (PE) fb Imezathyper (POE) at 20 DAS (54.33 q/ha), Pendimethalin (PE) fb Quizolofop ethyl @ at 20 DAS (52.13 q/ha) and Imezathyper (POE) (50.04 q/ha). Weed free treatment and Shaked (Propaquizafop + Imezathyper) as POE at 20 DAS recorded (59.32 and 40.12%, respectively) higher green fodder over weedy check.

Table 4.10: Effects of different weed management practices seed and fodder yield (q/ha)

Treatments	Seed yield	Green fodder yield
Weed check	4.43	39.73
Weed free	10.10	63.3
Pendimethalin (PE)	5.84	48.9
Pendimethalin (PE) fb one HW 20 DAS	9.49	55.57
Imezathyper (POE) at 20 DAS	6.87	50.04
(Propaquizafop + Imezathyper) as POE	9.47	55.67
Pendimethalin (PE) fb Imezathyper (POE)	9.04	54.33
Pendimethalin (PE) fb Quizolofop ethyl	8.42	52.13
SEm (\pm)	0.45	2.25
CD (p=0.05)	1.38	6.84

The maximum pods /plant, seeds/plant, test weight, seed and green fodder yield was observed in weed free followed by Pendimethalin fb one HW at 20 DAS, (Propaquizafop + Imezathyper) as POE. Pendimethalin fb Imezathyper and Pendimethalin fb Quizolofop ethyl at 20 DAS also reported significantly higher values of above parameters than weedy check. This might be because of efficient weed control by herbicides when combined with HW which finally influenced growth parameters, yield and yield attributes. Raman and Krishnamoorthy (1999) were found the similar results.

Variation in yield components of mungbean could be due to difference in growth parameters such as dry matter production. The DM production was outcome of growth parameters like plant height, no. of branches/ plant, no. of leaves and LAI. Higher growth attributes lead to higher DM production ultimately leads to higher yield.

Significantly highest weed density, weed dry weight, minimum number of leaves, plant height and growth and yield parameters, seed yield and green fodder yield were recorded under weedy check as compared to rest of treatments.

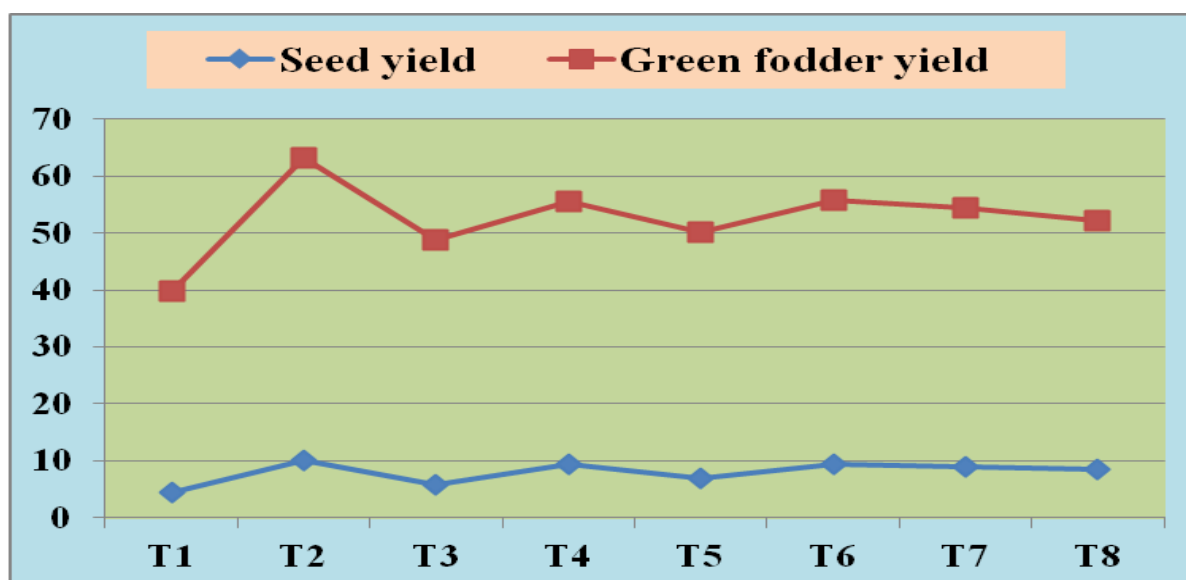


Figure 4.6: Effect of diverse weed control practices on seed and fodder yield (q/ha)

This might be due to vigorous weed growth resulted in more crop weed competition for nutrients, solar radiation, water and CO₂ etc. by weeds. Mungbean seed yield may be reduce up to 50-90% due to uncontrolled weeds depending upon cultivars, soil type and other environmental conditions (Kumar *et al.*, 2006).

4.2.4 Crop injury score (Phytotoxicity)

The data pertaining to crop injury scores by different herbicides treatments observed at 10 and 25 DAS were given in table 4.11. At 10 DAS no crop injury was recorded due to PE herbicides. At 25 DAS crop injury was recorded with application of Imezathyper (POE) at 20 DAS followed by Pendimethalin (PE) fb Imezathyper at 20 DAS.

Table 4.11 Crop injury by different herbicides under investigation

Treatments	Injury score (0 to 10)	
	10 DAS	25 DAS
Weed check	0	0
Weed free	0	0
Pendimethalin (PE)	0	0
Pendimethalin (PE) fb one HW 20 DAS	0	0
Imezathyper (POE) at 20 DAS	0	2
(Propaquizafop + Imezathyper) as POE at 20 DAS	0	0
Pendimethalin (PE) fb Imezathyper (POE) at 20 DAS	0	1
Pendimethalin (PE) fb Quizolofop ethyl at 20 DAS	0	0

4.2.5 Nutrient content and uptake by crop (seed and fodder) and weeds

4.2.5.1 Nitrogen content

The results revealed that weed management practices does not reported significant variation on NPK content of seed, green fodder and weeds (Appendix , Table- 5, 6 and 7).

4.2.5.2 Nutrients uptake by crop (seed and fodder) and weeds

4.2.5.2.1 Nitrogen uptake

The results revealed that, weed control treatments significantly effect on nitrogen uptake by seed, green fodder, weed and total N uptake (Table 4.12). The highest nitrogen uptake by seed and green fodder (39.10 and 42.16 kg/ha, respectively) was observed under weed free treatment. However, the lowest nitrogen uptake was recorded by seed and green fodder by weedy check (15.62 and 17.82 kg/ha, respectively).

Significantly highest nitrogen removal by weed was recorded under weedy check (44.85 kg/ha) followed by Pendimethalin (PE) (35.86 kg/ha). Weed free treatment was recorded minimum nitrogen uptake by weeds (0.95 kg/ha).

Table 4.12: Effects of different weed management treatments on nitrogen uptake by seed, green fodder, weed and total uptake (kg/ha)

Treatments	Nitrogen uptake by seed	Nitrogen uptake by fodder	Nitrogen uptake by weeds	Total uptake
Weed check	15.62	17.82	44.85	78.29
Weed free	39.10	42.16	0.95	82.21
Pendimethalin (PE)	21.81	25.57	35.86	83.25
Pendimethalin (PE) fb one HW 20 DAS	35.65	34.07	9.97	79.68
Imezathyper (POE) at 20 DAS	26.27	27.12	15.68	69.07
(Propaquizafop + Imezathyper) at 20 DAS	38.26	33.55	10.85	82.66
Pendimethalin (PE) fb Imezathyper at 20 DAS	34.93	30.14	15.59	80.66
Pendimethalin (PE) fb Quizolofop ethyl	32.92	27.27	12.53	72.72
SEm(±)	1.02	0.86	0.41	1.12
CD (p=0.05)	3.10	2.61	1.26	3.41

Results and Discussion

Total N uptake by seed, fodder and weed was reported under Pendimethalin (PE) (83.25 kg/ha) which was at par with Shaked (Propaquizafop + Imezathyper) at 20 DAS (82.66 kg/ha). The lowest total N uptake was recorded under Imezathyper (POE) at 20 DAS (69.07 kg/ha).

