

Effect of different weed management practices on growth and yield of chickpea (*Cicer arietinum*.L.) under riverine (*Diara*) area

By

**PANYAM LINGAREDDY GARI SAI LINGA
REDDY**

B.SC. (Ag.)



MASTER OF SCIENCE (AGRICULTURE)

IN

AGRONOMY

DEPARTMENT OF AGRONOMY

**DR. RAJENDRA PRASAD CENTRAL AGRICULTURAL UNIVERSITY,
PUSA, SAMASTIPUR, BIHAR- 848125 (INDIA)**

2020

Regd. No. M/Agro/346/2018-19 of RPCAU

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**A THESIS SUBMITTED TO DR. RAJENDRA PRASAD CENTRAL
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This is to certify that the thesis entitled, “Effect of different weed management practices on growth and yield of chickpea (*Cicer arietinum*.L.) under riverine (Diara) area” submitted in partial fulfillment of the requirements for the award of the degree of **Master of Science (Agriculture)** in Agronomy of the Faculty of Post-graduate studies, Dr. Rajendra Prasad Central Agricultural University, Pusa, Samastipur is a genuine record of bonafide research work carried out by **Mr Panyam Lingareddygar Sailinga Reddy** under my supervision and guidance.

The results of the investigation reported in this thesis have not so far been submitted for any other degree or diploma. The assistance and help received during the course of this investigation from different sources have been duly acknowledged.

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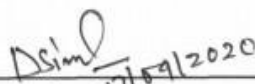
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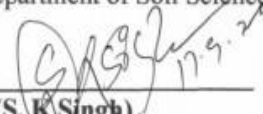


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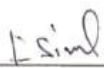
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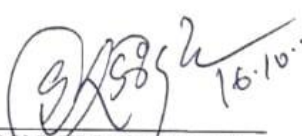

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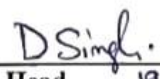
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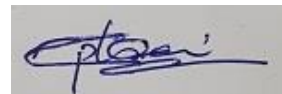
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ABBREVIATIONS USED

%	:	Percent
@	:	At the rate of
°C	:	Degree Celsius
M	:	Meter
Cm	:	Centimeter
mm	:	Millimeter
RH	:	Relative humidity
MSL	:	Mean sea level
m ha	:	Million hectare
m t	:	Million tonnes
Q	:	Quintal
EC	:	Emulsifiable concentrate
a.i	:	Active ingredient
kg	:	Kilogram
g	:	Gram
Ha	:	Hectare
<i>i.e.</i>	:	That is
<i>et al.</i>	:	And others
<i>Viz.</i>	:	Namely
e. g	:	For example
Df	:	Degree of freedom
dSm ⁻¹	:	Deci siemen per meter
EC	:	Electrical conductivity
Fig.	:	Figure
NS	:	Non-significant
DAS	:	Days after sowing
<i>fb</i>	:	Followed by
HW	:	Hand weeding
COC	:	Cost of cultivation
DAA	:	Days after application
NR	:	Net returns
B:C	:	Benefit cost ratio
CD	:	Critical difference

PE	:	Pre-emergence
PoE	:	Post-emergence
No.	:	Number
pH	:	Puissance de hydrogen
SEm±	:	Standard error of mean
`	:	Rupees
Hrs	:	Hours
/	:	Per
No/m ²	:	Number per square metre
RGR	:	Relative growth rate
NAR	:	Net assimilation rate
BLW	:	Broad leaf weeds
HI	:	Harvest index
WI	:	Weed index
WCE	:	Weed control efficiency

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ABSTRACT

A field experiment was undertaken during *Rabi* season of the year 2019-2020 at Dhab research farm, Pusa, Samastipur, Bihar to study “Effect of different weed management practices on growth and yield of chickpea (*Cicer arietinum*.L.) under riverine (*Diara*) area”.

For this study an experiment was designed with twelve treatments and arranged randomly in three replications. The twelve treatments comprised: T1- Pendimethalin @ 0.75 kg/ha (PE); T2- Pendimethalin @ 0.75 kg/ha(PE) + Quizalofop-p-ethyl @ 40 g/ha(PoE); T3- Oxyflurofen @ 100 g/ha(PE); T4- Pendimethalin @ 0.75 kg/ha(PE) + 1 hand hoeing at 30 DAS; T5- Oxyflurofen @ 100 g/ha(PE) + 1 hand hoeing at 30 DAS; T6- Quizalofop-p-ethyl @ 40 g/ha(PoE); T7- Propaquizafop @ 0.75 kg/ha(PoE); T8-One hoeing at 30 DAS by wheel hoe; T9-Mulching with rice straw at 30 DAS; T10-Mulching with black plastic mulch before sowing; T11-Weed free and T12-Weedy check.. “Sabour Chana -1” was taken as the test variety. The soil of the experimental plot was sandy loam in texture with pH 7.63, EC 0.18 dSm⁻¹, medium in organic carbon (0.69%), medium in available nitrogen (268.3 kg/ha), low in phosphorus (20.4 kg/ha) and low in potassium (112.5 kg/ha).

The results showed that growth characters viz., plant height and dry matter were influenced by various weed management treatments at all stages of crop growth. Weed free check recorded maximum growth parameters compared to other treatments. Among the other treatments, Mulching with black plastic mulch before sowing, Pendimethalin @ 0.75 kg a.i ha⁻¹ (PE) + Quizalofop-p-ethyl @ 40 g a.i ha⁻¹ (PoE) and Pendimethalin @ 0.75 kg a.i ha⁻¹ (PE) + 1 hand hoeing at 30 DAS had greater expression in respect to growth parameters. Weedy check treatment

seen with lean and lanky plants with less dry matter and less height compared to all other treatments. Relative growth rate was not influenced by various weed management treatments. Phytotoxicity symptoms were observed at 7 in T3-Oxyflurofen @ 100 g a.i ha⁻¹ (PE) and T5-Oxyflurofen @ 100 g a.i ha⁻¹ (PE) + 1 hand hoeing at 30 DAS which disappeared in 14 DAA.

In case of yield attributing characters viz., no. of pods/plant, number of seeds/pod, and test weight, weed free check recorded highest yield attributes, which is comparable to other treatments. Mulching with black plastic mulch before sowing, Pendimethalin @ 0.75 kg a.i ha⁻¹ (PE) + Quizalofop-p-ethyl @ 40 g a.i ha⁻¹ (PoE) and Pendimethalin @ 0.75 kg a.i ha⁻¹ (PE) + 1 hand hoeing at 30 DAS. Weedy check recorded least yield attributing characters with small pods and less grain weight compared to other treatments. Grain and haulm yields were significantly influenced by different treatments. Maximum grain and haulm yield was recorded with weed free check. But, amongst the other treatments, Mulching with black plastic mulch before sowing, Pendimethalin @ 0.75 kg a.i ha⁻¹ (PE) + Quizalofop-p-ethyl @ 40 g a.i ha⁻¹ (PoE) and Pendimethalin @ 0.75 kg a.i ha⁻¹ (PE) + 1 hand hoeing at 30 DAS performed remarkably. The lowest crop yields were obtained with weedy check.

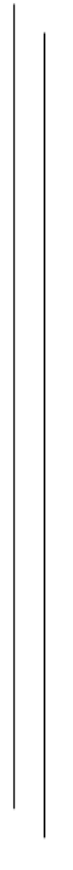
All the weed management treatments significantly recorded lowest weed population, dry weight compared to weedy check. Lowest weed population, weed dry weight, with highest WCE obtained from weed free check, which is on par with Mulching with black plastic mulch before sowing, Pendimethalin @ 0.75 kg a.i ha⁻¹ (PE) + Quizalofop-p-ethyl @ 40 g a.i ha⁻¹ (PoE) and Pendimethalin @ 0.75 kg a.i ha⁻¹ (PE) + 1 hand hoeing at 30 DAS.

Application of Pendimethalin @ 0.75 kg a.i ha⁻¹ (PE) + Quizalofop-p-ethyl @ 40 g a.i ha⁻¹ (PoE) resulted in higher net returns (₹74,223/ha) which is statistically in parity with Pendimethalin @ 0.75 kg a.i ha⁻¹ (PE) + 1 hand hoeing at 30 DAS. The maximum B: C ratio (1.99) was obtained from Pendimethalin @ 0.75 kg a.i ha⁻¹ (PE) + Quizalofop-p-ethyl @ 40 g a.i ha⁻¹ (PoE), and this is statistically equal to Pendimethalin @ 0.75 kg a.i ha⁻¹ (PE) + 1 hand hoeing at 30 DAS. With regards to gross returns, weed free check resulted in higher gross returns (₹1,15,446/ha).





CHAPTER - I



INTRODUCTION



CHAPTER I

INTRODUCTION

Chickpea (*Cicer arietinum* L.) associated to genus *Cicer*, family Fabaceae, and subfamily Faboideae. India is the chief grower of bengalgram in the world covering 9.51mha area and producing 8.83 MT of grain with mean productivity of 929 kg ha⁻¹. In Bihar chickpea is grown in an area of 0.59 m.ha with yearly production of 0.64 MT and average productivity is 1087 kg ha⁻¹ (Anonymous, 2018). Its N₂ fixation capacity plays a important role in the management of soil fertility and inspires farmers to include it in their crop rotation strategy (Maitin and Ebeling, 2001).

It has adequate amount of highly digestible dietary protein and also calcium, Iron, Niacin, Vitamin B and C.

Being a legume, it improves the soil fertility by fixing atmospheric nitrogen by maintaining symbiotic relationship with rhizobium. It fixes approximately 141 kg nitrogen per ha per year under good field management (Herridge *et al.*, 1995). it is grown for vegetable purpose after harvest of rice as catch crop (Sandhu *et al.*, 2002).

As an important crop in terms of nutrition to humans and soil health its yield is decreasing due to different factors. The crucial responsible limitations are insufficient moisture supplies and maximum weed infestation (Hussain *et al.*, 2015). It hardly compete with weeds due to sluggish growth and minimum leaf area growth at initial period. Some cultivars are susceptible to weed infestation while some are greatly tolerant (Mousavi *et al.*, 2007). In addition to production constraints, chickpea yield was strongly declined by weeds as they are orthodoxly grown-up on enduring soil moisture. As result their antagonism pose primary worry in water and nutrient use efficiency. About 25-80% range of yield losses in chickpea was due to weed infestation (Aslam *et al.*, 2007). Chickpea seed value can also be depreciated by weed invasion which created problem of storing along with market rate drop.

Weeds compete with the crop plants at initial growth stages under irrigated conditions and cause yield losses that differ from 40-80 percent (Ahlawat *et al.*, 1981; Vaishya *et al.*, 1996).

Weeds such as *Chenopodium album*, *Cynodon dactylon*, *Medicago hispida*, *Anagalis arvensis*, *Melilotus indica*, *Melilotus alba*, *Cyperus rotundus*, *Argemone Mexicana*, and

Solanum nigrum have been predominantly reported by many research workers which are affecting chickpea cultivation (Gupta *et al.*, 2012).

Though, the most commonly used practice for weed control by mechanical and manual weeding among farmers, but this widespread weed control practices observed to reduce due to shifting the agricultural labours to industries for improved wages. To overcome the situation of unavailability of labour during peak periods of weed control, reliance on herbicides is inevitable. Herbicides usage for weed control is a cost effective practice, however, toxicity have some concern for this practice. Mulching is an option for effective non-chemical weed regulator method with noteworthy results among cultural methods. Mulch is a physical material that safeguards the soil surface and to improve the resource conservation. Straw mulching ensued in improved grain yield and high water use efficiency in various chickpea cultivable varieties (Regar *et al.*, 2010).

Chickpea is one of the chief rabi pulse crop grown in Bihar. Weeds are one of the constraint of low productivity of chickpea in Bihar region. Essentially no efficient research has so far been done in the past to appraise different approaches of weed management in *diara* area of this region. Either due to fear of acceptance of chemical weed control by farmers or meagre of selective herbicides available in market for broad spectrum weed control.

Hence, keeping these fact in view, a field experiment entitled “**Effect of different weed management practices on growth and yield of chickpea (*Cicer arietinum*.L.) under riverine (*Diara*) area**” will be conducted at Dr. Rajendra Prasad Central Agricultural University, Pusa, Bihar with the following objectives:

1. To evaluate the effect of different weed management practices on growth and yield of chickpea.
2. To find out an appropriate weed management practices for chickpea cultivation under riverine area.
3. To assess the phyto-toxicity of different herbicides on chickpea.
4. To workout the economics of different weed control treatments



CHAPTER - II



REVIEW OF LITERATURE



CHAPTER II

REVIEW OF LITERATURE

2.1 LOSSES DUE TO WEEDS

Bhan and Singh (1991) noticed that the percentage decrease in bengalgram seed yield was 50 percent because of weed infestation throughout the period, while the weedy condition caused 22.8 % reduction in economic yield during the first 30 days.

Buttar *et al.*, (2008) reported that in winter pulses, weeds will offer serious competition and leads to a 75 % decrease in chickpea productivity.

Chopra *et al.* (2001), conveyed that yield reduction in chickpea crop ranges from 30-75 per cent due its sluggish growth at initial stages and poor weed control.

In a two-year study, Singh *et al.* (1990) observed a 79 % reduction in chickpea yield because of weed menace.

Jain *et al.* (2002) observed that weeds are causing huge damage to bengalgram production depending on the weed population in field and losses in chickpea yield were estimated to be between 40 and 80%.

Kumar and Singh (2010) witnessed that weeds in chickpea, decreased grain yield ranging from 29 % to 70 %.

Patel *et al.* (2006) conveyed that weeds have an impact on crop production, yield and reduced soil productivity, available soil moisture regime, nutrients, resulting in substantial yield losses of up to 88 per cent in chickpea.

Poonia and pithia (2013) stated that the prevailing weedy condition during the crop period resulted in a 54.7 per cent decrease in chickpea yield over hand weeding.

Sesharee *et al.* (1996) witnessed a 61.7% yield loss because of heavy competition from weeds in chickpea cultivation.

Sharma *et al.* (2007) testified that, dependent on the weed vegetation type present and its intensity in an area, the chickpea yield losses might gone up to 50-70%.

Singh and Singh (1985) witnessed that the reduction in yield was 22.8, 46.0 and 50.8 per cent for crop weed interaction in chickpea for the first 30 days, up to 90 days and throughout the crop period.

Singh and Singh (1992) observed that chickpea seed yield was decreased by 17.1 percent in the first 30 days due to weed competition, which increased to 50 percent when the whole crop season was permitted.

Singh *et al.* (2008) estimated 40-80% decreased in yield of chickpea from weeds. However, it was based on the duration of weed infestation and weed flora in chickpea.

2.2 weeds associated with the crop

Bhutada and Bhale (2013) noted that the major chickpea weed flora during the rabi season were *Amaranthus* spp., *Argemone mexicana*, *Melilotus* spp., *Portulaca oleraceae*, *Euphorbia hirta*, *Digera arvensis*, *Physalis minima*, *Cyperus* spp., *Convolvus arvensis*, etc.

Buttar *et al.* (2008) while investigating a field trial in 2003 to 2006 in winter season at Bathinda, Punjab on loamy sand soil assessed the efficacy of diverse herbicides in chickpea. The observed weed vegetation in weedy check plots at 60 DAS was *Chenopodium album* L. (32.3%), *Melilotus* spp. (29.9%), *Phalaris minor* Retz. (19.8%), *Cynodon dactylon* (L.) Pers. (14.7%) and *Cyperus rotundus* (3.3%).

During the 2012-13 winter season, Singh *et al.* (2016) performed the field experiment in sandy clay loam soil. *Melilotus* spp., *Chenopodium album*, *Cynodon dactylon*, and *Medicago hispida* infested the experimental field during the years. Amid herbicide treatments, successive application of pendimethalin (1 kg / ha) as PE tailed by Quizalofop (50 g / ha) as PoE documented minimum density and weed dry weight, and exhibited the maximum chickpea yields.

Hassan *et al.* (2010) conducted a survey in District Lakki Marwat to highlight the flora infested with chickpea. the average ranking and Importance Value depicted *Astraglaous* spp, *Fumaria indica* L, *Medicago denticulate* Willd., and *Asphodelus tenuifolius* L. as As the most significant chickpea field weeds in the Lakki Marwat district. Only sensible management of these species can allow chickpea growers to harvest their bumper crop yields.

Kumar *et al.* (2008) stated that *Melilotus indica*, *Cyprus* spp., *Chenopodium album*, and *Anagalis arvensis* weeds were the most major weeds of the chickpea experimental fields.

Patel et al. (2006) noted that the leading experimental field weed flora consisted of *Eleusine indica*, *Eragrostis major*, *Asphodolus tenuifolius* and *Dactyloctenium aegyptium* among the monocots and *Chenopodium* spp., *Melilotus indica*, *Boerhavia diffusa* and *Digera arvensis* as dicot weeds in chickpea.

Ratnam et al. (2011) in his investigation at Guntur during 2006 to 2009 on clay loamy soil in chickpea reported the weed flora which is dominant were grasses (*Cynodon dactylon*, *Panicum* spp. and *Echinochloa* spp.), sedges (*Cyperus* spp.) and BLW (*Portulaca oleracea*, *Chrozophora rottleri*, *Aristolochia bracteata*, *Digera arvensis* and *Trianthema portulacastrum*.)

Saxena and Ali (1995) noticed that the predominant weeds grown in chickpea on sandy soils of study plot at Kanpur, Uttar Pradesh, were *Cyperus rotundus*, *Chenopodium album*, *Cynodon dactylon*, *Convolvulus arvensis*, *Sorghum halepense*, and *Ageratum*.

Singh and Singh (1992) noted that *Melilotus alba* Desr, *Melilotus indica* (L), *Chenopodium album* and *Fumaria* spp. were the prevailing weeds on the loamy soils of Pantnagar, UP.

Sukhadia et al. (1999) testified that *Chenopodium album* (0.39%), *Physalis minima* (0.54%), *Portulaca oleracea* (1.74%), *Eluopus villosus* (4.07%), *Indigofera glandulosa* (11.51%), *Echinochloa crusgalli* (26.18%) and *Digera arvensis* (38.33%) contributed 82.76% of the total Chickpea weed flora.

2.3 CRITICAL PERIOD OF CROP-WEED INTERFERENCE

Chopra et al. (2003) in his investigation noted that the first 40 to 50 DAS in chickpea cultivation was the peak time of weed crop competition. Crucial phase of chickpea crop weed competition was rarely greater at 1-2 months after sowing (Varshney and Arya, 2004).