Weed free recorded significantly highest nitrogen uptake by seed and fodder (39.10 and 42.16 kg/ha, respectively), this might be due to higher production of crop biomass and economic yield as compare to other treatments and also recorded lowest nitrogen uptake by weed, due to low weed infestation. Weed check recorded significantly highest nitrogen removal by weeds (44.85 kg/ha) as compare to other treatments because of maximum weed dry weight and weed infestation leads to higher N uptake by weeds.

4.2.5.2.2 Phosphorus uptake

The data indicating to phosphorus uptake by seed, green fodder weed and total phosphorus uptake were mentioned in table 4.13. The highest uptake of phosphorus by seed (4.74 kg/ha) was recorded under weed free which was at par with Pendimethalin (PE) fb one HW 20 DAS (4.32kg/ha) and (Propaquizafop + Imezathyper) at 20 DAS (4.23 kg/ha). The highest uptake of phosphorus by fodder (9.49 kg/ha) was recorded under weed free followed by (Propaquizafop + Imezathyper) at 20 DAS (7.82 kg/ha).

Maximum phosphorus removal by weed was recorded under weedy check (5.98 kg/ha) followed by Pendimethalin (PE) (5.09 kg/ha). Weed free recorded minimum phosphorus removal (0.17 kg/ha).

Significantly highest total uptake of phosphorus was recorded by seed, green fodder and weed under weed free (14.41 kg/ha) which was at par with (Propaquizafop + Imezathyper) at 20 DAS (14.12 kg/ha).

Maximum phosphorus uptake by crop was recorded under weed free because of higher biomass and yield. Maximum phosphorus removal by weeds recorded under weedy check, this might be due to higher weed biomass and weed density. Weed free recorded significantly lowest phosphorus removal by weeds because of lower weed infestation and dry weight of weeds.

Table 4.13: Effects of different weed management treatments on phosphorus uptake of seed, green fodder, weed and total (Kg/ha)

Treatments	Phosphorus uptake by seed	Phosphorus uptake by fodder	Phosphorus uptake by weeds	Total uptake
Weed check	1.63	3.96	5.98	11.58
Weed free	4.74	9.49	0.17	14.41
Pendimethalin (PE)	2.28	5.67	5.09	13.04
Pendimethalin (PE) fb one HW 20 DAS	4.32	7.35	1.58	13.25
Imezathyper (POE)	2.8	6.46	2.74	12.01
(Propaquizafop + Imezathyper) at 20 DAS	4.23	7.82	2.07	14.12
Pendimethalin (PE) fb Imezathyper at 20 DAS	3.8	6.74	2.48	13.02
Pendimethalin (PE) fb Quizolofop ethyl at 20 DAS	3.51	6.34	2.69	12.54
SEm(±)	0.2	0.23	0.11	0.27
CD (p=0.05)	0.62	0.71	0.32	0.82

4.2.5.2.3 Potassium uptake

Data perusal on potassium uptake showed (Table 4.14) that weed control practices recorded significantly difference in potassium uptake by seed, green fodder, weed and total uptake. The highest potassium uptake by seed and green fodder (14.67 and 52.18 kg/ha, respectively) was observed under weed free followed by Pendimethalin (PE) fb one HW 20 DAS (13.05 and 41.41 kg/ha, respectively). The minimum potassium uptake was recorded by seed and green fodder under weedy check (4.76 and 20.24 kg/ha, respectively). Maximum uptake of potassium by weeds was recorded under weedy check treatment (25.30 kg/ha) followed by Pendimethalin (PE) (18.85 kg/ha). Weed free treatment was recorded minimum potassium uptake (0.77 kg/ha). The highest total uptake of potassium by seed, green fodder and weed was recorded under weed free (67.64 kg/ha) followed by (Propaquizafop + Imezathyper) at 20 DAS (61.71 kg/ha). The minimum total uptake was recorded by weedy free (50.29 kg/ha).

Table 4.14: Effects of different weed management treatments on potassium uptake of seed, green fodder, weed and total (kg/ha)

Treatments	Potassium uptake by seed	Potassium uptake by fodder	Potassium uptake by weeds	Total uptake
Weed check	4.76	20.24	25.30	50.29
Weed free	14.67	52.18	0.77	67.64
Pendimethalin (PE)	6.79	31.37	18.85	57.00
Pendimethalin (PE) fb one HW 20 DAS	13.05	41.41	6.79	61.25
Imezathyper (POE) at 20 DAS	8.76	31.03	12.10	51.91
(Propaquizafop + Imezathyper) at 20 DAS	12.21	41.22	8.27	61.71
Pendimethalin (PE) fb Imezathyper at 20 DAS	10.63	36.47	9.31	56.41
Pendimethalin (PE) fb Quizolofop ethyl	10.74	32.98	10.35	54.06
SEm(±)	0.32	0.49	0.25	0.74
CD (p=0.05)	0.96	1.47	0.77	2.25

All weed control measures tended to enhance the nutrient uptake by seed and green fodder compared to weedy check (Table 4.12, 13 and 14). As nutrient uptake by crop is a function of yield and nutrient content. Application of herbicides and HW leads to, more uptakes of nutrients by crop due to minimum crop weed competition had parallel increased in nutrient availability, superior crop growth and higher crop biomass production tied with more nutrient content. These results are in harmony with finding of Chhodavadia *et al.* (2013), Komal *et al.* (2015) and kaur *et al.* (2010).

4.3 Soil quality parameters after harvest of crop

4.3.1 pH_s, EC₂ and Organic carbon of soils

The data mentioned in table 4.15 showed that pH, EC₂ and OC of soil were not reaching up to the level significance by various weed management practices.

4.3.2 Available Nitrogen (kg/ha)

The data showed in table 4.15 reflect that the use of weed management treatment significantly affected the available nitrogen content of soil. Weed free treatment recorded maximum N content (208.67 kg/ha) followed by Pendimethalin as PE fb one HW at 20 DAS (193.33 kg/ha). Other treatments also recorded significantly higher N content over weedy check (158.33 kg/ha). This might be due to more nitrogen uptakes by weeds in weedy check. In weed free treatment due to low CWC leads to lowest nitrogen removal by weeds this leads to higher nitrogen content in weed free.

Table 4.15: Effects of different weed management treatments on pH, EC₂ (dS/m) and available OC (%), N, P and K (kg/ha)

Treatments	pH ₂	EC ₂	OC	N	P	K
Initial value	7.32	0.33	0.53	164.00	19.50	227.70
Weed check	7.26	0.34	0.64	158.33	24.87	209.40
Weed free	7.12	0.31	0.57	208.67	23.33	190.50
Pendimethalin (PE)	7.30	0.36	0.61	179.33	24.82	208.56
Pendimethalin (PE) fb one HW 20 DAS	7.25	0.35	0.63	193.33	24.17	198.23
Imezathyper (POE) at 20 DAS	7.29	0.33	0.58	174.67	22.87	204.50
(Propaquizafop + Imezathyper) at 20 DAS	7.33	0.33	0.56	171.33	22.30	195.50
Pendimethalin (PE) fb Imezathyper at 20 DAS	7.43	0.32	0.62	173.33	23.70	201.22
Pendimethalin (PE) fb Quizolofop ethyl at 20 DAS	7.23	0.33	0.61	180.33	24.65	203.49
SEm(±)	0.22	0.01	0.02	3.67	0.62	4.46
CD (p=0.05)	NS	NS	NS	11.13	NS	NS

4.3.4 Available Phosphorus (P)

The data pertaining to available phosphorus content in soil was not reaching up to level of significance under various treatments (Table 4.15). However, weedy check treatment recorded maximum value of phosphorus content of soil (24.87 kg/ha). Application of Propaquizafop + Imezathyper as POE at 20 DAS recorded significantly

lowest phosphorus content in soil (22.30 Kg/ha). This might be due to lowest phosphorus uptake by crop recorded under weedy check, this leads to higher phosphorus content of soil.

4.3.5 Available Potassium (K)

The data pertaining to available potassium content in soil revealed that various weed management practices does not significantly differ in potassium content of soil. Weedy check was recorded highest potassium content (209.40 kg/ha) followed by Pendimethalin as PE (208.56 kg/ha). This might be due to lowest uptake of nutrient by crop recorded in weedy check and pendimethalin as PE treatment.

4.3.6 Bacterial, Actinomycetes and fungal count in soil (CFU/g soil)

Growing of mungbean did not significance differences on bacterial population at 30 DAS and harvest (Table 4.16 and 4.27). The bacterial population increase from sowing to harvest. At 30 DAS lowest bacterial population was recorded by application of Pendimethalin (PE) + Imezathyper at 20 DAS followed by (Propaquizafop + Imezathyper) as POE. At harvest lowest bacterial population was recorded by application of Imezathyper (POE) at 20 DAS. Maximum bacterial count recorded in weedy weed free at both stages.

The actinomycetes population was significantly affected by different weed management treatments under mungbean cultivation at 30 DAS. Highest actinomycetes count was observed with weedy free followed by weed check treatments. At 30 DAS lowest counts were recorded with (Propaquizafop + Imezathyper) as POE followed by Pendimethalin (PE) fb Imezathyper at 20 DAS.

At harvest lowest counts were recorded Pendimethalin (PE) fb Imezathyper at 20 DAS followed by Imezathyper (POE) at 20 DAS. At 30 DAS fungous counts were significantly influenced by various weed control treatments. At 30 DAS weed free was recorded maximum counts followed by weed check, same time minimum counts were recorded by Pendimethalin (PE) + Imezathyper at 20 DAS followed by (Propaquizafop + Imezathyper). At harvest minimum count was recorded with (Propaquizafop + Imezathyper) followed by Imezathyper (POE) at 20 DAS.

Table 4.16: Effects of various weed management treatments on Bacterial, Actinomycetes and Fungi population at 30 DAS

Treatments	Bacterial $\times 10^6$ (CFU/ g soil)	Actinomycetes ($\times 10^5$ CFU/ g soil)	Fungi ($\times 10^4$ CFU/ g soil)
Before sowing	11.23	5.78	0.76
Weed check	12.56	8.33	1.63
Weed free	13.88	8.72	2.07
Pendimethalin (PE)	12.40	7.18	1.30
Pendimethalin (PE) fb one HW	12.55	7.68	1.44
Imezathyper (POE) at 20 DAS	12.05	7.20	1.21
(Propaquizafop + Imezathyper) as POE at 20 DAS	12.01	6.57	1.02
Pendimethalin (PE) fb Imezathyper (POE) at 20 DAS	11.59	6.73	0.84
Pendimethalin (PE) fb Quizolofop ethyl at 20 DAS	12.18	7.12	1.23
SEm(\pm)	0.43	0.17	0.07
CD (p=0.05)	NS	0.53	0.22

The microbial activity has a direct impact on the nutrient availability as other properties related to soil productivity, the population of microbe's viz., bacteria, actinomycetes and fungi is increase with the crop advances with decreasing rate this might be due to adverse affects of herbicides. The adverse effects of herbicides appear instantly after the application when their concentration in soil is maximum. Later on, microbial count take part in degradation process and chemical concentration decreases (Radivojevic *et al.*, 2004). The recommended dose did not affect the microbial counts significantly. A low concentration of Imezathyper in soil is compensated for high microbial activity due to high persistency in soil up to 5 to 24 months (Hollaway *et al.*, 2006). Weedy free recorded maximum microbe's because of no residues of herbicides. The results were agreement with findings of Khairnar *et al.* (2013).

Table 4.17: Effects of various weed management treatments on Bacterial, Actinomycetes and Fungi population at harvest

Treatments	Bacterial ($\times 10^6$ CFU/ g soil)	Actinomycetes ($\times 10^5$ CFU/ g soil)	Fungi ($\times 10^4$ CFU/ g soil)
Before sowing	11.23	5.78	0.76
Weed check	18.63	18.1	6.47
Weed free	19.97	19.6	7.17
Pendimethalin (PE)	18.06	17.35	6.17
Pendimethalin (PE) fb one HW 20 DAS	18.2	18.01	6.82
Imezathyper (POE) at 20 DAS	17.03	17.13	6.14
(Propaquizafop + Imezathyper) as POE at 20 DAS	17.67	17.42	6.03
Pendimethalin (PE) fb Imezathyper (POE) at 20 DAS	17.73	16.47	6.37
Pendimethalin (PE) fb Quizolofop ethyl at 20 DAS	17.83	17.37	6.33
SEm(\pm)	0.48	0.5	0.22
CD (p=0.05)	1.44	1.52	0.68

4.4 Fodder quality parameters

4.4.1 Dry matter (DM) and organic matter (OM)

The analyzed data on dry matter of mungbean fodder was mentioned in table 4.18 and figure 4.7 which revealed that significant effect observed due to the weed management treatments. Weed free was recorded significantly maximum dry matter (28.83%) followed by Pendimethalin as PE fb one HW at 20 DAS (27%) which was at par Pendimethalin (PE) fb Imezathyper (POE) (26.40%). Other treatment observed significantly higher dry matter over weedy check. Weedy check was recorded significantly lowest dry matter (24.53%).

Weed free and Pendimethalin as PE fb one HW at 20 DAS recorded lowest weed growth and crop weed competition for air (CO_2) leads to increased photosynthesis activities of plants, which helped generate greater dry matter accumulation (Srinivashu *et al.*, 2004). Weedy check recorded highest percentage of OM (88.73%) followed by pendimethalin (88.66%).

4.4.2 Crude protein (CP)

To provide reasonable diet to the animal protein is very significant constituents of animal feed because of it play prime role to enhance enlargement and productivity of animals as it is used for build up new tissue as well as repairing injured tissue. The data recorded on CP (Table 4.18 and figure 4.7) showed that the use of weed management treatment significantly affected. Weed free was recorded maximum value of CP (15.16%) followed by Pendimethalin as PE fb Quizolofop ethyl at 20 DAS (14.19%). Weedy check was observed minimum CP content as (12.77%). Crude protein is an excellent quality indicator of forage crop.

Weed free recorded highest CP content might be due to less crop weed competition for nutrients, this leads to higher absorption of nutrient by crop and ultimately leads to high amino acid and crude protein. Crude protein lower in dual purpose mungbean as compare with fodder mungbean this might be due to most of the protein transferred to fruit (grain).

4.4.3 Acid detergent fiber (ADF) and Neutral detergent fiber (NDF)

From quality view the minimum value of NDF is pleasing character of any quality fodder. The data recorded on ADF and NDF (table 4.18 and figure 4.7) showed that the use of weed management treatment not reached up to level of significance. Weedy check was recorded significantly highest NDF value (41.97%) followed by Imezathyper as POE (41.41%). Weed free was recorded lowest NDF value (37%). The total NDF (%) of crop were decided by crop morphology, genetic constituents and agronomic managements. Low NDF content indicates good quality fodder.

Weedy check recorded significantly maximum ADF value (31.09%) followed by Imezathyper as POE (30.21 %). Weed free treatment observed significantly lowest ADF value (28.07%).

4.4.4 Acid detergent lignin (ADL)

The data pertaining to acid detergent lignin did not reached up to level of significance by different weed management treatments were mentioned in Table 4.18 and figure 4.7. Weedy check was recorded maximum value (5.67%) followed by Imezathyper (POE) at 20 DAS (5.30 %) and Imezathyper as POE (5.30 %). ADL is the percentage of plant material which is insoluble in 72 % sulphuric acid. ADL will decide the crude lignin fraction. Lignin has been used to predict digestibility. Inverse relationship is there between lignin content and digestibility.