Singh et al. (2004) observed that the first 8 to 9 weeks after sowing were deemed critical for chickpea weed competition whereas Sharma et al. (2007) and Kumar and Singh (2010) reported that 30 to 60 DAS was the crucial phase of weed competition due to early sluggish growth in chickpea.

2.4 WEED CONTROL

2.4.1 CHEMICAL WEED CONTROL

Buttar *et al.* (2008) specified that the pendimethalin @ 1.25 kg ha⁻¹ as PE application documented the lower average weed dry matter (73 kg ha⁻¹) in chickpea.

Chinnusamy *et al.* (2006) conveyed that applying propaquizafop @ 100 g ha⁻¹ expressively decreased the density of sedges at 40 days after planting which was on equivalence with the other doses (50, 75 or 200 g ha⁻¹) and HW twice at 20 and 40 DAS.

Chopra *et al.* (2001) noted that with pendimethalin @1.0 kg as PE application there is a significant decrease in the count of *Melilotus indica*, *Phalaris minor*, *Chenopodium album* and *Fumaria parviflora*.

Density of BLW as well as total weeds in onion was significantly minimised with the pendimethalin @ 0.75 kg ha⁻¹ as PE application (Chinnusamy *et al.*, 2006).

Mishra *et al.* (2005) stated that pendimethalin @1.0 kg ha⁻¹ as PE application significantly reduced the growth of *Cuscuta compestris* in chickpea crop.

Propaquizafop @ 0.1 kg ha⁻¹ as PoE at 20 DAS efficaciously controlled *Lolium rigidum*, *Avena fatua*, *Bromus tectorum* in chickpea fields (Espinosa *et al.*, 1999).

propaquizafop @ 75 g ha⁻¹ as PoE at 20 DAS was more injurious to monocots and at 60 DAS @ 50 g ha⁻¹ unrelenting to indicate active control of monocots as well as dicot weeds in soybean (Billore *et al.*, 1997).

Singh and Singh (1987) noticed 65 and 60 per cent reduced population of weeds with the pendimethalin as PE application and fluchloralin each @ 1.25 kg ha⁻¹, respectively, when related to the weedy check plot.

Tewari and Tiwari (2004) have noted that Pendimethalin @ 1.0 kg / ha as PE showed productive in governing *Asphodelus tenuifolius* and also caused effective morbidity of the *Chenopodium album*, *Anagalis arvensis* and verified to be twice equal to manual weeding, regardless of the application method.

Varsheny and Arya (2004) discovered that pendimethalin @ 1.25 kg ha⁻¹ application and isoproturon @ 0.75 kg ha⁻¹ application effectively decreased the biomass and density of *Anagalis arvensis* and *Chenopodium album* over the control plot.

2.4.2 INTEGRATION OF HAND WEEDING WITH CHEMICALS

Balyan and Malik (1996) noted in chickpea that dry matter buildup of weeds was decreased with the pendimethalin @ 1.0 kg ha⁻¹ as PE application or trifluralin @ 1.0 kg ha⁻¹ as pre-plant incorporation monitored by one HW at 60 DAS.

Chopra *et al.* (2001) detected in chickpea that sharp decline in dry weight of weeds with one HW at 25 DAS along with fluchloralin @ 0.4 kg ha⁻¹ as pre-plant incorporation or pendimethalin @ 0.5 kg ha⁻¹ as PE.

Dry weight of weeds was decreased to the degree of 64.86 per cent and 57.04 per cent at 60 DAS and at harvest, correspondingly, with the pendimethalin @ 0.75 kg ha⁻¹ as PE application tailed by HW at 45 DAS in chickpea (Arya, 2004).

Singh *et al.* (2008) noted that pendimethalin @ 0.5 kg ha⁻¹ as PE application or trifluralin @ 0.5 kg ha⁻¹ as pre-plant incorporation integrated with one HW at 45 DAS decreased the dry matter production of weeds remarkably to the range of 86 and 82 % correspondingly, as related to weedy check.

With pendimethalin @ 0.5 kg ha⁻¹ as PE application coupled with one hoeing at 40 DAS in chickpea expressively reduced weed density and dry weight (Singh *et al.*, 2006).

2.4.3 HAND WEEDING

Ahlawat *et al.* (1978) noted that HW at 30, 45 or 60 DAS efficiently controlled the weed competition therefore documented maximum grain yield and net returns of bengal gram equated to treatments with herbicides application.

Balyan and Malik (1991) stated that HW twice at 30 and 60 DAS resulted in average dry matter reduction of 92 and 93 per cent in *Chenopodium album* and other weeds respectively compared to weedy check.

Dadhich and Malik (1991) noted in gram that the dry weight of weeds is maximum with weedy check (829.9 kg ha⁻¹) and minimum with HW twice at 25 and 45 DAS (66.6 kg ha⁻¹).

In chickpea manual weeding at 30 and 60 DAS shown efficient in governing all types of weeds (Kumar and Kolar (1988))

Upadhaya and Bhalla (2002) reported in chickpea crop grown on clay soils of Jabalpur, India, that significant reduction of Weed density with one HW at 30 DAS

Yadav and Singh (1988) detected that in chickpea HW at 25 and 45 DAS can completely govern *Chenopodium album* and *Asphodelus tenuifolius*.

2.5 WEED CONTROL EFFICIENCY

Buttar *et al.* (2008) showed that the pendimethalin @ 0.75 kg ha⁻¹ as PE documented the highest mean WCE(82.52 per cent), and the minimum mean weed dry matter (0.73 q ha⁻¹) which was statistically equal to pendimethalin @ 1.00 kg ha⁻¹, pendimethalin@ 0.50 kg ha⁻¹+ one hand weeding at 30 DAS, trifluralin @ 1.25 kg ha⁻¹and trifluralin @ 1.00 kg ha⁻¹.

Singh *et al.* (1990), detected the maximum WCE in chickpea (100%) with 2 hand weedings at 25 and 65 DAS

Tewari and Tiwari (2004) documented that with pendimethalin @ 1.0 kg ha⁻¹ as PE and Oxadiazon with a dosage of 1.25 kg ha⁻¹ the greater WCE was documented in Chickpea.

2.6 WEED INDEX

Kachhadiya *et al.* (2009) recorded considerably lower weed index with oxyfluorfen as pre-emergence application @ 0.120 kg a.i. followed by application of imazethapyr as post-emergence @ 0.05 kg a.i. ha⁻¹ in chickpea at 30-35 DAS.

Kour *et al.* (2014) stated that pendimethalin @ 1 kg ha⁻¹ as PE in the chickpea + mustard intercropping system produced maximum weed-control efficiency (85.16 percent), net returns (20,373 ha⁻¹) and B:C ratio (1.71).

Muhammad *et al.* (2011) recorded that the weed index (WI) was highest in untreated plots (50.1%) while the lowest was 7.34-10.35 percent in Stomp 330E @ 3.00 lit ha⁻¹ and 35.59-38.0 percent in Puma Super 75EW @ 1.25 liters ha⁻¹.

2.7 NUTRIENT UPTAKE BY WEEDS

Dadhich and Malik (1991) reported that, in chickpea significantly higher uptake of nutrients (54.6 N, 7.7 P₂O₅ and 72.4 K₂O kg ha⁻¹) is detected with weedy check and minimum uptake of nutrients (8.3 N, 1.2 P₂O₅ and 12.6 K₂O kg ha⁻¹) was assasinated with HW at 25 and 45 DAS.

Dadhich *et al.* (1989) noticed that all weed control treatments studied in Bengal gram documented weeds with less nutrient uptake compared to the weedy check.

Gediya *et al.* (1989) concluded that in chickpea, intake of nutrients by weeds was minimum with the fluchloralin @ 0.9 kg ha⁻¹ + one weeding at 30 DAS (0.1, 0.1 and 0.1 kg N, P and K ha⁻¹, correspondingly) and the maximum uptake was observed with the weedy check (13.9 , 4.6 and 10.1 kg N,P and K ha⁻¹, correspondingly).

2.8 OBSERVATIONS ON CROP

2.8.1 Visual phytotoxic effect of herbicides on crop

Hoseiny-Rad and Jagannath (2011) noted that phytotoxicity percentage increases along with increased dose of imazethapyr in chickpea.

Vasilakoglou *et al.* (2013) indicated that their responses to herbicides tested vary in the common vetch, lentil, chickpea, and red pea. Pendimethalin 1.30 kilograms a.i. 0.96 kg ha⁻¹ S-metolachlor and 0.11 kg ha⁻¹ flumioxazin in pre-emergence induced the least phytotoxicity to common vetch, lentil, chickpea or red pea.

2.8.2 Plant height and drymatter production as influenced by weed management measures

Height of the plant and branches per plant were not significant between various treatments tested in chickpea for weed control. (Buttar et al, 2008).

Patel *et al.* (2006) found greater plant height (58.87 cm) with a pendimethalin as PE application @ 0.75 kg that was on equivalence with oxadiargyl @ 0.075 kg (58.65 cm) and 1.0 kg fluchlorine ha⁻¹ in bengalgram (58.38 cm).

Singh *et al.* (2008) confirmed that the difference in plant height was observed to be non-significant in chickpea crop with various treatments under investigation.

Varshney and Arya (2004) conveyed that pendimethalin @1.25 kg ha⁻¹ as PE in chickpea shown significant results in plant height (45.9 cm), no. of branches per plant (5.0) and plant accumulation of dry matter (17.51 g plant⁻¹). ha⁻¹.

2.8.3 Yield characters as predisposed by weed management measures

Arya (2004) reported the highest equivalent yield for chickpea (Rs. 2783 kg ha⁻¹) with pendimethalin as PE application @ 0.75 kg ha⁻¹ fb 1 HW at 45 DAS.

Poonia and Pithia (2013) inferred that with pendimethalin @ 1.0 kg ha⁻¹ as PE + hoeing at 30-35 DAS had given greater seed yield (13877 kg ha⁻¹) over unweeded check 689 kg ha⁻¹ and persisted on equivalence with oxyfluorfen 23.5 %EC @ 0.25 kg ha⁻¹ as PE at 20 DAS+ hoeing at 30-35 DAS and pendimethalin @ 1.0 kg ha⁻¹ as PE + HW at 25-30 DAS that respectively produced 1356 and 1207 kg ha⁻¹ grain yield of chickpea.

Ratnam *et al.* (2011) recorded that oxyfluorfen 100 g ha⁻¹ as PE fb hand weeding at 30 DAS had a higher grain yield of 2272 kg ha⁻¹ and was equivalent to HW at 15 and 30 DAS.

2.8.4 seed yield

Arya (2004) noticed the maximum equivalent yield for chickpea (2783 kg ha⁻¹) with pendimethalin as PE application @ 0.75 kg ha⁻¹ + 1 HW at 45 DAS.

Buttar *et al.*, (2008) noted that higher grain yield of chickpea was attained with the pendimethalin @ 1.25 kg ha⁻¹ as PE application and was equivalence with pendimethalin @ 0.5 kg ha⁻¹ + 1 HW at 30 DAS.

Highest pod yield of groundnut was observed the with pendimethalin @ 1.5 kg ha⁻¹ as PE fb imazethapyr @ 75 g ha⁻¹ at 20 DAS which was equivalence with HW at 20 and 40 DAS. (Sasikala *et al.* 2004)

Kachhadiya *et al.* (2009) described that fluchloralin @ 0.65 kg ha⁻¹ as PE application or oxyfluorfen @ 0.120 kg ha⁻¹ supplemented with imazethapyr @ 0.05 kg ha⁻¹ as POE application at 30 to 35 DAS resulted in maximum seed yield of chickpea which was similarly effective with weed free conditions.

Marwat *et al.*, (2004) conveyed that greater seed yield of chickpea was noted with post-emergence application at 20 DAS with clodinafop propargyl @ 0.03 kg ha⁻¹ (1220 kg ha⁻¹), followed by oxadiazon @ 0.36 kg ha⁻¹ (1193.33 kg ha⁻¹), propaquizafop @ 0.15 kg ha⁻¹ (1180 kg ha⁻¹) and fenoxaprop-p-ethyl @ 0.75 kg ha⁻¹ (1173.33 kg ha⁻¹).

Maximum chickpea grain yield was observed with HW at 20 and 40 DAS (1428 kg ha⁻¹) tailed by pendimethalin @ 1.0 kg ha⁻¹ as PE (1081 kg ha⁻¹). (Tewari and Tiwari 2004)

Singh *et al.* (2002) noted that pendimethalin @ 1.0 kg ha⁻¹ as PE supported the highest rate of increase in bengal gram yield (72 per cent) and net yield (Rs. 4,363) over farmer method.

Upadhyaya and Bhalla (2002) recorded the maximum yield of chickpea (1350 kg ha⁻¹) with one HW at 30 DAS.

Veeraputhiran *et al.* (2008) stated the maximum grain yield of blackgram with imazethapyr @ 90 g ha⁻¹ as POE application (759 kg ha⁻¹).

2.8.5 nutrient uptake by crop

Dadhich and Malik (1991) noticed that higher uptake of N and P by chickpea at 25 and 45 DAS with two hand weedings, which was 132 and 177.7 per cent higher than the weedy check.

Total N, P, and K uptake by chickpea documented with fluchloralin preplant incorporation @0.9 kg ha⁻¹ was expressively higher than weedy control by 21, 5 and 6 kg/ha respectively. (Gediya et al., 1989)

2.9 ECONOMICS

Butler and Aggrawal (2008) observed that the greater net return (Rs. 11,149/ha) and B:C ratio (1:43) were documented among different weed management treatment applications of pendimethalin at 0.75 kg/ha *fb* by pendimethalin @ 1.0 kg/ha.

During 2008-09 Khope *et al.* (2011) directed a field trial at the CCSHAU Research Farm, Hisar. A total of 13 treatments consisting of different doses of quizalofop-P-ethyl, imazethapyr, and chlorimuron ethyl were equated with untreated and weed-free check controls replicated thrice in a RBD. The net profit economics shows that herbicidal weed control treatment in chickpea is a better substitute to the mechanical and physical weed control method.

Kaushik *et al.* (2014) led a study at Satna and detected that cultivation costs involved maximum in hand weeded treatment and were due to extreme labour costs intricated in repeated three-hand weeding. Integrated herbicide + hand weeding treatments required higher costs than single application of herbicides and only one HW treatment due to the extra labor costs involved in manual weeding.

Kumar *et al.* (2011) from Meerut detected that the pendimethalin as PE application @ 0.5 kg ha⁻¹ + One HW @ 30 DAS provides a greater grain yield with a maximum gross income, net income and benefit cost ratio tailed by metribuzine at 250 g a.i ha⁻¹ + one HW at 30 DAS in chickpea.

Patil *et al.* (2002) in his investigation noted that Pendimethalin as PE application @ 0.75 kg ha⁻¹ + one HW at 45 DAS yielded the greater net profit of Rs. 14,000 ha⁻¹ and B:C ratio of 2.18, respectively.

Pedde *et al.* (2013) noted the highest monetary return on weed-free check treatment tailed by pendimethalin 0.75 kg ha⁻¹ *fb* cultural treatment and the highest B:C ratio with pendimethalin 0.75 kg ha⁻¹.

Ratnam *et al.* (2011) from Guntur found that PE application of oxyfluorfen 100 g ha⁻¹ *fb* HW at 30 DAS had the maximum BCR (0.12) among weed management treatments.

Sharma and Goswami (2010) observed that twice at 30 and 60 DAS hand weeding yielded the highest net yield (Rs. 14,782 ha⁻¹ and 12,663 ha⁻¹) with B:C ratio of (1.29 and 0.96) in 1st and 2nd years separately, in chickpea + linseed inter-cropping.

Singh *et al.* (2013) organized a front line demonstration in 160 ha in 20 villages at 400 farmers fields to demonstrate the economic benefits and production potential of improved chickpea technologies. The enhanced weed management technologies showed a higher mean net income of Rs. 36176/ha with a B:C ratio of 3.84 equated to local control (Rs 26992/ha, 3.63).

Tamang *et al.* (2014) reported that hand-weeding treatments, though significantly reducing weed biomass and improving grain yield, gave less B:C ratio due to maximum labor costs.



CHAPTER - III



MATERIALS AND METHODS



CHAPTER III

MATERIAL AND METHODS

The present field experiment entitled "Effect of different weed management practices on growth and yield of chickpea (*Cicer arietinum* L.) under riverine area" was conducted at Bairiya Dhab Research Farm of Dr. Rajendra Prasad Central Agricultural University, Pusa, Samstipur, Bihar, India during *rabi* season 2019-20. The descriptions of the resources used, the investigational methods pursued and the techniques employed throughout the investigation were briefly discussed in this chapter.

3.1 EXPERIMENTAL SITE

3.1.1. Field Location

The field trial was guided at Bairiya Dhab Research Farm of Dr. Rajendra Prasad Central Agricultural University Pusa is located at on the southern bank of river Bhurhi Gandhak in samastipur district of state bihar at 25.98° North latitude and 84.69° East longitudes with an altitude of 52.92m above the mean sea level. Investigational field was equally fertile with even topography and was linked to the main irrigation channel with the solar power operated tubewell as well as electrical operated tubewell for Supply of irrigation quickly and in time during the crops irrigation sensitive stages. During the experimental period for removal of excess irrigation water proper drainage system also provided.

3.1.2 Climate and weather

The experimental site mainly comes under the sub-tropical climatic condition frequently exposed to extreme weather conditions i.e. colder winter and hotter summer. This area also falls under the south-west monsoon region and received a average annual precipitation of (1018.8mm and 1134.6 mm) out of which 559.2 mm & 466.2 mm rains were received between July-November in the years of study, respectively.

It is comes under the Middle gangetic plain zone (NWPZ) at National level. The maximum temperature rises upto 45°C in summers (May to June) and minimum temperature falls to 10°C in winters. However, the total rainfall and its distribution are subject to large variations. The weather data for crop period was documented at the meteorological station situated very close to the experimental area and has been shown graphically in Fig. 1.