Table 4.18: Effects of different weed management treatments on DM, ADF, NDF, ADL, CP, EE and total ash (%)

Treatments	DM	OM	CP	NDF	ADF	ADL	EE	Total ash
Weed check	21.67	88.73	12.2	41.97	31.06	5.67	2.41	11.27
Weed free	28.83	87.83	15.16	37.00	28.07	4.72	2.65	12.17
Pendimethalin (PE)	24.67	88.66	13.23	40.15	28.53	5.17	2.48	11.34
Pendimethalin (PE) fb one HW 20 DAS	27.00	87.84	14.19	37.16	27.57	4.97	2.62	12.16
Imezathyper (POE) at 20 DAS	25.33	88.35	13.37	41.41	30.21	5.30	2.53	11.65
(Propaquizafop + Imezathyper) as POE	26.4	88.39	13.95	38.00	28.87	4.93	2.61	11.61
Pendimethalin (PE) fb Imezathyper (POE)	25.33	87.33	13.67	37.33	29.6	5.18	2.42	12.02
Pendimethalin (PE) fb Quizolofop ethyl	24.33	88.11	13.47	37.50	27.00	4.83	2.54	11.89
SEm(±)	0.55	0.26	0.29	1.95	1.1	0.19	0.06	0.26
CD (p=0.05)	1.66	NS	0.89	NS	NS	NS	NS	NS

4.4.5 Ether extract and total ash

The analyzed data on ether extract and total ash content of mungbean fodder was mentioned in table 4.18 and figure 4.7 which did not significant due to the weed management treatments. Weed free was recorded significantly highest EE and total ash (2.65 and 12.17%, respectively) followed by Pendimethalin as PE fb one HW at 20 DAS (2.62 and 12.16 % respectively). Weedy check recorded lowest value of both EE and total ash (2.41% and 11.27 %, respectively).

Ash is the inert residue residual after the moisture and organic matter have been detached by heating in the presence of oxidizing agents, which are provide an approximate measure about total amount of minerals present within a feed and foods.

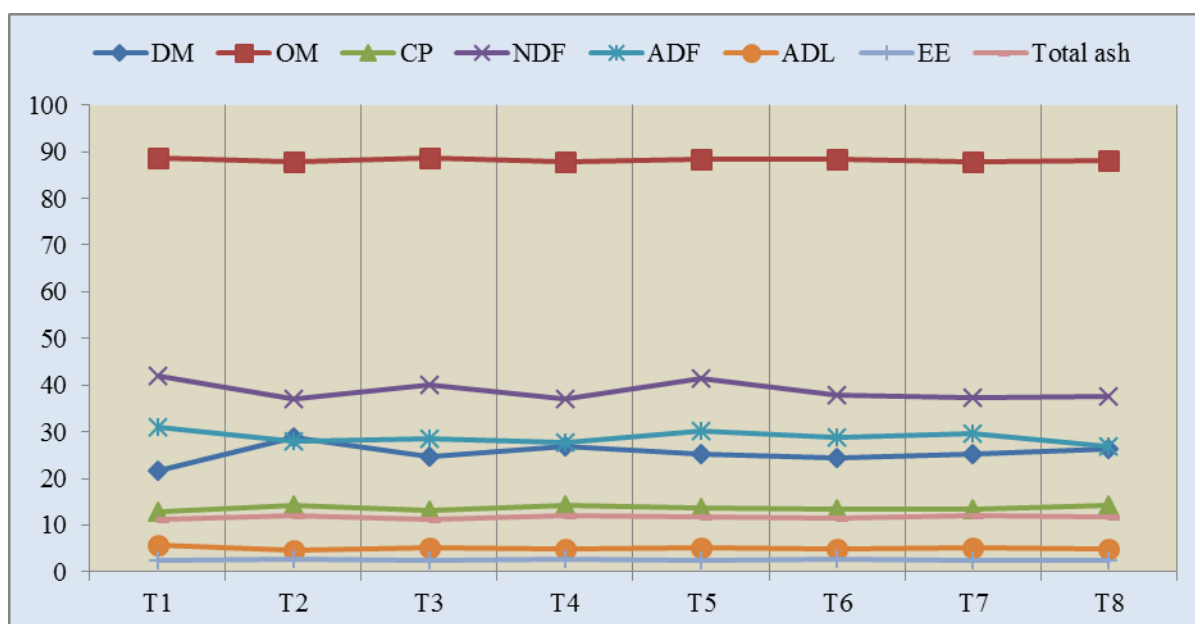


Figure 4.7: DM, OM, CP, NDF, ADF, ADL, EE and total ash (%) of mungbean as influenced by weed control treatments

4.5 Seed quality parameters

4.5.1 Germination percentage

The data mentioned in table 4.19 showed that the use of weed management treatment significantly affected the germination percentage of mungbean. Weed free was recorded significantly highest germination percentage (98%) followed by Pendimethalin as PE fb one HW at 20 DAS (95.33%) Pendimethalin as PE fb Quizolofop ethyl at 20 DAS (94.33%) and. Weedy check was observed significantly lowest germination percentage (85.33%).

4.5.2 Shoot, root and seedling length (cm)

The analyzed data on shoot and root length (cm) mungbean was recorded in table 4.19 which showed that significant effect observed due to the weed management treatments. Weed free was recorded significantly highest shoot, root and seedling length (25.63, 14.20 and 39.83 cm, respectively). Three treatment recorded higher shoot length by application of Pendimethalin as PE fb one HW at 20 DAS (24.43 cm) Pendimethalin as PE fb Quizolofop ethyl at 20 DAS (23.63 cm), and (Propaquizafop + Imezathyper) (23.47 cm).

The highest root length was recorded under application of Pendimethalin as PE fb one HW at 20 DAS (13.73 cm) after weed free which was at par on Pendimethalin as PE fb Quizolofop ethyl at 20 DAS (13.07 cm).

The highest seedling length was recorded under application of Pendimethalin as PE fb one HW at 20 DAS (38.17 cm) after weed free which was at par on (Propaquizafop +

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Imezathyper) (36.80). Weedy check was recorded significantly lowest shoot, root and seedling length (22.5, 10.1, 32.67 cm, respectively).

4.5.3 Seedling dry weight (g)

The data indicating to seedling dry weight (g) significantly affected by different weed management treatments were mentioned in Table 4.19. Weed free was recorded significantly maximum seedling dry weight (0.158g) followed by Pendimethalin as PE + Quizolofop ethyl at 20 DAS (0.156g), Pendimethalin as PE fb one HW at 20 DAS (0.15g) and (Propaquizafop + Imezathyper) (0.15g). Weedy check recorded significantly minimum seedling dry weight (0.14g).

Table 4.19: Effects of different weed control treatments on germination %, shoot, root and seedling length (cm)

Treatments	Germination %	Shoot length	Root length	Seedling length
Weed check	85.33	22.57	10.10	32.67
Weed free	98.00	25.63	14.20	39.83
Pendimethalin (PE)	92.33	23.17	12.50	35.67
Pendimethalin (PE) fb one HW 20 DAS	95.33	24.43	13.73	38.17
Imezathyper (POE) at 20 DAS	93.67	23.27	12.83	36.10
(Propaquizafop + Imezathyper) as POE at 20 DAS	94.33	23.47	13.33	36.80
Pendimethalin (PE) fb Imezathyper (POE) at 20 DAS	94.00	23.13	12.83	35.97
Pendimethalin (PE) fb Quizolofop ethyl at 20 DAS	94.33	23.63	13.07	36.70
SEm(±)	0.51	0.20	0.26	0.28
CD (p=0.05)	1.55	0.6	0.78	0.85

4.5.4 Vigour index I and II

The analyzed data on vigour index I mungbean is recorded in table 4.20 which showed that significant effect observed due to the weed management treatments same time vigor index II did not significantly affected. Weed free was observed significantly highest vigour index I and II (3903 and 14.96 respectively) followed by Pendimethalin as PE fb HW

20 DAS (3638 and 14.31 respectively). Weedy check was recorded significantly lowest vigour index I and II (2787.67 and 11.75).

Higher seed quality might be due to less competition with crop by weeds for nutrients, moisture, space and air, by control of weeds, finally leads to improve health, growth and seed quality parameter of mungbean. Pendimethalin as PE fb one HW at 20 DAS treatment significantly reduce weed infestation and improve seed quality parameters.

Table 4.20: Effects of different weed management treatments on seedling dry weight (g), vigour index I and II

Treatments	Seedling dry weight	Vigour index I	Vigour index II
Weed check	0.13	2787.73	11.75
Weed free	0.16	3903.33	14.96
Pendimethalin (PE)	0.14	3293.33	13.60
Pendimethalin (PE) fb one HW 20 DAS	0.15	3638.50	14.31
Imezathyper (POE) at 20 DAS	0.15	3381.63	13.96
(Propaquizafop + Imezathyper) as POE at 20DAS	0.15	3471.70	14.15
Pendimethalin (PE) fb Imezathyper at 20 DAS	0.15	3381.07	13.91
Pendimethalin (PE) fb Quizolofop ethyl at 20DAS	0.15	3461.90	14.30
SEm(±)	0.001	35.51	2.18
CD (p=0.05)	0.01	107.7	NS

4.6 Economics

The information of gross, net return and Benefit: Cost ratio ratios of different treatments are given in Table 4.21

4.6.1 Cost of cultivation (Rs/ha)

Among different weed management treatments, maximum cost of cultivation was recorded under weed free (Rs 25,783) followed by Pendimethalin (PE) + 1 HW at 20 DAS (Rs 22,134). Weed check was recorded lowest cost of cultivation (Rs 18,534). Weed free condition maintained by repeated HW, leads to increase cost of cultivation.

4.6.2 Gross return (Rs/ha)

The data mentioned in table 4.21 indicate that weed free was recorded highest gross return (Rs 80,700) followed by Pendimethalin as PE fb one HW at 20 DAS (Rs 75,240) and

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(Propaquizafop + Imezathyper) at 20 DAS) (Rs 75,114). Weedy check was recorded lowest gross return i.e. Rs 37,191.

Table 4.21: Effects of different weed management treatments on cost of cultivation, gross return, net return (Rs/ha) and B: C ratio

Treatments	Cost of cultivation	Gross return	Net return	B:C ratio
Weed check	18,534	37,191	18,656	1.01
Weed free	25,783	80,700	54,916	2.13
Pendimethalin (PE)	19,183	48,507	29,323	1.56
Pendimethalin (PE) + 1 HW at 20 DAS	22,134	75,240	53,105	2.40
Imezathyper (POE) at 20 DAS	19,502	55,939	36,437	1.87
(Propaquizafop + Imezathyper) at 20 DAS)	20,034	75,114	55,079	2.75
Pendimethalin (PE) fb Imezathyper at 20 DAS	20,683	71,881	51,197	2.48
Pendimethalin (PE) fb Quizolofop ethyl at 20 DAS	20,117	67,180	47,063	2.34

4.6.3 Net return (Rs/ha)

The data mentioned in table 4.21 indicate that Shaked (Propaquizafop + Imezathyper) at 20 DAS was recorded highest net return (Rs 55,079) followed by weed free (Rs 54,916) and Pendimethalin (PE) + 1 HW at 20 DAS (Rs 53,105). Weedy check was recorded lowest net return i.e. Rs 18,656.

4.6.4 Benefit: Cost ratio

The highest B: C was recorded under Shaked (Propaquizafop + Imezathyper) (2.75) followed by Pendimethalin (PE) fb Imezathyper (2.48), this was due to low cost of cultivation and higher economic returns over rest of treatments.

CHAPTER -5

Summary and Conclusions

SUMMARY AND CONCLUSIONS

A field experiment was conducted on “**Evaluation of weed management practices in summer mungbean (*Vigna radiata*) under zero tillage condition**” during summer season 2019-20 at Agronomy Research Farm, ICAR-National Dairy Research Institute, Karnal, Haryana has been planned with the following objectives, i) To evaluate the efficiency of different herbicides, ii) To assesses the effect of different herbicides on fodder, seed yield and its quality and iii) To work out the economics of different treatments. The experiment was laid out in Randomized Block Design consisting of 8 treatments and three replications viz. T₁- Weedy check, T₂- Weed free , T₃ – Pendimethalin (PE) @ 0.75 kg/ha, T₄ –Pendimethalin fb HW at 20 DAS, T₅ –Imezathyper (POE) @ 75 gm/ha at 20 DAS, T₆ – Shaked (Propaquizafop + Imezathyper) (2 L/ha), T₇ – Pendimethalin @ 0.75 kg/ha fb Imezathyper @ 75 gm/ha at 20 DAS and T₈ – Pendimethalin @ 0.75 kg/ha fb Quizolofop ethyl @ 50 gm/ha at 20 DAS . The soil of experiment site was clay loam in texture and neutral in reaction (pH-7.32), medium in organic carbon (0.53%) and low in available nitrogen (164 kg/ha), medium in available phosphorus (19.5 kg/ha) and potassium (227.7 kg/ha). The observations were recorded on various growth and yield attributes, yield, nutrient content and uptake; seed quality parameters; fodder quality parameters; soil physical and chemical properties; weed count and their dry weight and economics of various treatments. Statistical analysis of the data was done using standard ANOVA technique. The salient findings of present investigation are summarized below:

Weed studies

- A total of 11 species of weeds including 4 grasses, 5 broadleaf and 2 sedges weeds were observed during experimentation. Among the grassy weeds, *Cynodon dactylon*, *Panicum repens*, *Digitaria ciliaris* and *Brachiria mutica* were the most prominent weeds. The broadleaf weed *Amaranthus viridic*, *Trianthema portulacastrum*, *Digera arvensis*, *Euphorbia hirta* and *Portulaca oleracea*. *Cyperus rotundus* and *Cyperus iria* were the prominent sedge was recorded.
- At 30 DAS lowest no. of grassy weeds was recorded in weed free followed by Shaked (1.22 and 1.89, respectively), lowest no. of sedge, broadleaf and total weed population were recorded under weed free (1.12, 1.56 and 3.71, respectively) followed by Pendimethalin (PE) fb one HW 20 DAS (2.55, 3.24 and 5.90, respectively).

Summary and Conclusions

- At harvest, the lowest no. of grassy, sedges, broadleaf and total weed population were recorded with weed free (1.48, 1.82, 1.86 and 2.91, respectively) followed by Shaked (2.31, 3.77, 15.45 and 45.67, respectively). Lowest dry weight of weeds was recorded with weed free followed by Shaked and Pendimethalin (PE) fb one HW 20 DAS, over rest of treatments.
- The highest weed control efficiency and weed control index at 30 DAS and harvest and lowest weed index at harvest were recorded under weed free (96.29, 94.89 and 98.49, 97.33 and 0%, respectively) followed by Pendimethalin (PE) fb one HW 20 DAS (83.53, 78.04 and 66.61, 75.91 and 6.07% respectively) and Shaked. However, Shaked recorded higher WCI at harvest over rest of treatments excepts weed free. Weedy check recorded highest weed index (56.14%).