Weather data

3.2 Weather Conditions Prevailed During *rabi* 2019-2020

The maximum weekly mean temperature ranged from 10⁰C to 44⁰C and the minimum weekly mean temperature ranged from 5⁰C to 36⁰C respectively. The maximum temperature was attained during the last week of the crop during the 1st week of April, whereas minimum temperature was observed in the middle of the cropping session. The weekly maximum mean RH differing from 64 to 96 % and that of minimal RH ranged from 31 to 83. Over the crop growth phases, a total of 227.22 mm rainfall was recorded

Table 1: Meteorological data during experimentation

Month	Temperature (°C)		Relative Humidity (%)		Total Rainfall (mm)	Evaporation (mm)
	Maximum	Minimum	Morning	Evening		
October	29.62	22.27	91	82.25	6.6	2.7
November	28.25	17.47	93	68.75	0.0	5.56
December	22.22	10.42	92.4	73.4	22	1.02
January	19.79	9.31	91.51	74.13	6.2	1.04
February	24.80	11.21	91.88	63.46	24	1.73
March	29.92	16.81	84.45	55.59	29.6	2.15
April	33.82	19.87	84.46	63.00	143.8	2.3

3.3 EXPERIMENTAL SOIL

Initial sample of soil was collected scatterdly from the field at a depth of 0-30 cm by using screw auger from various parts of the experimentation site. A part of it is utilized for the mechanical analysis and another part is dried at room temperature and grinded to break the clods, later it was sieved by using 2 mm sieve and used for chemical studies.

Table 2 : Initial physico-chemical properties of investigational site (0-15 cm) of soil depth

Sl. No.	Parameters	Value	Methods Employed	Rating
A	Physical Properties (Soil)			
	Sand (%)	56.85	Bouyoucous Hydrometer Method (Piper, 1966)	Sandy loam
	Silt (%)	31.35		
	Clay (%)	11.80		
	Textural class	Sandy loam	Textural Diagram (Black et al,1965)	
B	Chemical Properties			
	Soil pH	7.63	(1:2.5) Soil water suspension measured with Beckman Glass neutral electrode pH meter (Jackson, 1973)	Saline
	EC (dSm ⁻¹)	0.18 ds/m	1:2.5 Soil water suspension in the safe measured with Systronics range conductivity meter (Jackson, 1973)	In safer range
	Organic Carbon (%)	0.69 %	Walkley and Black method (Jackson, 1973)	Medium
	Available N (kg ha ⁻¹)	268.3 kg/ha	Alkaline Permanganate method (Subbiah and Asija, 1956)	Medium
	Available P (kg ha ⁻¹)	20.4 kg/ha	Sodium Bicarbonate method (Olsen et al., 1954)	low
	Available K (kg ha ⁻¹)	112.5 kg/ha	Ammonium acetate method (Jackson, 1973)	low
	Available Zn (ppm)	0.54	DTPA-extractable (Lindsay and Norvell, 1978)	low
	Available Fe (ppm)	23.41	DTPA-extractable (Lindsay and Norvell, 1978)	Sufficient

3.4 CROPPING HISTORY

Particulars of the crops and the cropping systems trailed on the investigational field have been given in Table 2.

Table 3: The cropping history of the investigational site

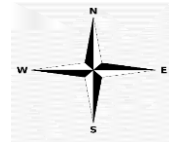
Year	Season	
	Kharif	Rabi
2017-18	Dhaincha	Wheat
2018-19	Dhaincha	Wheat
2019-20	Dhaincha	Chickpea (Experimental crop)

3.5 EXPERIMENTAL DETAILS

3.5.1 LAYOUT OF THE EXPERIMENT:

- Location : Dhab research area of RPCAU.
- Test crop : Chickpea
- Variety : Sabour chana-1 (Recently release)
- Design : RBD
- Replication : Three (03)
- Spacing : 30 cm X 10 cm
- Plot size
 - Gross plot size : 5.4 m X 3.4 m
 - Net plot size : 4.2 m X 3.0 m
- Seed rate : 80 kg/ha
- Year : 2019-20

Fig.1 : Field Layout Plan of the Experiment



R1	R2	R3
T₆	T₄	T₃
T₁	T₁₁	T₁₀
T₅	T₇	T₁₂
T₃	T₉	T₈
T₈	T₆	T₂
T₁₁	T₁	T₇
T₁₀	T₁₂	T₄
T₂	T₃	T₆
T₉	T₅	T₁₁
T₇	T₁₀	T₁
T₄	T₈	T₉
T₁₂	T₂	T₅

Table 4 : TREATMENT DETAILS

Treatment Details	
T1	Pendimethalin @ 0.75 kg a.i ha ⁻¹ (PE)
T2	Pendimethalin @ 0.75 kg a.i ha ⁻¹ (PE) + Quizalofop-p-ethyl @ 40 g a.i ha ⁻¹ (PoE).
T3	Oxyflurofen @ 100 g a.i ha ⁻¹ (PE)
T4	Pendimethalin @ 0.75 kg a.i ha ⁻¹ (PE) + 1 hand hoeing at 30 DAS
T5	Oxyflurofen @ 100 g a.i ha ⁻¹ (PE) + 1 hand hoeing at 30 DAS
T6	Quizalofop-p-ethyl @ 40 g a.i ha ⁻¹ (PoE).
T7	Propaquizafop @ 0.75 kg a.i ha ⁻¹ (PoE)
T8	One hoeing at 30 DAS by wheel hoe
T9	Mulching with rice straw at 30 DAS
T10	Mulching with black plastic mulch before sowing
T11	Weed free check
T12	Weedy check

3.5.2 Cultivar Description

- Variety - Sabour Chana – 1
- Average yield 24q/ha
- Semi-erect type with a height of 58-60cm
- Maturity – 130-135 days
- Seed type - Bold

3.6 CULTIVATION DETAILS

Calendar of operations that are performed at various stages are given below and mentioned in Appendices.

3.6.1 Field Preparation

The field was made ready with tractor-drawn cultivator working twice and leveled with rotavator.

3.6.2 Seeds and Sowing

On 05.11.2019, healthy and well matured bold seeds were selected and sown at a depth of 4 cm, adjusting a spacing of 30 cm between rows and 10 cm inside the row.

3.6.3 Nutrient management

The required dose of nutrients for chickpea is 20:50:25, which is supplied from urea, DAP, and MOP fertilisers as a basal dose. Micro nutrients boron has been applied at the flowering stage by spraying.

3.6.4 Herbicides and application

The herbicide comprised in the pre-emergence trail was pendimethalin and oxyfluorfen. The essential amount of herbicide was mixed in water at a spray size of 500 l ha⁻¹ and sprayed homogeneously at 3 DAS as a pre-emergence application with knapsack sprayer equipped with flat fan nozzle as per the treatments (T1, T2 , T3 , T4, and T5).

Treatments involving post-emergence application of herbicides (T2, T6 and T7) were sprayed uniformly with a flood jet nozzle-fitted knapsack sprayer as per the 20 DAS treatments.

Treatments involving hand hoeing (T₄, T₅ and T₈) was done at 30 DAS on 05.12.2019.

Treatment involving mulching with black plastic mulch(T₁₀) was done before sowing and rice straw(T₉) was done at 30 DAS on 05.12.2019.

3.6.5 Plant protection measures

Crop was infected with grey mould disease during the podding stage. spraying of carbendazim @ 3 g l⁻¹ on canopy was done to protect the crop against the disease.

3.6.6 Irrigation

Two irrigations have been given during the growth of crop, one at the time of sowing other at pod development stage.

3.6.7 Harvesting

The crop was reaped on 15.04.2020. The boundary rows were reaped first and subsequently net plots separately. The plants were sun dried thoroughly on the threshing floor. Threshing was done by thrashing the plants gently with wooden mallet.

3.7 OBSERVATIONS ON WEEDS

3.7.1. Weed Density (No/m²)

Total number of weeds which include grasses, broadleaf and sedges were counted at 30, 60, 90 DAS, and at harvest in random squares of 50 cm x 50 cm (0.25 m²) from net plot area of respective plot. These were expressed as total weed density per square meter and denoted as number/square meter.

3.7.2 Weed Dry matter (g /m²)

Total number of weeds which include grasses, broadleaf and sedges enclosed in a square of 0.25 m² (50 x 50 cm) were obtained from net plots at 30, 60, 90 DAS and at harvest time. Samples picked were sun-dried for two days, further they were oven-dried at 70^o till they achieve a consistent weight and were recorded and expressed in g/ m².

3.7.3 Weed Control Efficiency (%)

It is usually determined on the from weed dry biomass recorded from each treatment by utilising the formula recommended by Sankaran and Mani (1974).

$$\text{WCE (\%)} = \frac{\text{DWC} - \text{DWT}}{\text{DWC}} \times 100$$

WCE – “Weed control efficacy in percentage”

DWC – “Weed dry weight in weedy check.”

DWT – “weed dry weight in weed control treatment.”

3.7.4 Weed index (%)

It denotes the amount of decline in yield resulting from weed competition. It was calculated for various treatments by adopting the formula recommended by Gill and Kumar, (1969).

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

Where,

X= “Grain yield from weed-free plot.”

Y= “Grain yield from the treated plot for which weed index has to be determined.”

3.8. OBSERVATIONS ON CROP

3.8.1 Pre-harvest observations

3.8.1.1 Initial and final plant population

Initial plant population at 20 DAS and final plant population at the time of harvest was documented for each plot.

3.8.1.2 Sampling

Five successive plants need to be collected every time for the purpose of destructive sampling from the border row on either side to document dry matter production. The collected samples were initially sun-dried and later they are oven-dried at 70 °C till they obtain a consistent mass. The final dry biomass was measured by electronic balance and indicated in grams.

3.8.1.3 Non-destructive Sampling

Five healthy plants were picked scatterdly in each plot and they are tagged leaving two rows on both sides of the every plot. The biometric details and after harvest data also need to be calculated from the tagged plants.

3.8.1.4 Plant height (cm)

This parameter has been caluculated using a scale on five random plants that were tagged. The height starting from bottom of the stem to tip of the longest leaf has been measured. Total mean of all the observations were caluculated and conveyed in centimeters.

3.8.1.5 Dry matter production (g/plant)

Plants from net plot were collected parting two rows from the border and they were cut from ground level and taken to calculate the dry weight. This is was followed during all stages of recording observations. The plants are sun dried for about 2 or 3 days to loose wetness afterwards kept in oven at 70⁰ C in oven for about 48 hours or until attaining abiding dry weight. Later the weight obtained per plant is recorded in grams.

3.8.1.6 Number of branches per plant

The number of branches per plant was calculated for five plants in each net plot and averaged per plant and expressed number of branches per plant.

3.8.1.7 Crop injury score

A simple assessing scale of 0-10 rating was used to assess the phytotoxic performance of various herbicides on maize after application of chemical at 7 and 14 DAA suggested by Rao (1986).

Table 5. “Qualitative analysis of herbicide impact on crop in the visual scoring scale of 0 to 1”

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

3.8.2. Post - harvest Observations

3.8.2.1 Pods per plant

It was calculated by averaging total number of pods for five plants from net plot.

3.8.2.2 Seeds per pod

It was calculated by averaging the number of seeds attained out of all the pods of five tagged plants.

3.8.2.3 Test Weight

Small sample of grain obtained from net plot were weighed by using a sensitive measuring balance. The total amount of seeds in the sample were counted and weight of 100 seeds is expressed as the test mass in grams.

3.8.2.4 Seed and haulm yield

Harvested plants from net plot are collected and desiccated under the sun. Mass of the produce was recorded after complete drying. Grain yield was documented after threshing and cleaning the produce. The variance between the biological yield and the grain yield is haulm yield.

3.8.2.5 Harvest index (%)

The term “**harvest index**” is being used to quantify the crop yield versus the total biomass yield that is produced by the agricultural crops. HI is taken as a measure of reproductive efficiency of crop plants. Here grain (economic yield) divided by grain + straw yield (biological yield) was calculated to get harvest index. The formula is as shown below.

$$\text{Harvest index (HI) in \%} = \frac{\text{Economic yield}}{\text{Biological yield}} \times 100$$

3.9 ECONOMICS

This includes the costs incurred for all the inputs and outputs of the crop production and calculation depends on the existing market prices. The below mentioned economic variables were calculated and mentioned in Appendix I.

3.9.1 Cost of cultivation (₹/ha)

All factors accounting to the production of crop in the field beginning from site preparation to harvesting, threshing and storage are considered based on the respective treatments in the different plots. The current market prices of all the inputs and labour cost are counted making upto cost of cultivation along with land rent for the cropping area.

3.9.2 Gross returns (₹/ha)

Gross returns (GR) is defined as the total income gained after selling the products obtained from the field like grain, straw, stone. It is expressed in rupees per hectare.

3.9.3 Net returns (₹/ha)

Net returns (NR) refers to the actual income determined by deducing the cultivation costs from gross returns.

3.9.4 Benefit-cost ratio

A unitless parameter perceived by dividing the net profit with total cost.

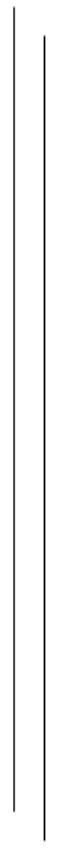
$$\text{B:C ratio} = \text{Net Returns} / \text{Cost of cultivation}$$

3.11 STATISTICAL ANALYSIS

The observations attained from numerous parameters both from field and laboratory then subjected to standard statistical procedure by ANOVA. Data of weed densities and weed biomass were undergone root transformation ($\sqrt{x+0.5}$) preceding to statistical procedure. The values in the parenthesis will be original and transformed values are outside. The significance impact of various treatments on performance of maize was tested using F test given by Fischer in 1938. The critical difference and standard error was estimated for all the treatments at 5 % loss of significance. The outcomes were interpreted accordingly in the details of the experimental results



CHAPTER - IV



RESULTS AND DISCUSSIONS



RESULTS AND DISCUSSION

The current trial entitled “**Effect of different weed management practices on growth and yield of chickpea (*Cicer arietinum*.L.) under riverine (*Diara*) area**” was conducted in *rabi* season of 2019-2020 at Dhab research farm, Pusa (Bihar). In this chapter, an attempt was made to analyse the variations in the treatments exhibited at successive growth and developmental stages. The results obtained during the investigation were summarized and described in the present section.

4.1 Weed flora documented in the investigational location

The principal weeds which were noticed in the investigational plot belong to grasses, sedges and broad-leaved weeds at different growth periods.

Table 6. “Weed flora documented in the experimental plot during *rabi* (2019-2020)”

S. No.	Botanical name	Common name	Family
Grasses			
1.	<i>Cynodon dactylon</i>	Bermuda grass	Poaceae
2.	<i>Dactyloctenium aegyptium</i>	Crow foot grass	Poaceae
3.	<i>Echinochloa colona</i>	Barnyard grass	Poaceae
Sedges			
4.	<i>Cyperus rotundus</i>	Nut sedge	Cyperaceae
Broad leaved weeds			
5.	<i>Achyranthes aspera</i>	Prickly chaff flower	Amarantaceae
6.	<i>Cleome viscosa</i>	Wild mustard	Capparidaceae
7.	<i>Leucas aspera</i>	Thumbai	Lamiaceae

4.1.1 Weed population (No. /m²)

Weed count documented at 30, 60 and 90 DAS and at harvest has been evaluated species wise and are furnishes below

4.1.1.1 Sedges (number m⁻²)

The population of sedges varied remarkably because of diverse weed control measures at varied phases of crop development and are shown in the table 5

At 30 DAS, lowest number of sedges was documented under T₁₁ (0.71 m⁻²) that is better to all other treatments. Amid the various treatments, minimum sedge density (1.05 m⁻²) was recorded under mulching with black plastic mulch before sowing and remaining treatments have not shown any reduction in sedge population as other treatments are inferior in controlling the sedges. Nevertheless, weedy check reported the maximum sedge count (3.60 m⁻²).

At 60 DAS also lowest count of sedges was documented under T₁₁ (0.71 m⁻²) that is better to all other treatments. Amid the various treatments, minimum sedge density (0.95 m⁻²) was documented under T₁₀ followed by T₄, T₅, and T₈ which shown significant reduction in sedge population due to hand hoeing and hoeing with wheel hoe at 30 DAS. Herbicidal treatments with pendimethalin, oxyflorefen, quizalofop-p-ethyl and propaquizafop are inferior in controlling sedges. However, weedy check reported the maximum sedge population (4.41 m⁻²)

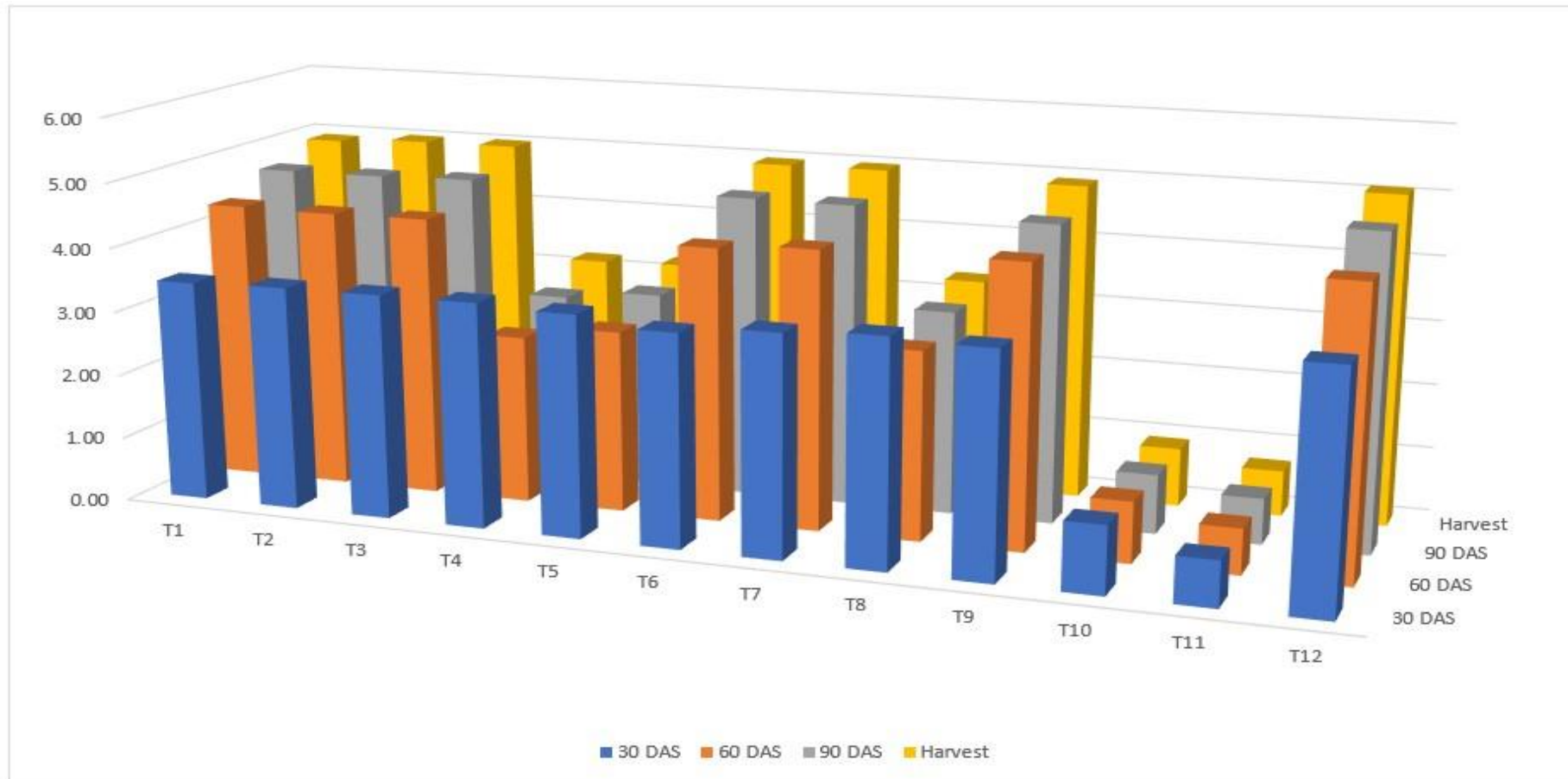
At 90 DAS also lowest count of sedges was documented under T₁₁ (0.71 m⁻²) that is better to all other treatments. Amid the various treatments, minimum sedge density (0.92 m⁻²) was documented under T₁₀ tailed by T₄, T₅, and T₈ which shown significant reduction in sedge population. However, weedy check reported the maximum sedge population (4.83 m⁻²)

At harvest also lowest number of sedges was recorded under T₁₁ (0.71 m⁻²) that is better to all other treatments. Amid the various treatments, minimum sedge density (0.91 m⁻²) was documented under T₁₀ tailed by T₄, T₅, and T₈ which shown significant reduction in sedge population. However, weedy check reported the maximum sedge population (5.08 m⁻²)

Table 7. Density of sedges (m⁻²) as influenced by different weed management practices

Treatments	30 DAS	60 DAS	90 DAS	At Harvest
T1-Pendimethalin @ 0.75 kg a.i ha ⁻¹ (PE)	3.44 (11.36)	4.35 (18.47)	4.67 (21.30)	4.92 (23.76)
T2-Pendimethalin @ 0.75 kg a.i ha ⁻¹ (PE) + Quizalofop-p-ethyl @ 40 g a.i ha ⁻¹ (PoE).	3.48 (11.65)	4.34 (18.33)	4.68 (21.38)	4.99 (24.46)
T3-Oxyflurofen @ 100 g a.i ha ⁻¹ (PE)	3.49 (11.66)	4.35 (18.46)	4.71 (21.67)	5.00 (24.55)
T4-Pendimethalin @ 0.75 kg a.i ha ⁻¹ (PE) + 1 hand hoeing at 30 DAS	3.49 (11.68)	2.61 (6.32)	2.92 (8.10)	3.20 (9.83)
T5-Oxyflurofen @ 100 g a.i ha ⁻¹ (PE) + 1 hand hoeing at 30 DAS	3.44 (11.33)	2.82 (7.46)	3.07 (8.96)	3.23 (9.98)
T6- Quizalofop-p-ethyl @ 40 g a.i ha ⁻¹ (PoE).	3.29 (10.32)	4.23 (17.45)	4.70 (21.63)	4.97 (24.20)
T7-Propaquizafop @ 0.75 kg a.i ha ⁻¹ (PoE)	3.41 (11.15)	4.32 (18.14)	4.70 (21.57)	4.98 (24.31)
T8-One hoeing at 30 DAS by wheel hoe	3.49 (11.68)	2.92 (8.19)	3.16 (9.55)	3.32 (10.55)
T9-Mulching with rice straw at 30 DAS	3.44 (11.38)	4.36 (18.47)	4.61 (20.78)	4.92 (23.74)
T10-Mulching with black plastic mulch before sowing	1.05 (0.60)	0.95 (0.40)	0.92 (0.35)	0.91 (0.33)
T11-Weed free check	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)
T12-Weedy check	3.60 (12.50)	4.41 (19.00)	4.83 (22.80)	5.08 (25.36)
SEm ±	0.09	0.12	0.11	0.12
CD (p = 0.05)	0.28	0.35	0.32	0.36
CV%	5.4	6.0	5.2	5.5

“Fig 2. Density of sedges (m^{-2}) as influenced by different weed management practices”



4.1.1.2 Grasses (number m⁻²)

The population of grasses changed remarkably because of various weed control practices at varied phases of crop development and are shown in the table 6

At 30 DAS, least number of grasses was documented under T₁₁ (0.71 m⁻²) that is better to all other treatments. Amid various treatments, minimum grasses density (1.90 m⁻²) was recorded under T₁₀ followed by T₁, T₂, T₃, T₄ and T₅ because of preemergence application of pendimethalin and oxyflorefen have shown significant reduction in grasses and remaining treatments have not shown any significant reduction in grasses population. However, weedy check reported the maximum grasses population (6.46 m⁻²).

At 60 DAS also minimum count of grasses was documented under T₁₁ (0.71 m⁻²) that is better to all other treatments. Amid various treatments, minimum grasses density (1.70 m⁻²) was recorded under T₁₀ followed by T₂, T₄, T₅, T₆ and T₇ which shown significant reduction in grasses population because of application of pre and post emergence herbicides. However, weedy check reported the maximum grasses population (7.12 m⁻²)

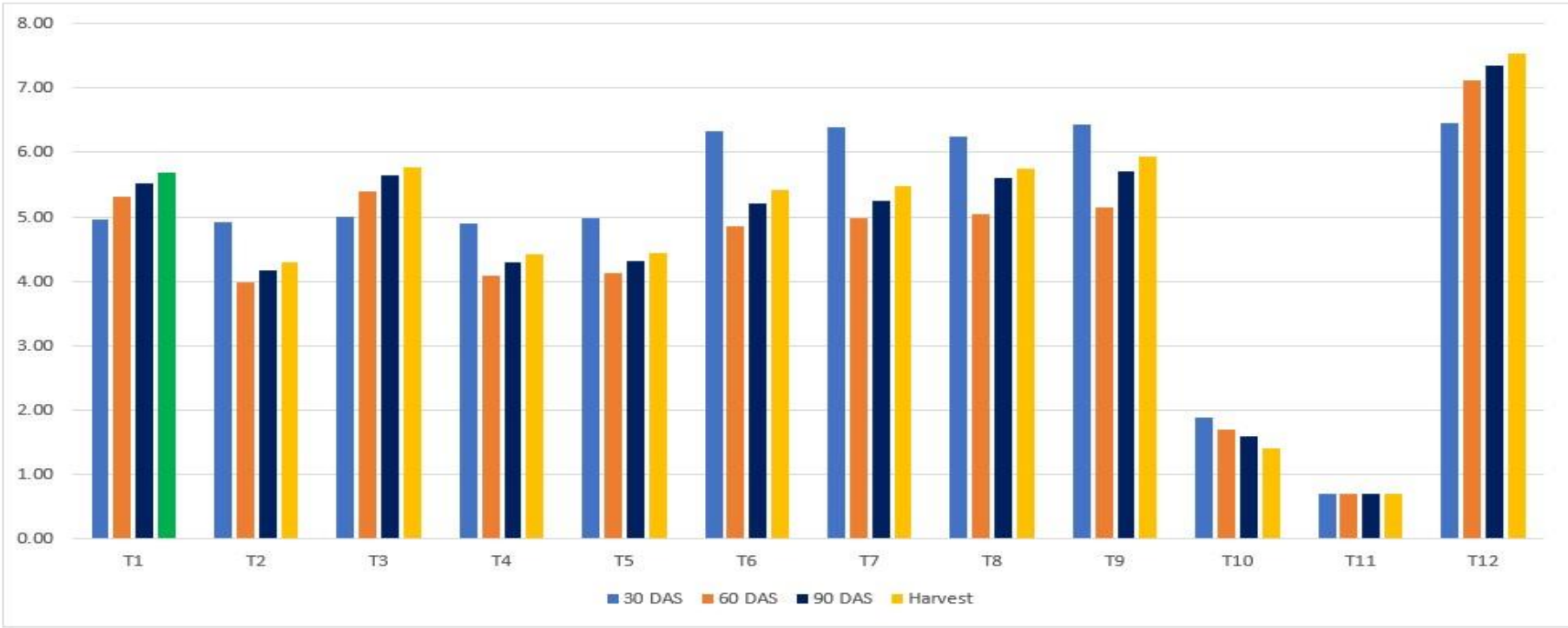
At 90 DAS also minimum count of grasses was documented under T₁₁ (0.71 m⁻²) that is better to all other treatments. Amid various treatments, minimum grasses density (1.60 m⁻²) was recorded T₁₀ because mulching at initial stages does not allow the weeds to germinate followed by T₂, T₄, and T₅ which shown significant reduction in grasses population because of association of PE and PoE herbicides and hoeing. However, weedy check reported the maximum grasses population (7.34 m⁻²)

At harvest also lowest number of grasses was recorded under T₁₁ (0.71 m⁻²) that is better to all other treatments. Amid various treatments, minimum grasses density (1.40 m⁻²) was recorded T₁₀ followed by T₂, T₄, and T₅ which shown significant reduction in grasses population. However, weedy check reported the maximum grasses population (7.53 m⁻²)

Table 8. Density of grasses (m⁻²) as influenced by different weed management practices

Treatments	30 DAS	60 DAS	90 DAS	At Harvest
T1-Pendimethalin @ 0.75 kg a.i ha ⁻¹ (PE)	4.96 (24.12)	5.32 (27.87)	5.53 (30.12)	5.69 (31.95)
T2-Pendimethalin @ 0.75 kg a.i ha ⁻¹ (PE) + Quizalofop-p-ethyl @ 40 g a.i ha ⁻¹ (PoE).	4.92 (23.78)	3.98 (15.41)	4.17 (16.96)	4.30 (18.11)
T3-Oxyflurofen @ 100 g a.i ha ⁻¹ (PE)	5.01 (24.67)	5.40 (28.64)	5.65 (31.53)	5.76 (32.77)
T4-Pendimethalin @ 0.75 kg a.i ha ⁻¹ (PE) + 1 hand hoeing at 30 DAS	4.89 (23.46)	4.09 (16.26)	4.29 (17.94)	4.41 (18.98)
T5-Oxyflurofen @ 100 g a.i ha ⁻¹ (PE) + 1 hand hoeing at 30 DAS	4.98 (24.28)	4.12 (16.57)	4.31 (18.12)	4.44 (19.22)
T6- Quizalofop-p-ethyl @ 40 g a.i ha ⁻¹ (PoE).	6.34 (39.67)	4.85 (23.12)	5.21 (26.64)	5.41 (28.82)
T7-Propaquizafop @ 0.75 kg a.i ha ⁻¹ (PoE)	6.39 (40.33)	4.98 (24.34)	5.25 (27.12)	5.47 (29.46)
T8-One hoeing at 30 DAS by wheel hoe	6.26 (38.67)	5.04 (24.97)	5.60 (30.92)	5.74 (32.51)
T9-Mulching with rice straw at 30 DAS	6.43 (40.96)	5.15 (26.06)	5.71 (32.12)	5.93 (34.76)
T10-Mulching with black plastic mulch before sowing	1.90 (3.14)	1.70 (2.46)	1.60 (2.12)	1.40 (1.55)
T11-Weed free check	0.71 (0.0)	0.71 (0.0)	0.71 (0.0)	0.71 (0.0)
T12-Weedy check	6.46 (41.33)	7.12 (50.24)	7.34 (53.48)	7.53 (56.30)
SEm ±	0.17	0.15	0.14	0.15
CD (p = 0.05)	0.49	0.44	0.42	0.45
CV%	5.9	5.9	5.4	5.6

“Fig 3. Density of grasses (m⁻²) as influenced by different weed management practices”



4.1.1.3 Broad-leaved weeds (number m⁻²)

The population of BLW differed remarkably because of various weed control practices at diverse phases of crop development and are shown in the table 7

At 30 DAS, lowest count of BLW was documented under T₁₁ (0.71 m⁻²) that is better to all other treatments. Amid various treatments, minimum broad leaved weeds density (1.90 m⁻²) was recorded under T₁₀ followed by T₁, T₂, T₃, T₄ and T₅ because of preemergence application of pendimethalin and oxyflorefen have shown substantial decrease in both grasses and broad leaved weeds and remaining treatments have not shown any significant reduction in broad leaved weeds population. However, weedy check reported the maximum sedge population (7.42 m⁻²). Parallel findings were documented earlier by Chinnusamy *et al.* (2006).

At 60 DAS also lowest count of BLW was noted under T₁₁ (0.71 m⁻²) that is better to all other treatments. Amid various treatments, minimum broad leaved weeds density (1.62 m⁻²) was documented under T₁₀ tailed by T₂, T₄, and T₅ which shown significant reduction in broad leaved weeds population. However, weedy check reported the maximum broad leaved weeds population (8.20 m⁻²)

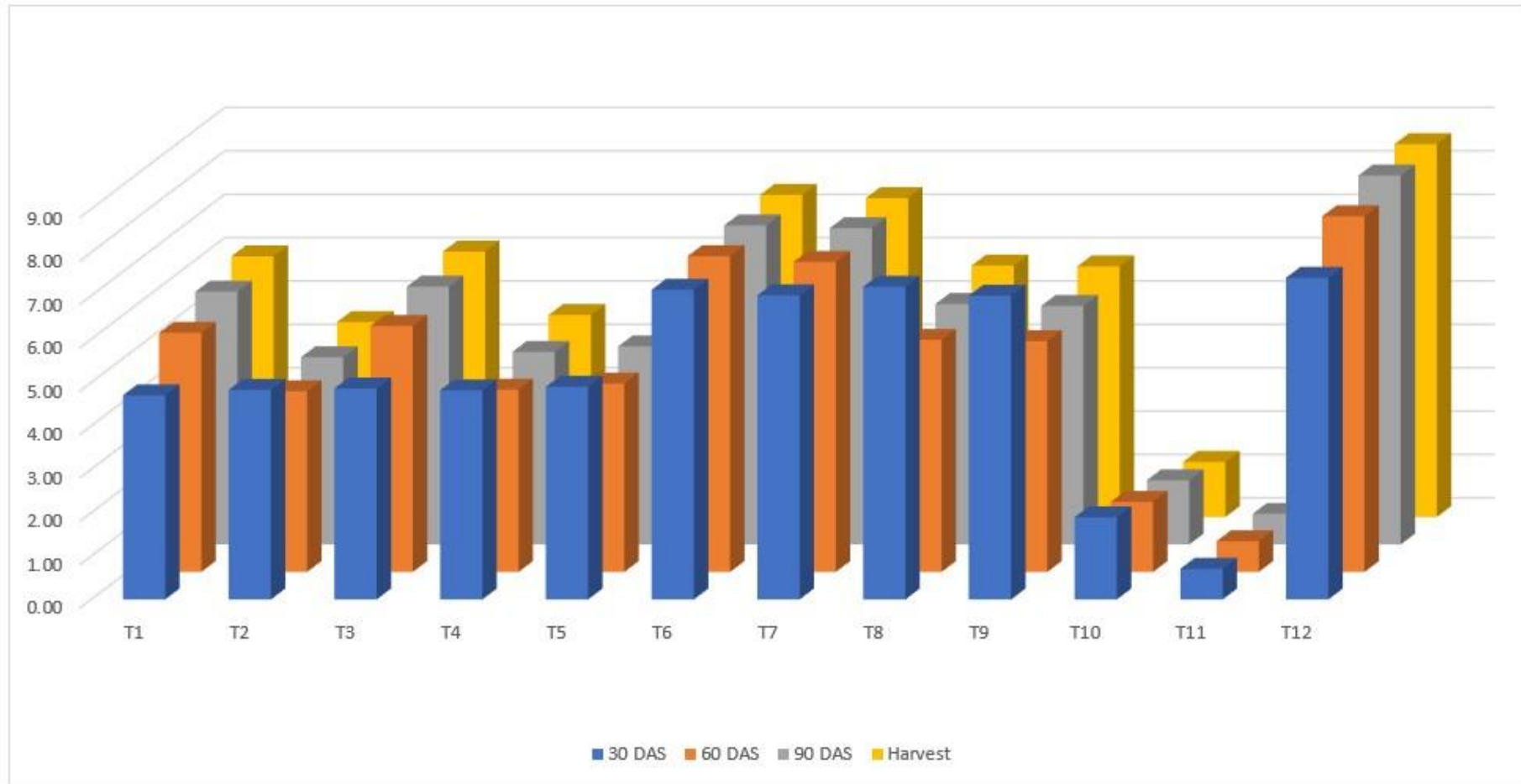
At 90 DAS also lowest count of broad leaved weeds was documented under T₁₁ (0.71 m⁻²) that is better to all other treatments. Amid various treatments, minimum broad leaved weeds density (1.48 m⁻²) was documented under T₁₀ tailed by T₂, T₄, and T₅ which shown significant reduction in broad leaved weeds population. However, weedy check reported the maximum broad leaved weeds population (8.51 m⁻²)

At harvest also lowest number of broad leaved weeds was documented under T₁₁ (0.71 m⁻²) that is better to all other treatments. Amid various treatments, minimum broad leaved weeds density (1.27 m⁻²) was documented under T₁₀ tailed by T₂, T₄, and T₅ which shown significant reduction in broad leaved weeds population because of association of PE and PoE herbicides and hoeing. Nevertheless, weedy check reported the maximum BLW population (8.60 m⁻²)

Table 9. Density of Broad leaved weeds (m^{-2}) as influenced by different weed management practices