Crop studies

- At 30 DAS and harvest, significantly tallest plant height (32.70 and 57.00cm, respectively) was recorded under weed free followed by Pendimethalin (PE) fb one HW 20 DAS (28.40 and 53.80cm, respectively) and Shaked. Weed check recorded lowest plant height at both the stages (16.07 and 32.17cm, respectively).
- At 30 DAS significantly maximum no. of branches and no. of leaves/plant were recorded with weed free (4.30 and 25.10, respectively) followed by Pendimethalin (PE) fb one HW 20 DAS (3.74 and 20.93, respectively). At harvest, similar trends were also observed in above parameters. Weed check recorded significantly lowest no. of branches and no. of leaves/ plant at both the stages.
- The maximum LAI at harvest was recorded with weed free (4.11) which were at par with Pendimethalin (PE) fb one HW 20 DAS (3.57) and Shaked (3.40). Weedy check recorded lowest LAI (2.30).
- At 40 DAS maximum no. and dry weight of nodule and root biomass/plant was recorded with weed free (27.03, 0.29 and 0.56, respectively) which was at par on Pendimethalin (PE) fb one HW 20 DAS (24.15, 0.26 and 0.50, respectively). However, Pendimethalin (PE) fb one HW 20 DAS was at par with Shaked.
- Weed free recorded the longest pod length (cm), no. of pods per plant, no. of seeds per pod and test weight (7.85, 21.03, 9.67 and 43.03) which was at par with Pendimethalin (PE) fb one HW 20 DAS and Shaked (Propaquizafop + Imezathyper) as POE at 20 DAS.

- Weed free treatment produced significantly highest seed yield (10.10 q/ha) which was at par on Pendimethalin (PE) fb one HW 20 DAS (9.49 q/ha) and Shaked (Propaquizafop + Imezathyper) as POE at 20 DAS (9.47 q/ha). However, both the treatments was on par with Pendimethalin (PE) fb Imezathyper (POE) at 20 DAS (9.04 q/ha).
- Significantly, highest green fodder yield (63.30 q/ha) was recorded under weed free followed by Shaked (Propaquizafop + Imezathyper) as POE at 20 DAS (55.67 q/ha). However, in green fodder yield rest of treatments was at with each other except weedy check and Pendimethalin (PE), were recorded lowest fodder yield.
- The maximum herbicidal injury on crop was recorded by application of Imezathyper (POE) at 20 DAS followed by Pendimethalin (PE) fb Quizolofop ethyl at 20 DAS.
- The maximum total uptake of nutrients (81.26 kg N/ha, 14.23 kg P/ha and 66.85 kg K/ha) by seed, fodder and weeds was recorded in weed free followed by Shaked (Propaquizafop + Imezathyper) at 20 DAS (71.81, 12.05 and 53.43 kg K/ha). However, highest total nutrient uptake by weeds was recorded in order of Weed check < Pendimethalin (PE) < Imezathyper (POE) at 20 DAS.
- Weedy check recorded the highest nutrients (44.85 kg N/ha, 5.98 kg P/ha and 25.30 kg K/ha) removal as compared to all treatments. While, lowest removal of nutrients by weeds (0.95 kg N/ha, 0.17 kg P/ha and 0.76 kg K/ha) was recorded in weed free. It was followed by (Pendimethalin (PE) fb one HW 20 DAS (9.97 kg N/ha, 1.58 kg P/ha and 6.79 kg K/ha).

Soil fertility status

- After harvest of crops, the various weed management practices does not affect on soil pH, EC, OC and available P and K up to the level of the significance.
- The weed free treatment recorded maximum available N (208.67 kg/ha) followed by Pendimethalin as PE fb one HW at 20 DAS (193.33 kg/ha). However, weedy check recorded lowest values of available N (158.33 kg/ha).
- At 30 DAS and harvest the highest value (no.) of bacteria, Actinomycetes and Fungal were recorded with weed free (13.88×10^6 CFU/g, 8.72×10^5 CFU/g and 2.07×10^4 CFU/g) and (19.97 $\times 10^6$ CFU/g, 19.60×10^5 CFU/g and 7.17×10^4 CFU/g) followed by weedy check (12.56×10^6 CFU/g, 8.33×10^5 CFU/g and $1.63 \times$

Summary and Conclusions

10^4 CFU/g) and (18.63×10^6 CFU/g, 18.10×10^5 CFU/g and 6.47×10^4 CFU/g), respectively.

Fodder quality parameters

- Among the fodder quality parameters, significantly highest DM and CP content were recorded with weed free treatment (28.83 and 14.36%) followed by Pendimethalin (PE) fb one HW 20 DAS (27.00 and 14.19%), respectively. However, ether extract, NDF, ADF and ADL content were not reached up to levels of significance.

Seed qualities parameters

- The significantly higher germination percentage, shoot, root and seedling length (cm) of seed was recorded with weed free (98.00%, 25.63, 14.20 and 39.83cm) over rest of treatments. The rest of treatments were at par with each other excepts weedy check, which were recorded lowest values of seed quality parameters.
- The highest seedling dry weight, vigour index I and II was recorded with weed free treatment (0.16, 3903.33 and 14.96, respectively) followed by Pendimethalin (PE) fb HW at 20 DAS.

Economics

- The highest cost of cultivation Rs 25,783/ha was observed in weed free followed by Pendimethalin (PE) + 1 HW at 20 DAS (Rs 22,134/ha) while lowest cost of cultivation was recorded in Pendimethalin (Rs 18,534/ha) followed by Imezathyper (POE) at 20 DAS (Rs 19,183/ha)
- The highest net returns was obtained under Shaked (Propaquizafop + Imezathyper) at 20 DAS (Rs 55,079/ha) followed by weed free (Rs 54,916/ha). However, the highest returns per rupee invested (B:C ratio, 2.75) was also obtained from Shaked (Propaquizafop + Imezathyper) at 20 DAS) followed by Pendimethalin (PE) fb Imezathyper at 20 DAS (2.48).

Conclusions

- The severe infestation of weeds reduced seed yield of summer mungbean to the extent of 58.86%. Among different weed management treatments, weed free treatment recorded maximum weed control efficiency and lowest weed index and consequently it produced the highest seed and fodder yield with higher seed quality parameters.
- However, to adopting the package of practices, economics was also a good indicator and in present experiment, statistically on par yield, seed quality, weed management and higher net returns and B:C ratio was recorded with application of Shaked (Propaquizafop + Imezathyper) @ 2 l/ha at 20 DAS may recommended for higher yield and net returns of summer mungbean under zero tillage condition.

Future line of work

- Comparison of different tillage practices may be studied.
- The analysis of residual and toxicity of different herbicides on both soil and plant may be studied.

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Annexures

Annexure

S. No.	Parameters	Rate for unit (Rs)
1	Tractor hours (per ha)	
	For sowing	400
2	Man days (per day)	300
3	Mungbean seed (per kg)	150
4	Urea (per kg)	5.91
5	DAP (per kg)	22.4
6	MOP (per kg)	16
7	Irrigation (per hour)	456
8	Rhizobium (per packet)	25
9	Pendimethalin (per kg)	465
10	Imezathyper (per kg)	670
11	Shaked (per kg)	600
12	Quizolofop- ethyl (per kg)	1650
13	Imidacloprid (per kg)	518
14	Seed price (Rs/q)	7050
15	Green fodder price (Rs/q)	150

Appendix

Table 1: Effects of different weed management practices on nitrogen budgeting (Kg/ha)

Treatments	Initial (A)	Applied (B)	Uptake (C)	Final (D)	Expected balance (X=(A+B)- C)	Actual gain/loss (Y=(D- A))	Apparent gain/loss (Z=(D-X))
Weed check	164.00	20.00	78.29	158.33	105.70	-5.67	52.62
Weed free	164.00	20.00	84.80	208.67	99.19	44.67	109.47
Pendimethalin (PE)	164.00	20.00	83.24	179.33	100.75	15.33	78.57
Pendimethalin (PE) fb one HW 20 DAS	164.00	20.00	79.68	193.33	104.31	29.33	89.01
Imezathyper (POE)	164.00	20.00	69.06	174.67	114.93	10.67	59.73
(Propaquizafop + Imezathyper) at 20 DAS	164.00	20.00	81.45	171.33	102.54	7.33	68.78
Pendimethalin (PE) fb Imezathyper at 20 DAS	164.00	20.00	80.65	173.33	103.34	9.33	69.98
Pendimethalin (PE) fb Quizolofop ethyl at 20 DAS	164.00	20.00	72.71	180.33	111.28	16.33	69.04