Treatments	30 DAS	60 DAS	90 DAS	At Harvest
T1-Pendimethalin @ 0.75 kg a.i ha ⁻¹ (PE)	4.71 (21.76)	5.51 (29.96)	5.83 (33.52)	6.01 (35.67)
T2-Pendimethalin @ 0.75 kg a.i ha ⁻¹ (PE) + Quizalofop-p-ethyl @ 40 g a.i ha ⁻¹ (PoE).	4.83 (22.95)	4.17 (16.94)	4.32 (18.21)	4.50 (19.79)
T3-Oxyflurofen @ 100 g a.i ha ⁻¹ (PE)	4.86 (23.23)	5.67 (31.72)	5.94 (34.86)	6.12 (36.97)
T4-Pendimethalin @ 0.75 kg a.i ha ⁻¹ (PE) + 1 hand hoeing at 30 DAS	4.82 (22.76)	4.20 (17.21)	4.44 (19.24)	4.66 (21.26)
T5-Oxyflurofen @ 100 g a.i ha ⁻¹ (PE) + 1 hand hoeing at 30 DAS	4.90 (23.56)	4.34 (18.41)	4.57 (20.38)	4.75 (22.14)
T6- Quizalofop-p-ethyl @ 40 g a.i ha ⁻¹ (PoE).	7.14 (50.48)	7.28 (52.50)	7.35 (53.57)	7.43 (54.65)
T7-Propaquizafop @ 0.75 kg a.i ha ⁻¹ (PoE)	7.01 (48.67)	7.15 (50.60)	7.29 (52.67)	7.35 (53.56)
T8-One hoeing at 30 DAS by wheel hoe	7.21 (51.46)	5.35 (28.17)	5.54 (30.26)	5.80 (33.14)
T9-Mulching with rice straw at 30 DAS	7.00 (48.56)	5.32 (27.86)	5.50 (29.76)	5.78 (32.94)
T10-Mulching with black plastic mulch before sowing	1.90 (3.14)	1.62 (2.18)	1.48 (1.78)	1.27 (1.22)
T11-Weed free check	0.71 (0.0)	0.71 (0.0)	0.71 (0.0)	0.71 (0.0)
T12-Weedy check	7.42 (54.61)	8.20 (66.84)	8.51 (71.96)	8.60 (73.56)
SEm ±	0.18	0.16	0.16	0.18
CD (p = 0.05)	0.52	0.48	0.46	0.53
CV%	5.8	5.7	5.3	5.9

“Fig 4. Density of Broad leaved weeds (m⁻²) as influenced by different weed management practices”



4.1.1.4 Total density of weeds (number m⁻²)

The population of total count of weeds varied remarkably because of diverse weed control practices at divergent phases of crop growth and are shown in the table 8

At 30 DAS, lower total count of weeds was documented under T₁₁ (0.71 m⁻²) that is better to all other treatments. Amid various treatments, minimum total sum of weeds (2.70 m⁻²) was noted under T₁₀ because mulching sheet act as a barrier for weeds to germinate followed by T₁, T₂, T₃, T₄ and T₅ and remaining treatments have not shown any significant reduction in total weeds count. However, weedy check reported the maximum total count of weeds population (10.43 m⁻²)

At 60 DAS also minimum count of total weeds was documented under T₁₁ (0.71 m⁻²) that is better to all other treatments. Amid various treatments, minimum total weeds density (2.32 m⁻²) was recorded under T₁₀ followed by T₄, T₅, and T₂ which shown significant reduction in total weeds count. However, weedy check reported the maximum total number of weeds population (11.68 m⁻²)

At 90 DAS also minimum count of total weeds was documented under T₁₁ (0.71 m⁻²) that is better to all other treatments. Amid various treatments, minimum total weeds density (2.14 m⁻²) was documented under T₁₀ tailed by T₄, T₅, and T₂ which shown significant reduction in total weeds count. However, weedy check reported the maximum total number of weeds population (12.18 m⁻²)

At harvest also lower number of total weeds was documented under T₁₁ (0.71 m⁻²) that is better to all other treatments. Amid various treatments, minimum total weeds density (1.84 m⁻²) was documented T₁₀ tailed by T₄, T₅, and T₂ which shown significant reduction in total weeds count. However, weedy check reported the maximum total number of weeds population (12.47 m⁻²)

4.1.2 Weed dry weight (g/m²)

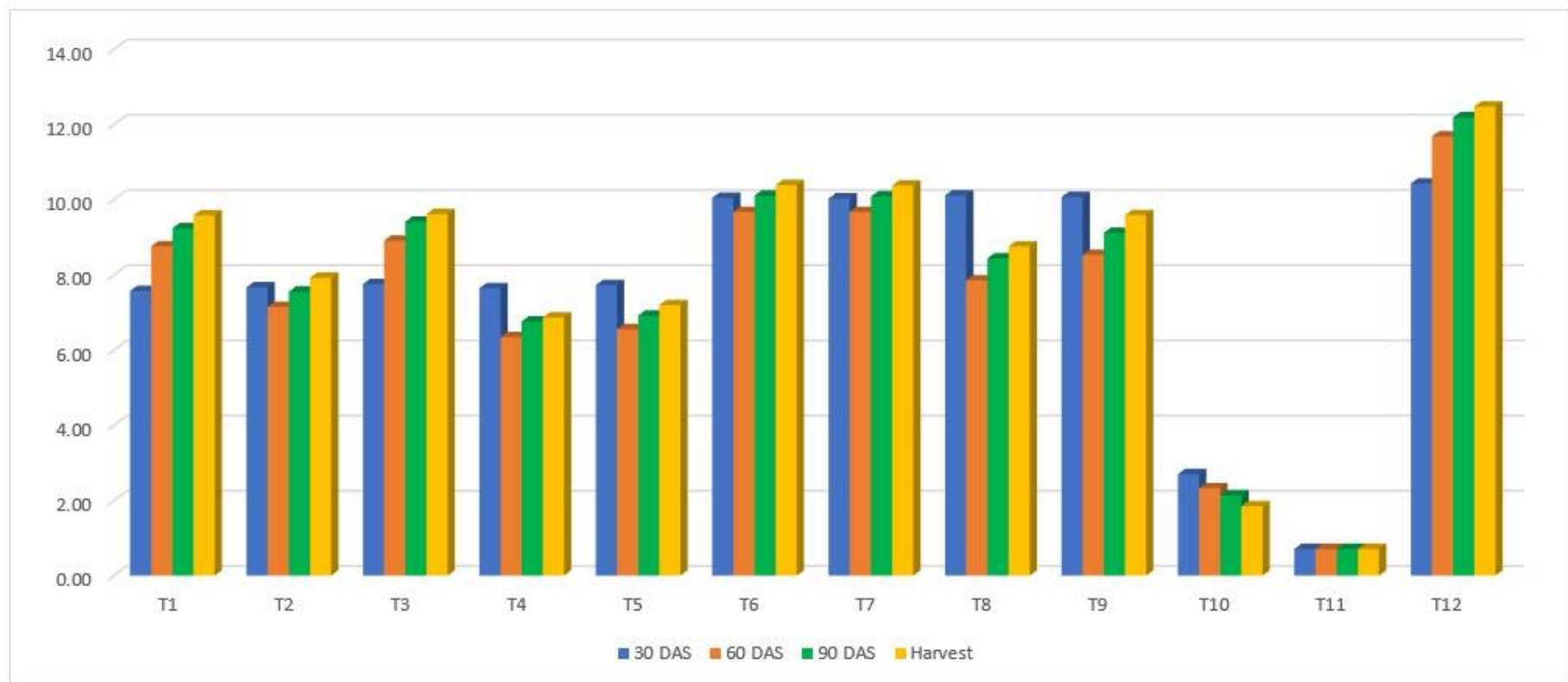
Weed dry weight documented at 30, 60 and 90 DAS and at harvest has been evaluated and summarized in Table 9 and characterized in Fig. 5

By looking at statistics it can be concluded that at various growth phases weedy check documented maximum weed dry matter and T₁₁ recorded lowest weed dry matter due to better weed control.

Table 10. Total density of weeds (m⁻²) as influenced by different weed management practices

Treatments	30 DAS	60 DAS	90 DAS	At Harvest
T1-Pendimethalin @ 0.75 kg a.i ha ⁻¹ (PE)	7.57 (57.24)	8.74 (76.30)	9.23 (84.94)	9.57 (91.37)
T2-Pendimethalin @ 0.75 kg a.i ha ⁻¹ (PE) + Quizalofop-p-ethyl @ 40 g a.i ha ⁻¹ (PoE).	7.67 (58.38)	7.15 (50.68)	7.55 (56.55)	7.93 (62.36)
T3-Oxyflurofen @ 100 g a.i ha ⁻¹ (PE)	7.75 (59.56)	8.91 (78.82)	9.41 (88.06)	9.73 (94.29)
T4-Pendimethalin @ 0.75 kg a.i ha ⁻¹ (PE) + 1 hand hoeing at 30 DAS	7.64 (57.90)	6.35 (39.79)	6.76 (45.28)	7.11 (50.07)
T5-Oxyflurofen @ 100 g a.i ha ⁻¹ (PE) + 1 hand hoeing at 30 DAS	7.72 (59.17)	6.55 (42.44)	6.92 (47.46)	7.19 (51.34)
T6- Quizalofop-p-ethyl @ 40 g a.i ha ⁻¹ (PoE).	10.04 (100.47)	9.67 (93.07)	10.11 (101.83)	10.39 (107.67)
T7-Propaquizafop @ 0.75 kg a.i ha ⁻¹ (PoE)	10.03 (100.15)	9.67 (93.08)	10.08 (101.37)	10.37 (107.33)
T8-One hoeing at 30 DAS by wheel hoe	10.11 (101.81)	7.85 (61.33)	8.46 (71.07)	8.75 (76.20)
T9-Mulching with rice straw at 30 DAS	10.07 (100.90)	8.54 (72.39)	9.12 (82.66)	9.60 (91.77)
T10-Mulching with black plastic mulch before sowing	2.70 (6.88)	2.32 (5.04)	2.14 (4.25)	1.84 (3.10)
T11-Weed free check	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)
T12-Weedy check	10.43 (108.44)	11.68 (136.08)	12.18 (148.24)	12.46 (155.22)
SEm ±	0.23	0.22	0.26	0.26
CD (p = 0.05)	0.69	0.66	0.76	0.77
CV%	5.2	5.3	5.8	5.7

“Fig 5. Total density of weeds (m⁻²) as influenced by different weed management practices”



At 30 DAS, T₁₁ documented minimum dry matter (0.7 g m⁻²) that is better to all other treatments. Amid other treatments T₁₀ (1.2 g m⁻²) recorded lowest weed dry matter which is followed by T₁, T₂, T₃, T₄ and T₅. These treatments are better when related to other treatments. This is because of regulator of weeds effectively at earlier stages by PE application of herbicides and hand weeding in weed free check. T₁₂ documented higher weed dry weight because of greater weed population and un-controlled weed growth (5.0 g m⁻²). These conclusions are parallel to conclusions of Goud *et al.*,(2013) and Buttar *et al.*,(2008)

At 60 DAS also T₁₁ documented lowest dry matter (0.7 g m⁻²) that is better to all other treatments. Amid other treatments T₁₀ (1.2 g m⁻²) recorded lowest weed dry matter which is followed by T₂, T₄ and T₅. These treatments are better when compared to other treatments. T₁₂ documented higher weed dry weight because of greater weed population and un-controlled weed growth (6.0 g m⁻²).

At 90 DAS also T₁₁ documented lowest dry matter (0.7 g m⁻²) that is better to all other treatments. Amid other treatments T₁₀ (1.3 g m⁻²) recorded lowest weed dry matter which is followed by T₂, T₄ and T₅. These treatments are better when compared to other treatments. T₁₂ documented higher weed dry weight because of greater weed population and un-controlled weed growth (6.18 g m⁻²).

At harvest also T₁₁ documented lowest dry matter (0.7 g m⁻²) that is better to all other treatments. Amid other treatments T₁₀ (1.08 g m⁻²) recorded lowest weed dry matter which is followed by T₂, T₄ and T₅. These treatments are better when compared to other treatments. T₁₂ documented higher weed dry weight because of maximum weed population and un-controlled weed growth (6.40 g m⁻²). Higher weed dry weight in weedy check was also conveyed by Choudhary *et al.*,(2005) and Patel *et al.*, (2008). T₂ treatment has recorded greater density of weeds and minimum dry weight than T₄ and T₅ treatments due to size of weeds observed in the treatment plots.

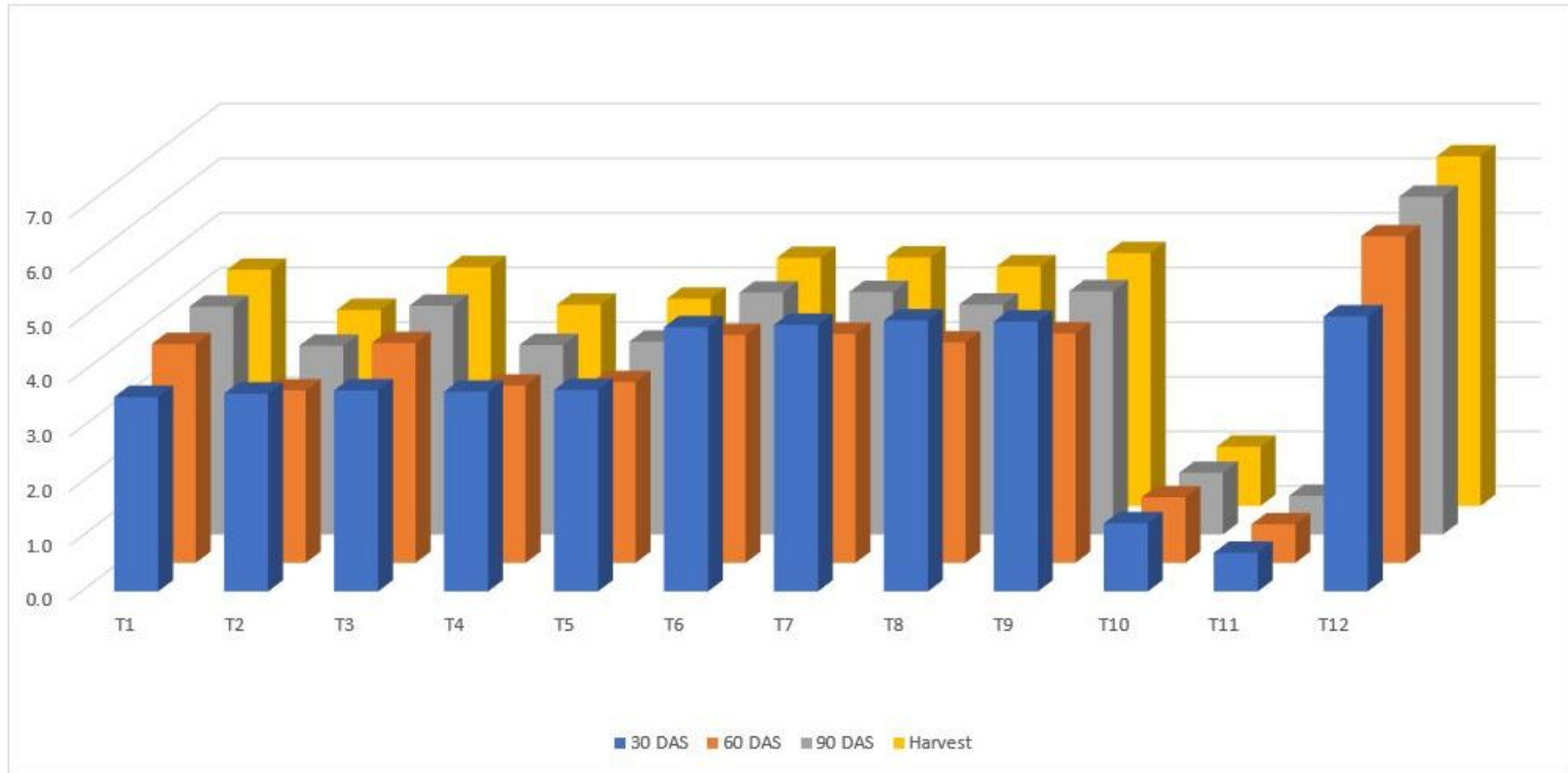
4.1.3 Weed control efficiency(WCE) (%)

WCE indicates the efficacy of applied herbicides or treatments effect in minimizing the dry matter of weeds. It was calculated by employing the weed dry matter

Table 11. Total dry weight of weeds (g/m²) as influenced by different weed management practices

Treatments	30 DAS	60 DAS	90 DAS	At Harvest
T1-Pendimethalin @ 0.75 kg a.i ha ⁻¹ (PE)	3.6 (12.23)	4.0 (15.61)	4.17 (16.96)	4.32 (18.22)
T2-Pendimethalin @ 0.75 kg a.i ha ⁻¹ (PE) + Quizalofop-p-ethyl @ 40 g a.i ha ⁻¹ (PoE).	3.6 (12.63)	3.2 (9.54)	3.45 (11.56)	3.59 (12.44)
T3-Oxyflurofen @ 100 g a.i ha ⁻¹ (PE)	3.7 (13.06)	4.0 (15.74)	4.19 (17.12)	4.37 (18.64)
T4-Pendimethalin @ 0.75 kg a.i ha ⁻¹ (PE) + 1 hand hoeing at 30 DAS	3.7 (12.87)	3.2 (10.09)	3.47 (11.64)	3.68 (13.12)
T5-Oxyflurofen @ 100 g a.i ha ⁻¹ (PE) + 1 hand hoeing at 30 DAS	3.7 (13.12)	3.3 (10.47)	3.53 (12.01)	3.79 (13.94)
T6- Quizalofop-p-ethyl @ 40 g a.i ha ⁻¹ (PoE).	4.8 (22.93)	4.2 (16.92)	4.43 (19.10)	4.54 (20.12)
T7-Propaquizafop @ 0.75 kg a.i ha ⁻¹ (PoE)	4.9 (23.32)	4.2 (17.10)	4.44 (19.21)	4.55 (20.21)
T8-One hoeing at 30 DAS by wheel hoe	5.0 (24.12)	4.0 (15.81)	4.21 (17.22)	4.39 (18.76)
T9-Mulching with rice straw at 30 DAS	4.9 (23.93)	4.2 (17.15)	4.45 (19.32)	4.63 (20.94)
T10-Mulching with black plastic mulch before sowing	1.2 (1.17)	1.2 (0.96)	1.13 (0.79)	1.08 (0.69)
T11-Weed free check	0.7 (0.0)	0.7 (0.00)	0.71 (0.00)	0.71 (0.00)
T12-Weedy check	5.0 (24.87)	6.0 (35.27)	6.18 (37.72)	6.40 (40.48)
SEm ±	0.11	0.12	0.16	0.12
CD (p = 0.05)	0.34	0.36	0.48	0.35
CV%	5.3	6.0	7.7	5.3

“Fig 6. Total dry weight of weeds (g/m²) as influenced by different weed management practices”



at 30, 60, 90 DAS, and at harvest. There was a noteworthy variance in weed control efficiency because of several weed management treatments.

At 30 DAS, WCE was higher under T₁₁ treatment (100%) that is better to all other treatments. In case of other treatments T₁₀ (33.78 %) recorded maximum weed control which is followed by T₁, T₂, T₄, T₃ and T₅. At 30 DAS all the post-emergence treatments documented lowest weed control. Lowest WCE was detected in weedy check (100%).