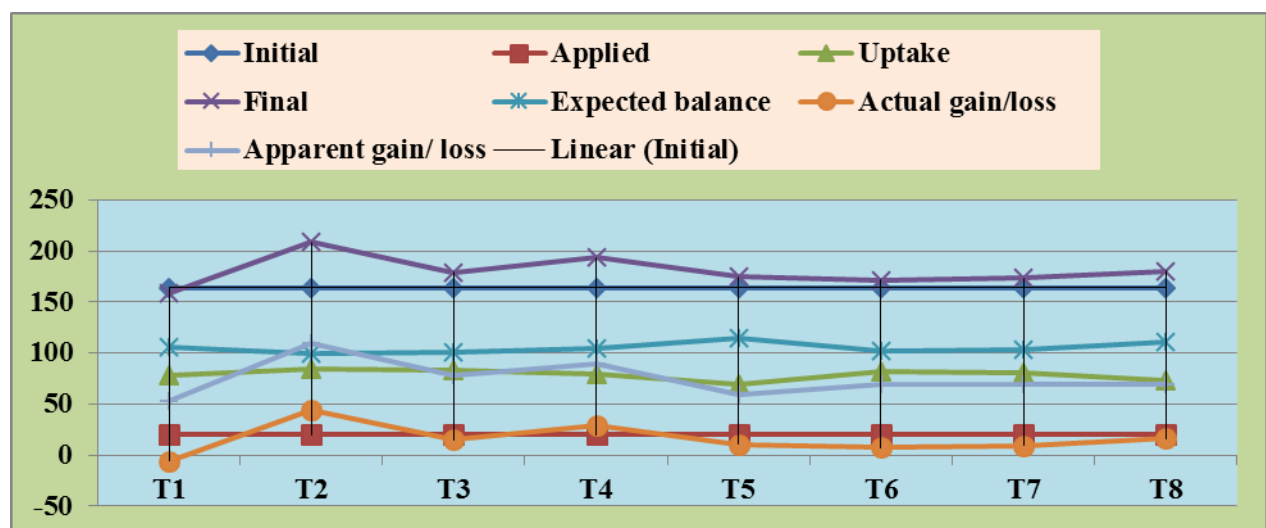


Figure 1: Effect of dissimilar weed management treatments on nitrogen budgeting

Table 2: Effects of different weed management treatments on phosphorus budgeting (Kg/ha)

Treatments	Initial (A)	Applied (B)	Uptake (C)	Final (D)	Expected balance (X=(A+B)-C)	Actual gain/loss (Y=(D-A))	Apparent gain/loss (Z=(D-X))
Weed check	19.50	30.00	11.57	23.33	37.92	3.83	-14.59
Weed free	19.50	30.00	14.72	22.23	34.77	2.73	-12.54
Pendimethalin (PE)	19.50	30.00	13.03	24.65	36.46	5.15	-11.81
Pendimethalin (PE) fb one HW 20 DAS	19.50	30.00	13.25	24.17	36.24	4.67	-12.07
Imezathyper (POE)	19.50	30.00	12.00	22.87	37.49	3.37	-14.62
(Propaquizafop + Imezathyper)	19.50	30.00	13.99	24.82	35.50	5.32	-10.68
Pendimethalin (PE) fb Imezathyper	19.50	30.00	13.01	23.70	36.48	4.20	-12.78
Pendimethalin (PE) fb Quizolofop ethyl	19.50	30.00	12.53	24.87	36.96	5.37	-12.09

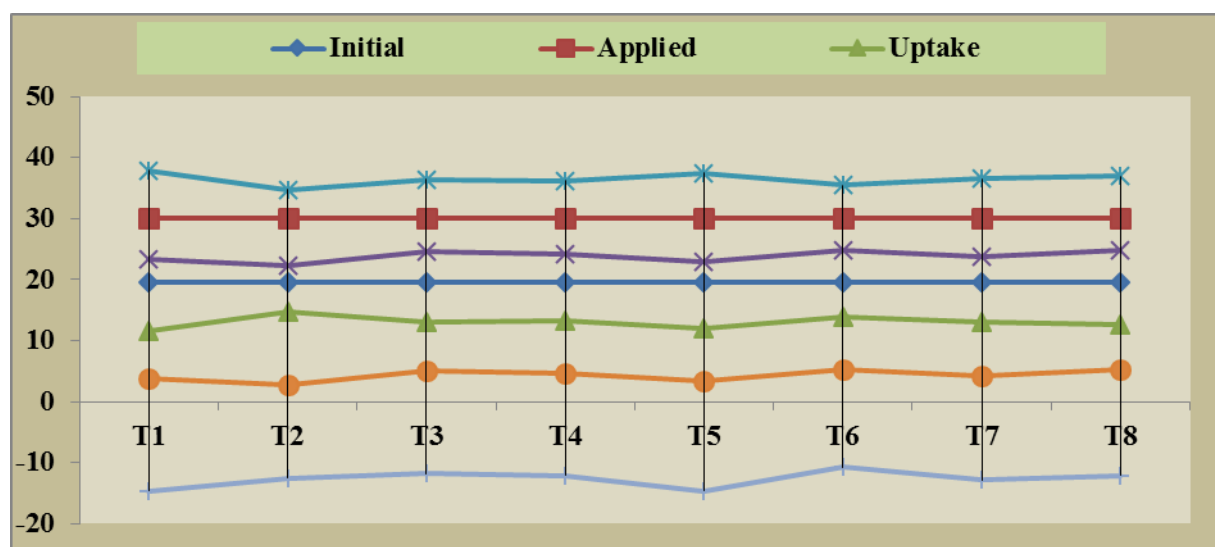


Figure 2: Effect of various weed management practices on phosphorus budgeting

Table 3: Effects of weed management treatments on potassium budgeting (Kg/ha)

Treatments	Initial (A)	Applied (B)	Uptake (C)	Final (D)	Expected balance (X=(A+B)-C)	Actual gain/loss (Y=(D-A))	Apparent gain/loss (Z=(D-X))
Weed check	236.45	40.00	50.29	209.40	226.15	-27.05	-16.75
Weed free	236.45	40.00	68.60	190.50	207.84	-45.95	-17.34
Pendimethalin (PE)	236.45	40.00	56.99	208.56	219.45	-27.89	-10.89
Pendimethalin (PE) fb one HW	236.45	40.00	61.25	198.23	215.19	-38.22	-16.96
Imezathyper (POE)	236.45	40.00	51.91	204.50	224.53	-31.95	-20.03
(Propaquizafop + Imezathyper)	236.45	40.00	61.32	195.50	215.12	-40.95	-19.62
Pendimethalin (PE) fb Imezathyper	236.45	40.00	56.41	201.20	220.03	-35.25	-18.83
Pendimethalin (PE) fb Quizolofop ethyl	236.45	40.00	54.05	203.50	222.39	-32.95	-18.89