At 60 DAS, WCE was maximum under T₁₁ treatment (100%) that is better to all other treatments. In case of other treatments T₁₀ (97.37 %) recorded maximum weed control which is followed by T₂, T₄, and T₅. These treatments reported better WCE compared to remaining treatments at 60 DAS. Lowest WCE was detected in weedy check (100%).

At 90 DAS, WCE was maximum under T₁₁ treatment (100%) that is better to all other treatments. In case of other treatments T₁₀ (97.99 %) recorded maximum weed control which is followed by T₂, T₄, and T₅. These treatments reported better WCE compared to remaining treatments at 90 DAS. Lowest WCE was observed in weedy check (100%).

At harvest, there was a noteworthy difference in WCE amid various treatments. WCE was maximum under T₁₁ treatment (100%) that is better to all other treatments. In case of other treatments T₁₀ (98.34 %) recorded maximum weed control which is followed by T₂, T₄, and T₅. These treatments reported better WCE compared to remaining treatments at at harvest. Lowest WCE was detected in weedy check (100%).

The higher WCE in the above treatments could be because of control of weeds effectively by hand weeding, application of PE and POE herbicides followed by hoeing. These findings were parallel to conclusions of Singh *et al.* (2008) and Goud *et al.* (2013).

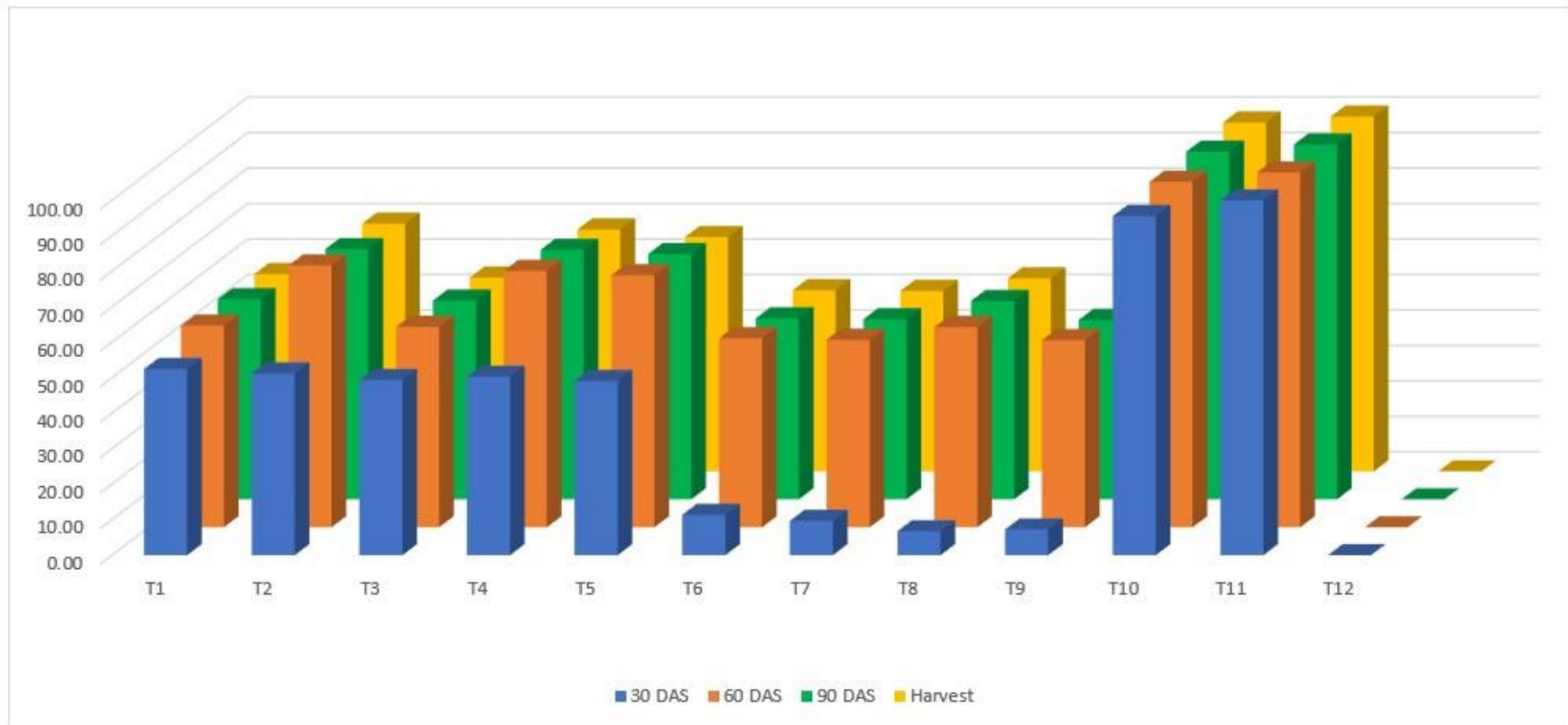
4.1.4 Weed index (%)

By looking into statistics it was revealed that amid herbicidal treatments, minimum weed index (0.00 %) was documented with T₁₁ followed by T₁₀ (3.31%), T₂ (14.18 %). These treatments are better than other treatments due to effective weed management and improved crop growth.. The higher weed index was documented from the weedy check (57.63%) because of zero weed control measures. These verdicts are parallel to conclusions of venkatesha *et al.* (2008), Ram *et al.* (2011), Kumar *et al.*(2015).

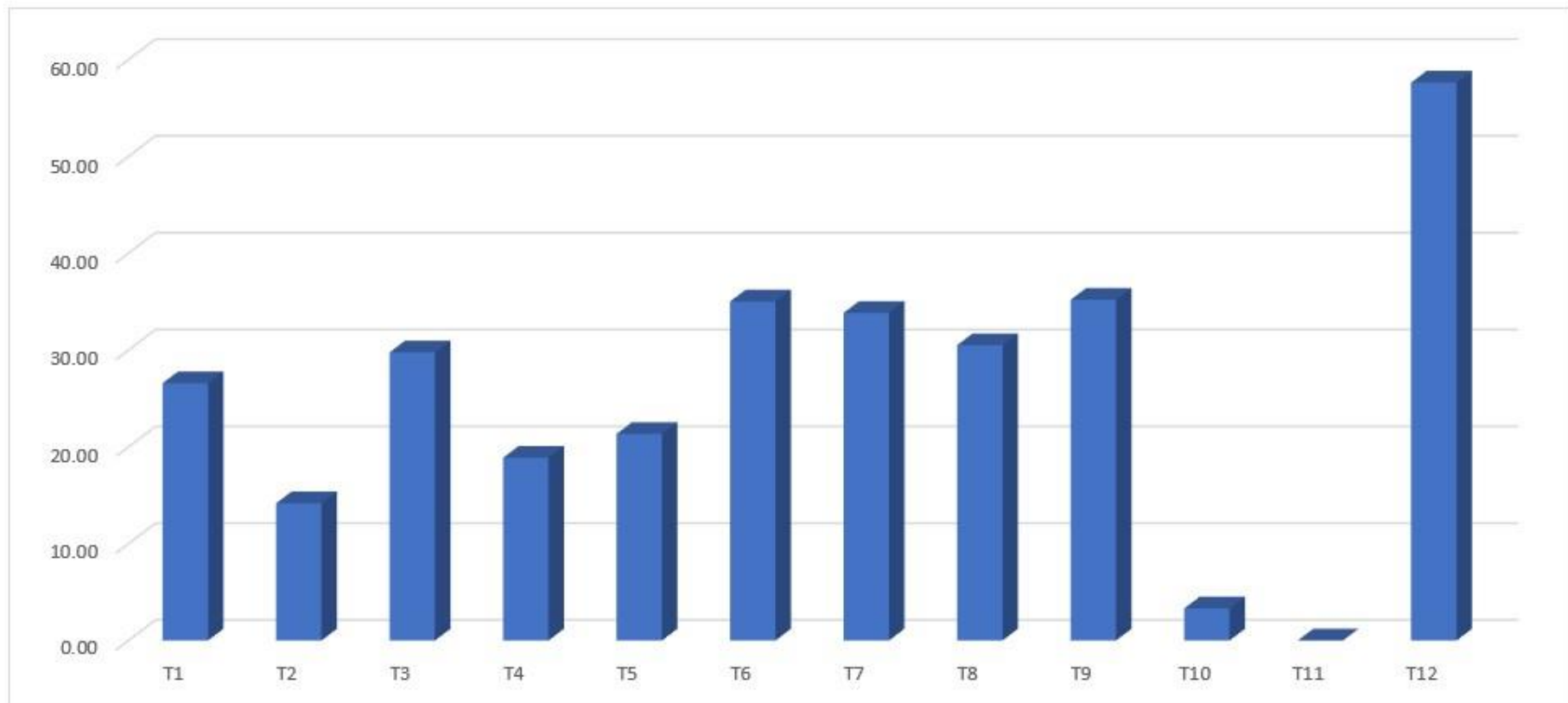
Table 12. Weed Control Efficiency(WCF) and Weed Index(%) as influenced by different weed management practices

Treatments	Weed Control Efficiency				Weed index(%)
	30 DAS	60 DAS	90 DAS	At Harvest	
T1-Pendimethalin @ 0.75 kg a.i ha ⁻¹ (PE)	52.48	56.84	56.42	55.63	26.58
T2-Pendimethalin @ 0.75 kg a.i ha ⁻¹ (PE) + Quizalofop-p-ethyl @ 40 g a.i ha ⁻¹ (PoE).	51.23	73.79	70.52	69.84	14.18
T3-Oxyflurofen @ 100 g a.i ha ⁻¹ (PE)	49.37	56.48	56.01	54.61	29.76
T4-Pendimethalin @ 0.75 kg a.i ha ⁻¹ (PE) + 1 hand hoeing at 30 DAS	50.30	72.27	70.31	68.18	18.88
T5-Oxyflurofen @ 100 g a.i ha ⁻¹ (PE) + 1 hand hoeing at 30 DAS	49.13	71.07	69.14	66.03	21.34
T6- Quizalofop-p-ethyl @ 40 g a.i ha ⁻¹ (PoE).	11.38	53.28	51.02	51.05	35.02
T7-Propaquizafop @ 0.75 kg a.i ha ⁻¹ (PoE)	9.67	52.86	50.76	50.85	33.85
T8-One hoeing at 30 DAS by wheel hoe	6.77	56.44	55.90	54.41	30.50
T9-Mulching with rice straw at 30 DAS	7.26	52.72	50.55	49.13	35.19
T10-Mulching with black plastic mulch before sowing	95.57	97.37	97.99	98.34	3.31
T11-Weed free check	100.00	100.00	100.00	100.00	0.00
T12-Weedy check	0.00	0.00	0.00	0.00	57.63
SEm ±	2.94	2.41	3.18	2.24	2.56
CD (p = 0.05)	8.66	7.10	9.38	6.62	7.54
CV%	12.6	6.7	9.1	6.5	17.3

“Fig 7. Weed Control Efficiency(WCF) as influenced by different weed management practices”



“Fig 8. Weed Index(%) as influenced by different weed management practices”



Pre-harvest observations on crop

4.2 Growth parameters

4.2.1 Initial and Final Plant population

Initially after germination and just before harvest, crop stand counts were taken for comparison of any toxic effects of herbicides on crop stand establishment.

In the table, data on the initial and final population of plants indicated that no significant differences were observed with different herbicide treatments under investigation, which showed that the herbicides with recommended doses in this study were safe for chickpea crops.

4.2.2 Plant height (cm)

The average values of plant height obtained during the crop period were shown in Table 12 and represented in Fig 9

Statistics on plant height was taken at various crop development phases i.e. 30, 60, 90 DAS, and at harvest revealed that plant height was notably influenced by several weed control treatments.

At 30 DAS, plant height is observed to be non -significant for weed control treatments. Nevertheless, T₁₀ documented maximum plant height (16.9 cm) which was on equivalence with T₁₁ (16.5 cm) followed by other weed control treatments. T₁₂ recorded lowest plant height (13.4).

Analysing data obtained at 60 DAS indicated that various treatments does have noteworthy influence on plant height. Greater plant height (27.5 cm) was noted under T₁₀ which was on equivalence with T₁₁ (16.5 cm) followed by T₂, T₄ and T₅ which are observed to be better than other treatments. The least plant height was documented from the T₁₂ (19.7 cm).

Analysing data obtained at 90 DAS showed that various treatments does have noteworthy influence on plant height. Greater plant height (41.0 cm) was documented under T₁₁ which was on equivalence with T₁₀ (40.4) followed by T₂, T₄ and T₅ which are observed to be better than other treatments. The least plant height was documented from the T₁₂ (19.7 cm).

Table 13. Plant population of Chickpea as influenced by different weed management practices

Treatments	20 DAS	At Harvest
T1-Pendimethalin @ 0.75 kg a.i ha ⁻¹ (PE)	32.3	32.0
T2-Pendimethalin @ 0.75 kg a.i ha ⁻¹ (PE) + Quizalofop-p-ethyl @ 40 g a.i ha ⁻¹ (PoE).	32.0	31.7
T3-Oxyflurofen @ 100 g a.i ha ⁻¹ (PE)	32.0	32.0
T4-Pendimethalin @ 0.75 kg a.i ha ⁻¹ (PE) + 1 hand hoeing at 30 DAS	32.0	32.0
T5-Oxyflurofen @ 100 g a.i ha ⁻¹ (PE) + 1 hand hoeing at 30 DAS	32.0	31.7
T6- Quizalofop-p-ethyl @ 40 g a.i ha ⁻¹ (PoE).	32.3	32.0
T7-Propaquizafop @ 0.75 kg a.i ha ⁻¹ (PoE)	32.0	32.0
T8-One hoeing at 30 DAS by wheel hoe	32.0	32.0
T9-Mulching with rice straw at 30 DAS	32.7	32.7
T10-Mulching with black plastic mulch before sowing	33.0	33.0
T11-Weed free check	33.0	33.0
T12-Weedy check	32.0	31.3
SEm ±	0.49	0.56
CD (p = 0.05)	NS	NS
CV%	2.6	3.0

“Fig 9. Plant population of Chickpea as influenced by different weed management practices”

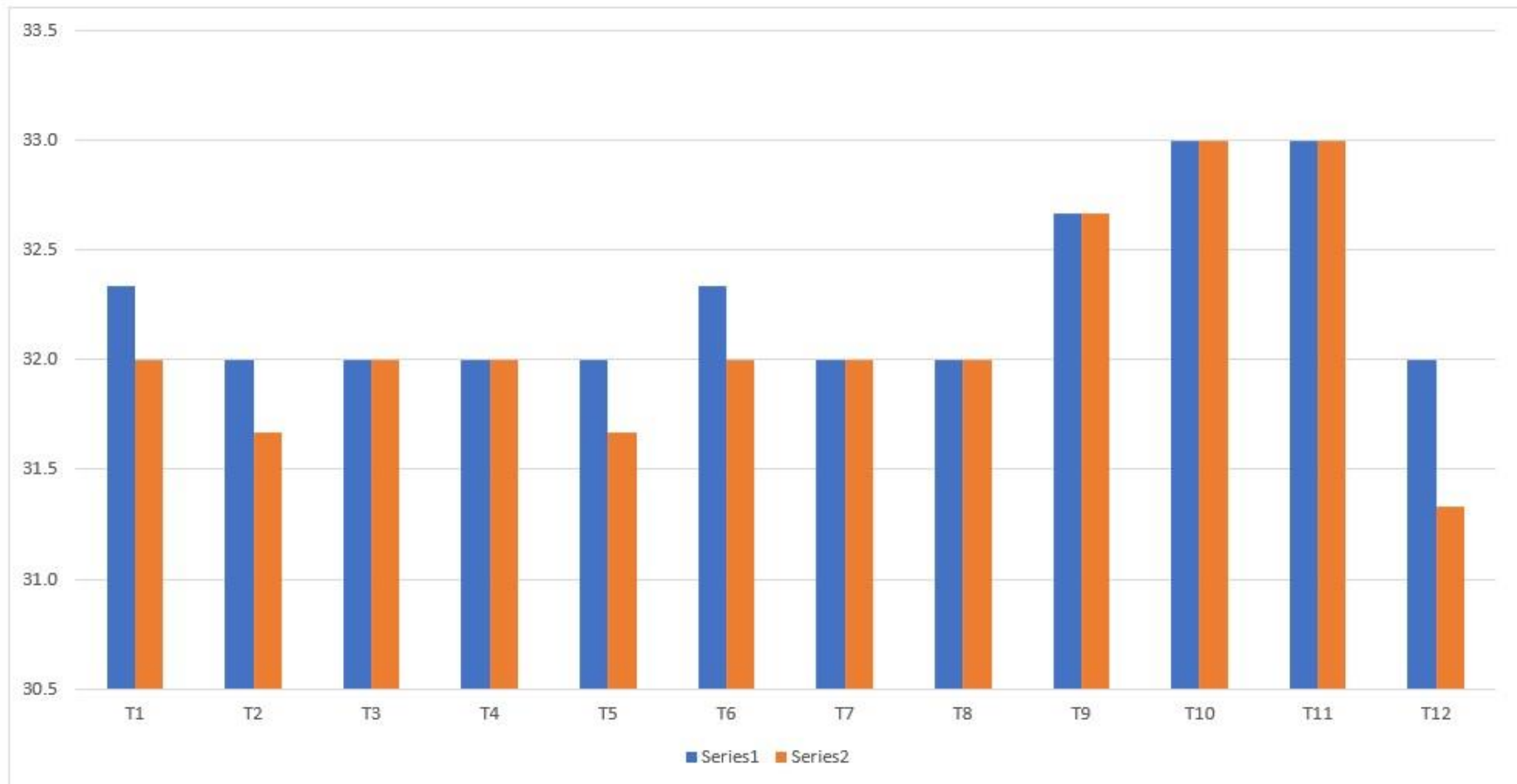
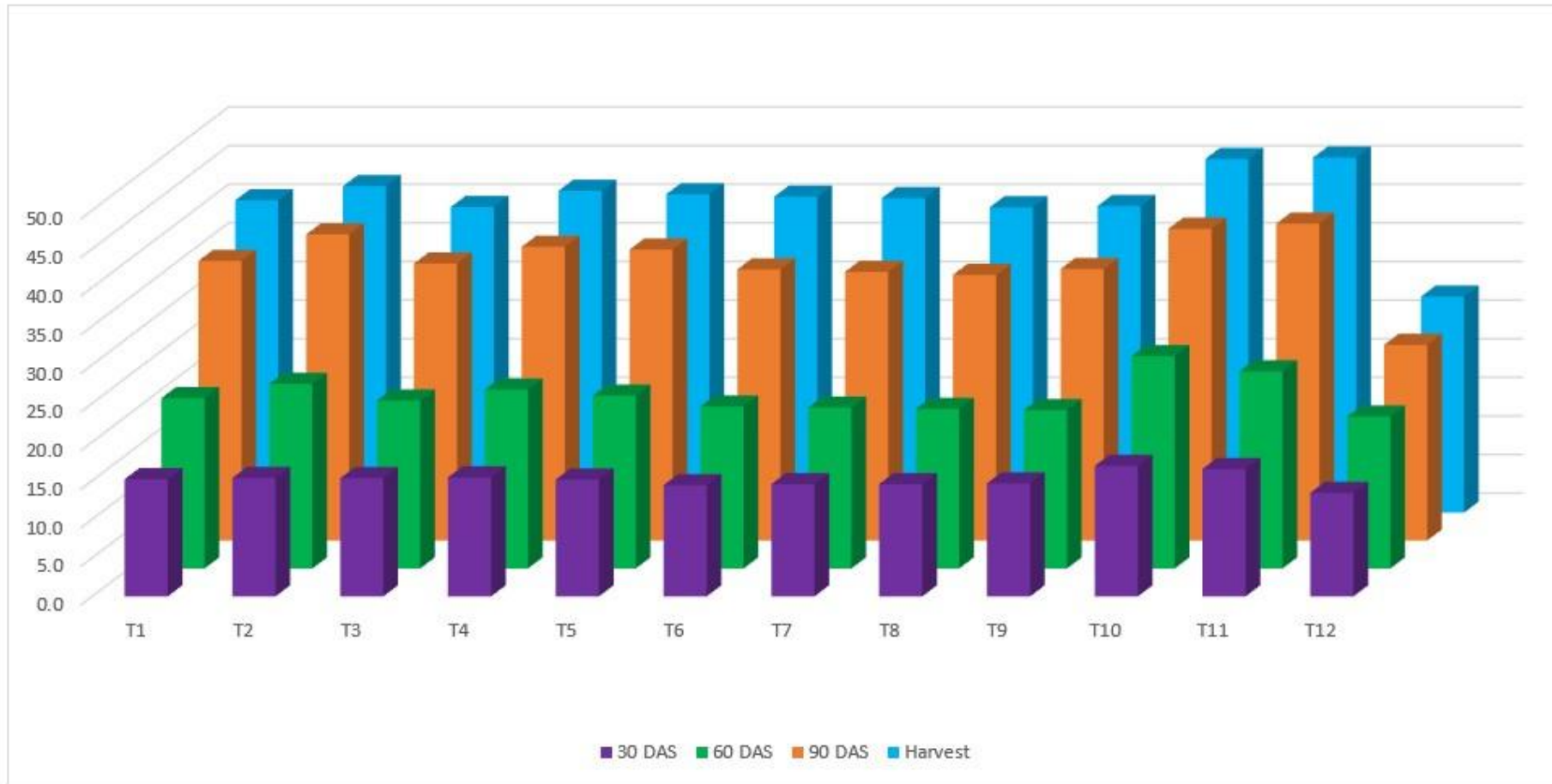


Table 14. Plant height (cm) of Chickpea as influenced by different weed management practices

Treatments	30 DAS	60 DAS	90 DAS	At Harvest
T1-Pendimethalin @ 0.75 kg a.i ha ⁻¹ (PE)	15.2	22.1	36.2	40.4
T2-Pendimethalin @ 0.75 kg a.i ha ⁻¹ (PE) + Quizalofop-p-ethyl @ 40 g a.i ha ⁻¹ (PoE).	15.3	23.9	39.6	42.3
T3-Oxyflurofen @ 100 g a.i ha ⁻¹ (PE)	15.3	21.7	35.9	39.6
T4-Pendimethalin @ 0.75 kg a.i ha ⁻¹ (PE) + 1 hand hoeing at 30 DAS	15.4	23.2	38.0	41.7
T5-Oxyflurofen @ 100 g a.i ha ⁻¹ (PE) + 1 hand hoeing at 30 DAS	15.1	22.4	37.7	41.2
T6- Quizalofop-p-ethyl @ 40 g a.i ha ⁻¹ (PoE).	14.4	21.0	35.1	40.9
T7-Propaquizafop @ 0.75 kg a.i ha ⁻¹ (PoE)	14.5	20.8	34.8	40.7
T8-One hoeing at 30 DAS by wheel hoe	14.5	20.7	34.4	39.5
T9-Mulching with rice straw at 30 DAS	14.6	20.5	35.2	39.7
T10-Mulching with black plastic mulch before sowing	16.9	27.5	40.4	45.8
T11-Weed free check	16.5	25.5	41.0	46.0
T12-Weedy check	13.4	19.7	25.3	28.0
SEm ±	0.77	0.90	1.62	1.47
CD (p = 0.05)	NS	2.66	4.78	4.33
CV%	8.9	7.0	7.8	6.3

“Fig 10. Plant height (cm) of Chickpea as influenced by different weed management practices”



Analysing data obtained at harvest indicated that various treatments does have noteworthy influence on plant height. Greater plant height (46.0 cm) was documented under T₁₁ which was on equivalence with T₁₀ (45.8) followed by T₂, T₄ and T₅ which are observed to be better to rest of the treatments. This could be due to improved availability of space, moisture and nutrients and well management of weeds at crucial phases of crop weed competition. The minimum plant height was documented from T₁₂ (19.7 cm) due to at various growth stages severe competition of weeds to crop for nutrients, moisture, space. These conclusions are parallel to conclusions of Goud *et al.*, (2013).

4.2.3 Plant dry weight (g/plant)

Statistics on plant dry weight as influenced by diverse weed control treatments is shown in Table 13 and represented in Fig. 10

Analysing data obtained at 30 DAS showed that various treatments does have noteworthy influence on plant dry matter accumulation (DMA). Maximum plant DMA (3.6 g/plant) was documented under T₁₁ and with T₁₀ (3.6 g/plant) and followed by T₁, T₂, T₃, T₄, T₅ and T₉ which are found to be better than other treatments. The least plant dry weight was documented from the T₁₂ (2.0 g/plant).

Analysing data obtained at 60 DAS indicated that various treatments does have significant influence on plant dry matter accumulation (DMA). Maximum plant DMA (11.3 g/plant) was documented under T₁₁ which is on equivalence with T₁₀ (11.0 g/plant) and followed by T₂, T₄, and T₅ which are found to be better than other treatments. The least plant dry weight was documented from the T₁₂ (5.0 g/plant).

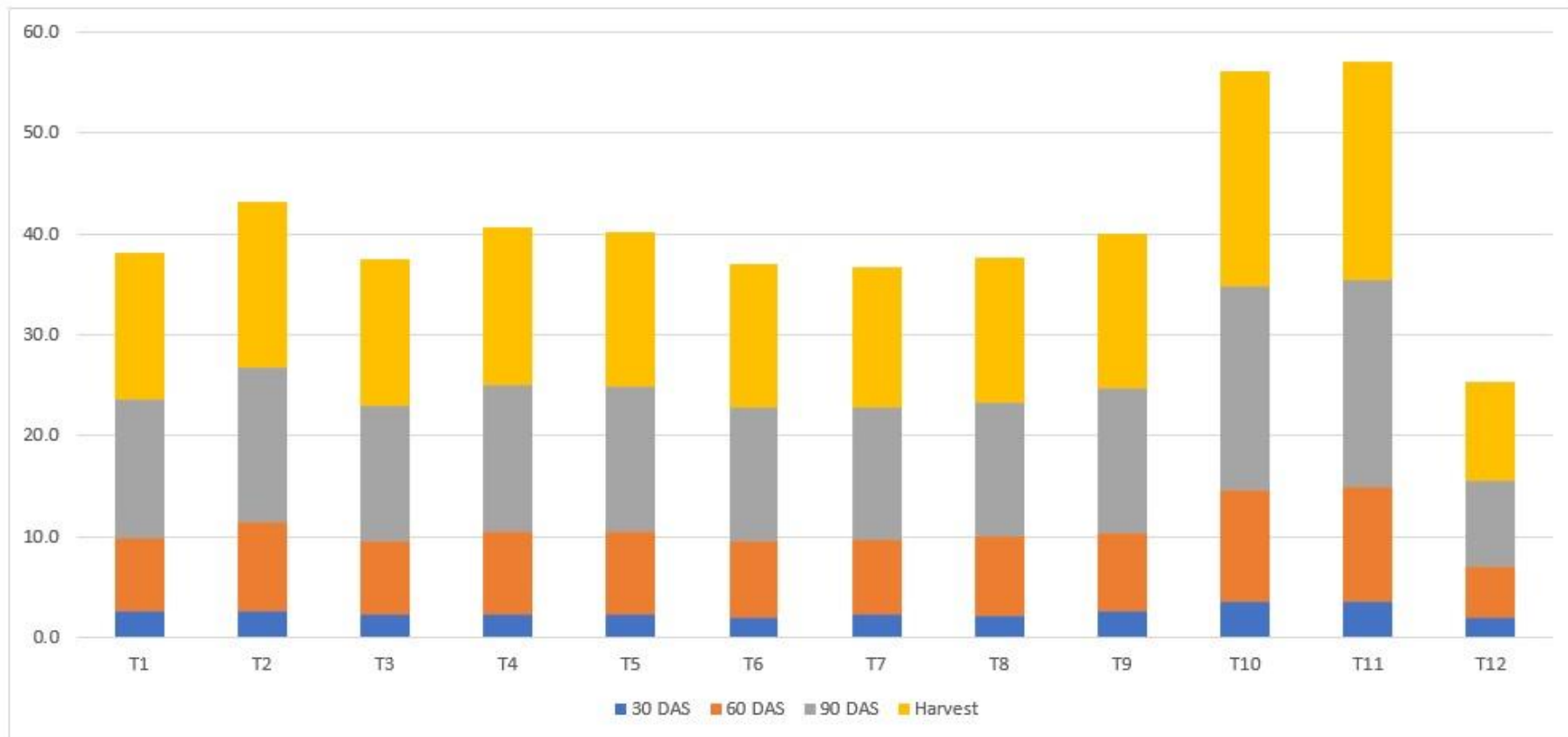
Analysing data obtained at 90 DAS specified that various treatments does have noteworthy influence on plant dry matter accumulation (DMA). Maximum plant DMA (20.5 g/plant) was documented under T₁₁ which is on equivalence with T₁₀ (20.2 g/plant) and followed by T₂, T₄, and T₅ which are found to be better than other treatments. The least plant dry weight was documented from the T₁₂ (7.2 g/plant).

Analysing data obtained at harvest indicated that various treatments does have significant influence on plant dry matter accumulation (DMA). Maximum plant DMA (21.7 g/plant) was documented under T₁₁ which is on equivalence with T₁₀ (21.3 g/plant) and followed by T₂,

Table 15. Dry Matter Accumulation (g/plant) of Chickpea as influenced by different weed management practices

Treatments	30 DAS	60 DAS	90 DAS	At Harvest
T1-Pendimethalin @ 0.75 kg a.i ha ⁻¹ (PE)	2.7	7.3	13.6	14.5
T2-Pendimethalin @ 0.75 kg a.i ha ⁻¹ (PE) + Quizalofop-p-ethyl @ 40 g a.i ha ⁻¹ (PoE).	2.7	8.8	15.4	16.5
T3-Oxyflurofen @ 100 g a.i ha ⁻¹ (PE)	2.4	7.2	13.4	14.5
T4-Pendimethalin @ 0.75 kg a.i ha ⁻¹ (PE) + 1 hand hoeing at 30 DAS	2.3	8.2	14.5	15.6
T5-Oxyflurofen @ 100 g a.i ha ⁻¹ (PE) + 1 hand hoeing at 30 DAS	2.4	8.1	14.4	15.4
T6- Quizalofop-p-ethyl @ 40 g a.i ha ⁻¹ (PoE).	2.0	7.6	13.2	14.2
T7-Propaquizafop @ 0.75 kg a.i ha ⁻¹ (PoE)	2.2	7.5	13.0	14.0
T8-One hoeing at 30 DAS by wheel hoe	2.2	7.8	13.4	14.4
T9-Mulching with rice straw at 30 DAS	2.6	7.8	14.3	15.3
T10-Mulching with black plastic mulch before sowing	3.6	11.0	20.2	21.3
T11-Weed free check	3.6	11.3	20.5	21.7
T12-Weedy check	2.0	5.0	8.5	9.9
SEm ±	0.16	0.30	0.52	0.49
CD (p = 0.05)	0.48	0.87	1.52	1.45
CV%	11.2	6.3	6.2	5.5

“Fig 11. Dry Matter Accumulation (g/plant) of Chickpea as influenced by different weed management practices”



T₄, and T₅ which are found to be better than other treatments. The least plant dry weight was documented from the T₁₂ (9.9 g/plant).

It was evident from the information, higher dry matter accumulation was documented under T₁₁ which is on equivalence with T₁₀ and followed by T₂, T₄, and T₅ which are observed to be superior to other treatments. This could be due to lack of weed competition, which created a pleasant environment for better crop growth and greater availability of moisture and nutrients, which was evident from Tables 4.16, 4.17, 4.18. Due to severe competition offered by weeds minimum dry matter accumulation of chickpea crop was observed in the weedy check at all phases of crop development.

4.2.4 Number of Branches per Plant

Table 14 data reveal that at 30 DAS, the consequence of weed control measures on the number of branches per plant has been observed to be non-significant.

Analysing data obtained at 60 DAS indicated that various treatments does have significant influence on number of branches per plant. Greater number of branches (17.2/plant) was documented under T₁₁ which is on equivalence with T₁₀ (16.8/plant) and followed by T₂, T₄, and T₅ which are found to be superior to other treatments. The least number of branches was documented from the T₁₂ (9.2/plant).

Analysing data obtained at 90 DAS showed that various treatments does have noteworthy influence on number of branches per plant. Greater number of branches (24.7/plant) was documented under T₁₁ which is on equivalence with T₁₀ (24.5/plant) and followed by T₂, T₄, and T₅ which are found to be better than other treatments. The least number of branches was documented from the T₁₂ (13.4/plant).

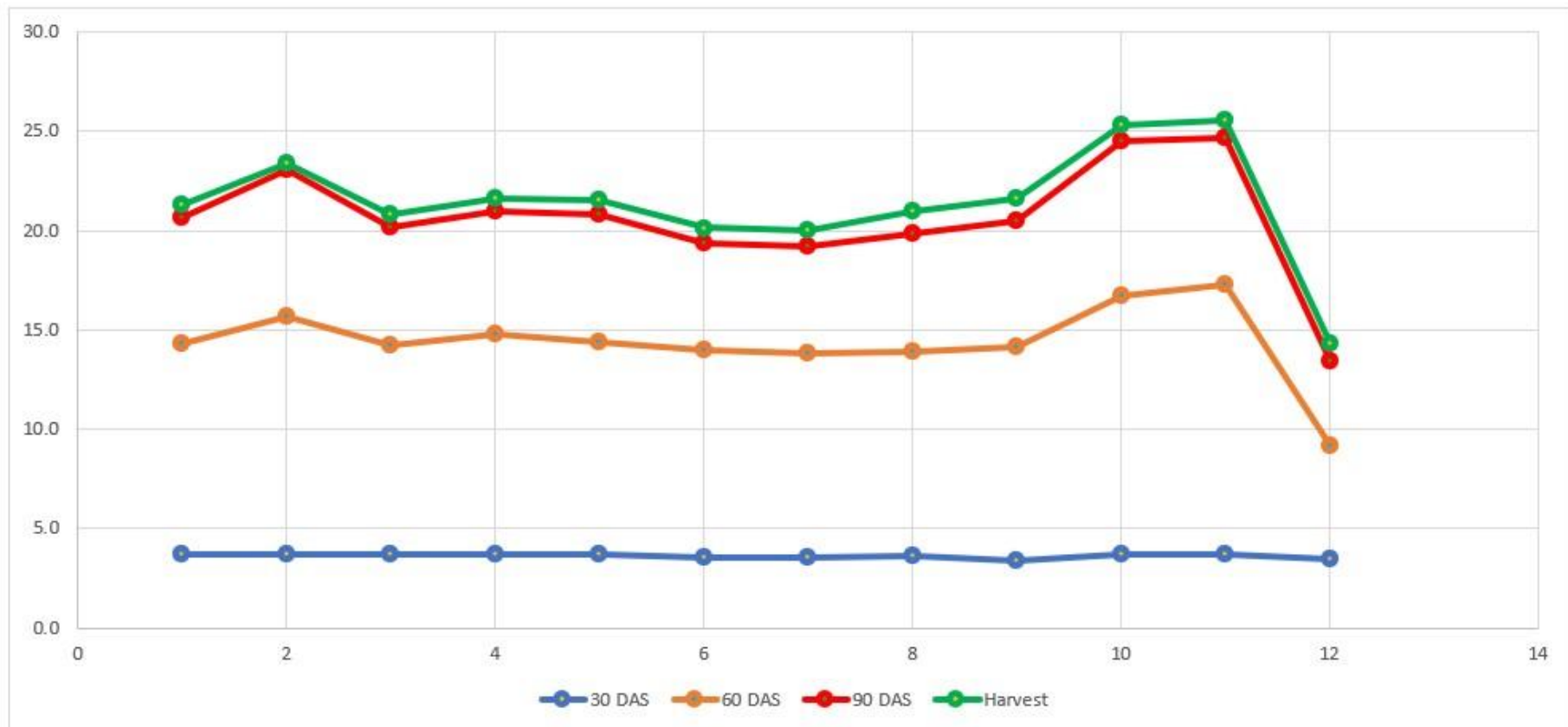
Analysing data obtained at harvest indicated that various treatments does have significant influence on number of branches per plant. Greater number of branches (25.6/plant) was documented under T₁₁ which is on equivalence with T₁₀ (25.3/plant) and followed by T₂, T₄, and T₅ which are found to be better than other treatments. The least number of branches was documented from the T₁₂ (14.3/plant).