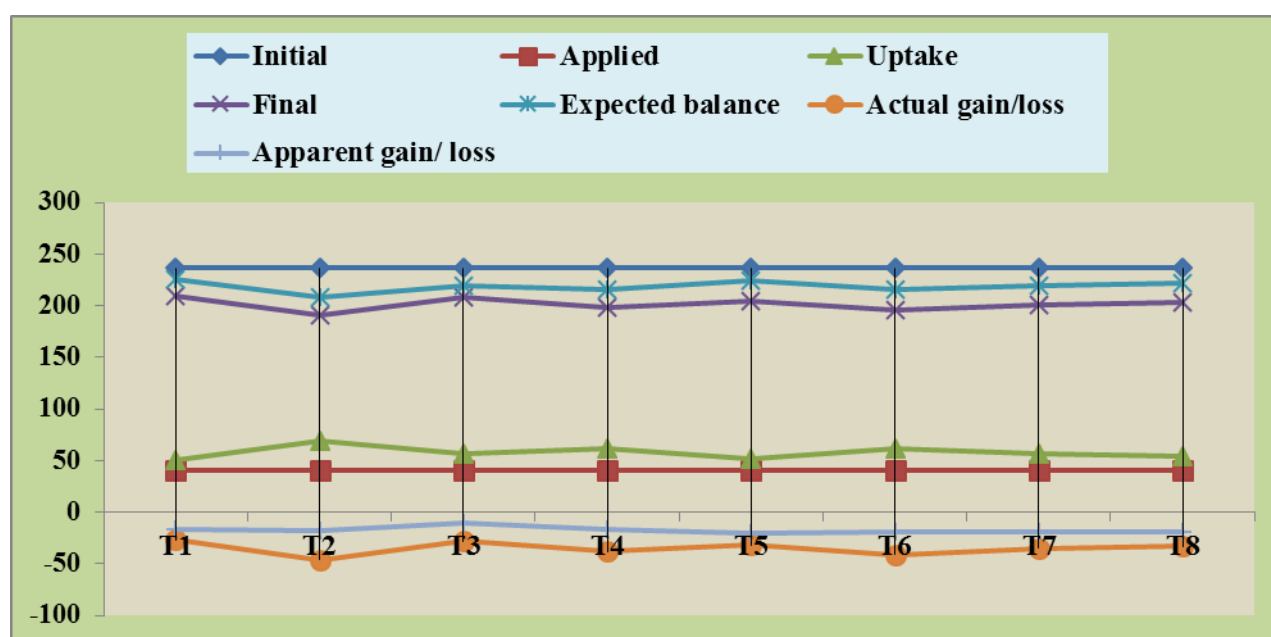
**Figure 3: Effect of different weed management practices on potassium budgeting**

Table 4: Effects of weed management practices on Fe, Mn, Cu and Zn (PPM)

Treatments	Fe	Mn	Cu	Zn
Weed check	9.65	4.67	0.77	0.52
Weed free	9.15	4.71	0.83	0.57
Pendimethalin (PE)	9.18	6.15	0.58	0.66
Pendimethalin (PE) fb one HW 20 DAS	9.79	5.58	0.77	0.56
Imezathyper (POE) at 20 DAS	8.88	5.94	0.83	0.54
(Propaquizafop + Imezathyper) at 20 DAS	9.90	5.98	0.78	0.57
Pendimethalin (PE) fb Imezathyper at 20 DAS	9.41	6.34	0.78	0.50
Pendimethalin (PE) fb Quizolofop ethyl at 20 DAS	8.60	6.02	0.81	0.63
SEm(±)	0.49	0.39	0.05	0.04
CD (p=0.05)	NS	NS	NS	NS

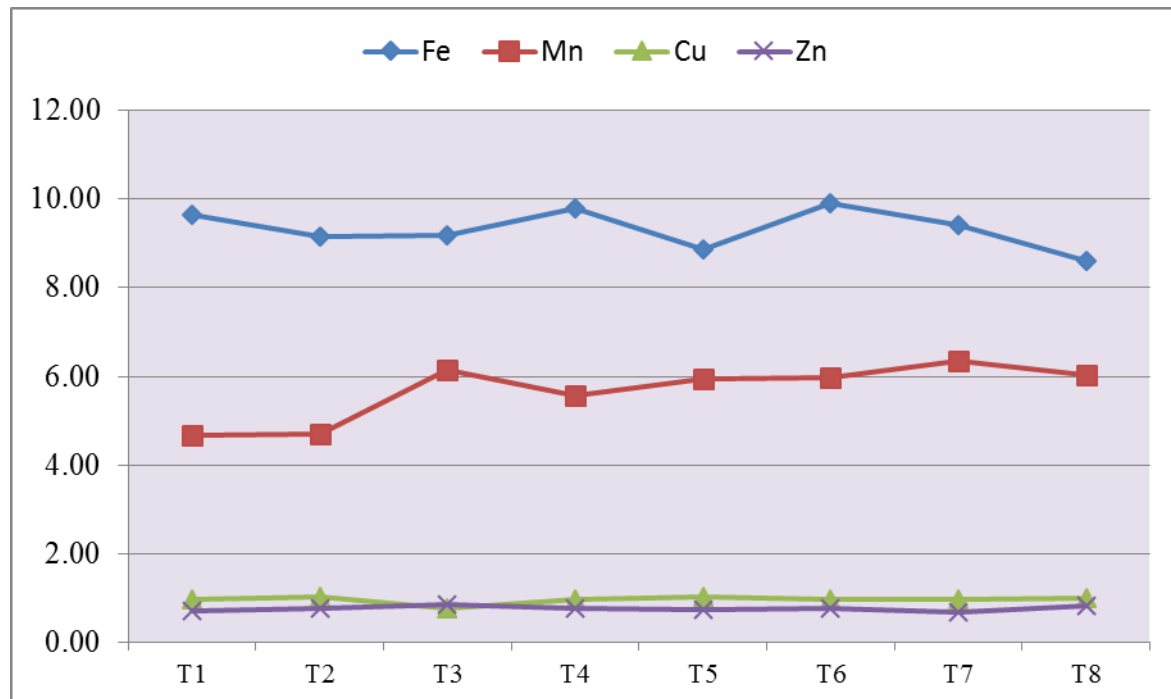


Figure 4: Effects of weed management practices on Fe, Mn, Cu and Zn (PPM)

Table 5: Effects of different weed management treatments on nitrogen content (%) of seed, fodder and weeds

Treatments	Nitrogen content in seed	Nitrogen content in fodder	Nitrogen content in weeds
Weed check	4.3	2.07	3.47
Weed free	4.37	2.31	3.10
Pendimethalin (PE)	4.50	2.30	3.72
Pendimethalin (PE) fb one HW 20 DAS	4.45	2.27	3.60
Imezathyper (POE) at 20 DAS	4.50	2.14	3.20
(Propaquizafop + Imezathyper) at 20 DAS	4.70	2.23	3.20
Pendimethalin (PE) fb Imezathyper at 20 DAS	4.60	2.19	3.52
Pendimethalin (PE) fb Quizolofop ethyl at 20 DAS	4.60	2.15	3.22
SEm (\pm)	0.14	0.07	0.16
CD (p=0.05)	NS	NS	NS

Table 6: Effects of different weed management practices on phosphorus content (%) of seed, fodder and weeds

Treatments	Phosphorus content in seed	Phosphorus content in fodder	Phosphorus content in weeds
Weed check	0.45	0.46	0.35
Weed free	0.54	0.52	0.46
Pendimethalin (PE)	0.47	0.47	0.37
Pendimethalin (PE) fb one HW 20 DAS	0.53	0.49	0.41
Imezathyper (POE) at 20 DAS	0.48	0.51	0.40
(Propaquizafop + Imezathyper) as POE	0.52	0.52	0.40
Pendimethalin (PE) fb Imezathyper POE	0.50	0.49	0.41
Pendimethalin (PE) fb Quizolofop ethyl at 20 DAS	0.49	0.50	0.39
SEm(\pm)	0.02	0.01	0.11
CD (p=0.05)	NS	NS	NS

Table 6: Effects of different weed management practices on Potassium content (%) of seed, fodder and weeds

Treatments	Potassium content in seed	Potassium content in fodder	Potassium content in weeds
Weed check	1.31	2.35	2.20
Weed free	1.67	2.86	2.50
Pendimethalin (PE)	1.40	2.60	2.26
Pendimethalin (PE) fb one HW 20 DAS	1.60	2.76	2.45
Imezathyper (POE) at 20 DAS	1.50	2.45	2.27
(Propaquizafop + Imezathyper) at 20 DAS	1.50	2.73	2.44
Pendimethalin (PE) fb Imezathyper at 20 DAS	1.40	2.65	2.33
Pendimethalin (PE) fb Quizolofop ethyl at 20 DAS	1.50	2.60	2.23
SEm(±)	0.07	0.11	0.10
CD (p=0.05)	NS	NS	NS