Due to weed free situation for a extended time which instigated the decreased crop weed competition in early stages and elimination of early and lately developed weeds by hand weeding in weed free check, mulching with black plastic mulch before sowing and pre and post-emergence

Table 16. No. of branches/plant of Chickpea as influenced by different weed management practices

Treatments	30 DAS	60 DAS	90 DAS	At Harvest
T1-Pendimethalin @ 0.75 kg a.i ha ⁻¹ (PE)	3.7	14.3	20.7	21.3
T2-Pendimethalin @ 0.75 kg a.i ha ⁻¹ (PE) + Quizalofop-p-ethyl @ 40 g a.i ha ⁻¹ (PoE).	3.6	15.7	23.1	23.4
T3-Oxyflurofen @ 100 g a.i ha ⁻¹ (PE)	3.5	14.2	20.2	20.8
T4-Pendimethalin @ 0.75 kg a.i ha ⁻¹ (PE) + 1 hand hoeing at 30 DAS	3.7	14.8	21.0	21.6
T5-Oxyflurofen @ 100 g a.i ha ⁻¹ (PE) + 1 hand hoeing at 30 DAS	3.7	14.4	20.8	21.5
T6- Quizalofop-p-ethyl @ 40 g a.i ha ⁻¹ (PoE).	3.5	14.0	19.3	20.1
T7-Propaquizafop @ 0.75 kg a.i ha ⁻¹ (PoE)	3.6	13.8	19.2	20.0
T8-One hoeing at 30 DAS by wheel hoe	3.6	13.9	19.9	21.0
T9-Mulching with rice straw at 30 DAS	3.4	14.1	20.5	21.6
T10-Mulching with black plastic mulch before sowing	3.7	16.8	24.5	25.3
T11-Weed free check	3.6	17.2	24.7	25.6
T12-Weedy check	3.5	9.2	13.4	14.3
SEm ±	0.04	0.59	0.73	0.68
CD (p = 0.05)	0.12	1.74	2.13	2.00
CV%	1.9	7.2	6.1	5.5

“Fig 12. No. of branches/plant of Chickpea as influenced by different weed management practices”



herbicides application followed by hoeing resulted in more number of branches in T₁₁, T₁₀, T₂, T₄ and T₅ treatments.

4.2.5 Root dry weight (g/plant)

Statistics on dry weight of root as influenced by various weed control treatments is shown in Table 15 and represented in Fig. 12

Analysing data obtained at 30 DAS showed that various treatments does have noteworthy influence on dry weight of root. Maximum dry weight of root (0.43 g/plant) was documented under T₁₁ and with T₁₀ (0.43 g/plant) and followed by T₄, T₂, T₃, T₈, T₅ and T₁ which are found to be better to other treatments. The least dry weight of root was documented from T₆ and the weedy check (0.20 g/plant).

Analysing data obtained at 60 DAS specified that various treatments does have noteworthy influence on dry weight of root. Higher dry weight of root (1.71 g/plant) was documented under T₁₁ which was on equivalence with T₁₀ (1.69 g/plant) and followed by T₄, T₂ and T₅ which are found to be better than other treatments. The minimum dry weight of root was documented from the T₁₂ (0.90 g/plant).

Analysing data obtained at 90 DAS showed that various treatments does have noteworthy influence on dry weight of root. Maximum dry weight of root (3.82 g/plant) was documented under T₁₁ which was on equivalence with T₁₀ (3.76 g/plant) and followed by T₂, T₄ and T₅ which are found to be better than other treatments. The minimum dry weight of root was documented from the T₁₂ (1.24 g/plant).

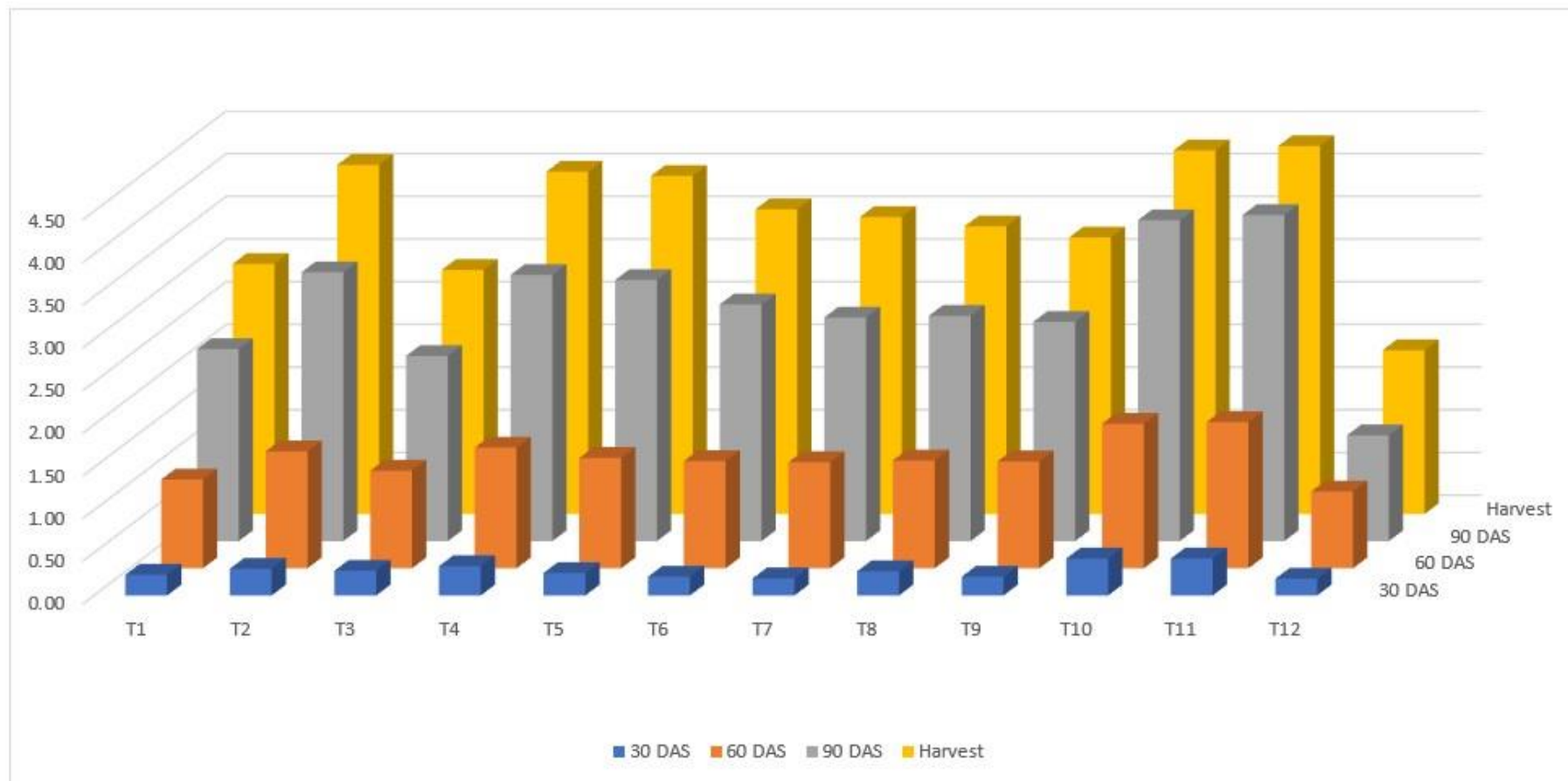
Analysing data obtained at harvest indicated that various treatments does have noteworthy impact on dry weight of root. Higher dry weight of root (4.31 g/plant) was documented under T₁₁ which was on equivalence with T₁₀ (4.26 g/plant) and followed by T₂, T₄ and T₅ which are found to be better than other treatments. The minimum dry weight of root was documented from the T₁₂ (1.92 g/plant).

It was evident from the data, higher root dry weight was documented under T₁₁ which is on equivalence with T₁₀ and followed by T₂, T₄, and T₅ which are found to be better than other treatments. This could be due to lack of weed competition, which created a pleasant environment for better crop growth and greater availability of moisture and nutrients. Due to severe competition offered by weeds minimum dry weight of root of chickpea crop was observed in the weedy check at all phases of crop growth.

Table 17. Root Dry Weight (g/plant) of Chickpea as influenced by different weed management practices

Treatments	30 DAS	60 DAS	90 DAS	At Harvest
T1-Pendimethalin @ 0.75 kg a.i ha ⁻¹ (PE)	0.24	1.04	2.25	2.93
T2-Pendimethalin @ 0.75 kg a.i ha ⁻¹ (PE) + Quizalofop-p-ethyl @ 40 g a.i ha ⁻¹ (PoE).	0.31	1.37	3.15	4.09
T3-Oxyfluorfen @ 100 g a.i ha ⁻¹ (PE)	0.29	1.14	2.17	2.86
T4-Pendimethalin @ 0.75 kg a.i ha ⁻¹ (PE) + 1 hand hoeing at 30 DAS	0.34	1.41	3.12	4.01
T5-Oxyfluorfen @ 100 g a.i ha ⁻¹ (PE) + 1 hand hoeing at 30 DAS	0.26	1.29	3.06	3.96
T6- Quizalofop-p-ethyl @ 40 g a.i ha ⁻¹ (PoE).	0.22	1.26	2.77	3.57
T7-Propaquizafop @ 0.75 kg a.i ha ⁻¹ (PoE)	0.20	1.24	2.62	3.48
T8-One hoeing at 30 DAS by wheel hoe	0.28	1.26	2.64	3.37
T9-Mulching with rice straw at 30 DAS	0.22	1.25	2.57	3.24
T10-Mulching with black plastic mulch before sowing	0.43	1.69	3.76	4.26
T11-Weed free check	0.43	1.71	3.82	4.31
T12-Weedy check	0.20	0.90	1.24	1.92
SEm ±	0.02	0.05	0.16	0.14
CD (p = 0.05)	0.06	0.16	0.48	0.42
CV%	11.4	7.2	10.3	7.0

“Fig 13. Root Dry Weight (g/plant) of Chickpea as influenced by different weed management practices”



4.2.6 Number of nodules / plant

Data relating to number of nodules per plant as influenced by diverse weed management measures in table revealed that no nodules have been detected on the roots of chickpea at all growth phases of crop.

The reason may be due to no symbiotic bacteria present in the soil of experimental plots or may be due to non viability of rhizobium culture applied to the seeds before sowing.

4.2.7 Days to 50% flowering

Table.17 presents the statistics relating to the number of days essential for 50 percent flowering as affected by various treatments.

The average no. of days essential to 50% flowering was 81 days. The data existing in Table.18 presented that treatments with various weed control measures had a non-significant consequence on the number of days essential for flowering by 50 per cent. Chickpea flowering may not be affected by the application of various weed control measures, since any crop 's flowering character is genetically controlled.

4.2.8 Number of days to maturity

Table 17 presents the data concerning to the no. of days to maturity as influenced by various weed control treatments. The mean number of days had been 130 days to maturity.

The data existing in Table18. showed that various weed management treatments had non-noteworthy result on average number of days to maturity. Different weed control measures might not influence the number of days to maturity in chickpea. Parallel results were found by Lyon and Wilson (2005).

4.2.9 Relative growth rate (RGR) (g/g/day)

RGR of chickpea was not remarkably influenced by various weed control treatments. Greater RGR was documented in T₆ and T₈ and lower RGR was noticed in T₁₂ at 30-60 DAS. But at 60-90 DAS maximum RGR was documented in T₃ and T₁. This may be happened because of better weed management practices at important stages of crop-weed competition.

Table 18. Number of nodules/plant of Chickpea as influenced by different weed management practices

Treatments	30 DAS	60 DAS	90 DAS	At Harvest
T1-Pendimethalin @ 0.75 kg a.i ha ⁻¹ (PE)	0	0	0	0
T2-Pendimethalin @ 0.75 kg a.i ha ⁻¹ (PE) + Quizalofop-p-ethyl @ 40 g a.i ha ⁻¹ (PoE).	0	0	0	0
T3-Oxyflurofen @ 100 g a.i ha ⁻¹ (PE)	0	0	0	0
T4-Pendimethalin @ 0.75 kg a.i ha ⁻¹ (PE) + 1 hand hoeing at 30 DAS	0	0	0	0
T5-Oxyflurofen @ 100 g a.i ha ⁻¹ (PE) + 1 hand hoeing at 30 DAS	0	0	0	0
T6- Quizalofop-p-ethyl @ 40 g a.i ha ⁻¹ (PoE).	0	0	0	0
T7-Propaquizafop @ 0.75 kg a.i ha ⁻¹ (PoE)	0	0	0	0
T8-One hoeing at 30 DAS by wheel hoe	0	0	0	0
T9-Mulching with rice straw at 30 DAS	0	0	0	0
T10-Mulching with black plastic mulch before sowing	0	0	0	0
T11-Weed free check	0	0	0	0
T12-Weedy check	0	0	0	0
SEm ±	-	-	-	-
CD (p = 0.05)	-	-	-	-
CV%	-	-	-	-

Table 19. Days to 50% flowering and Days to maturity of Chickpea as influenced by different weed management practices

Treatments	Days to 50% flowering	Days to maturity
T1-Pendimethalin @ 0.75 kg a.i ha ⁻¹ (PE)	80.7	130.0
T2-Pendimethalin @ 0.75 kg a.i ha ⁻¹ (PE) + Quizalofop-p-ethyl @ 40 g a.i ha ⁻¹ (PoE).	80.7	130.0
T3-Oxyflurofen @ 100 g a.i ha ⁻¹ (PE)	80.3	130.0
T4-Pendimethalin @ 0.75 kg a.i ha ⁻¹ (PE) + 1 hand hoeing at 30 DAS	80.7	129.3
T5-Oxyflurofen @ 100 g a.i ha ⁻¹ (PE) + 1 hand hoeing at 30 DAS	81.0	131.7
T6- Quizalofop-p-ethyl @ 40 g a.i ha ⁻¹ (PoE).	81.0	129.3
T7-Propaquizafop @ 0.75 kg a.i ha ⁻¹ (PoE)	81.0	131.3
T8-One hoeing at 30 DAS by wheel hoe	81.0	131.7
T9-Mulching with rice straw at 30 DAS	80.7	129.7
T10-Mulching with black plastic mulch before sowing	80.3	131.0
T11-Weed free check	80.7	130.3
T12-Weedy check	80.3	130.0
SEm ±	0.27	0.63
CD (p = 0.05)	NS	NS
CV%	0.6	0.8

“Fig 14. Days to 50% flowering and Days to maturity of Chickpea as influenced by different weed management practices”

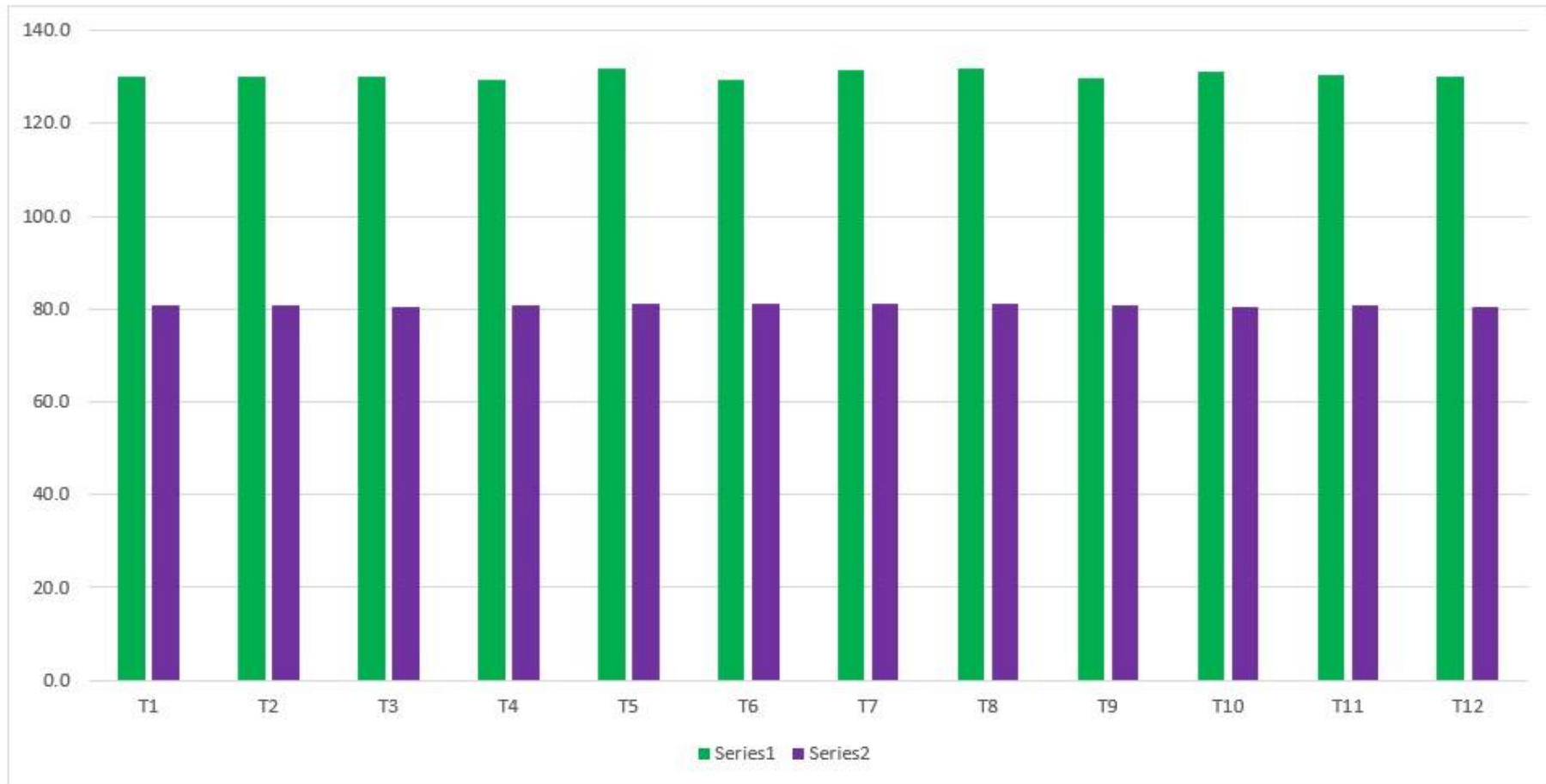


Table 20. Relative Growth Rate RGR (g/g/day) of Chickpea as influenced by different weed management practices

Treatments	30-60 DAS	60-90 DAS
T1-Pendimethalin @ 0.75 kg a.i ha ⁻¹ (PE)	0.0336	0.0151
T2-Pendimethalin @ 0.75 kg a.i ha ⁻¹ (PE) + Quizalofop-p-ethyl @ 40 g a.i ha ⁻¹ (PoE).	0.0396	0.0119
T3-Oxyflurofen @ 100 g a.i ha ⁻¹ (PE)	0.0371	0.0153
T4-Pendimethalin @ 0.75 kg a.i ha ⁻¹ (PE) + 1 hand hoeing at 30 DAS	0.0419	0.0131
T5-Oxyflurofen @ 100 g a.i ha ⁻¹ (PE) + 1 hand hoeing at 30 DAS	0.0411	0.0131
T6- Quizalofop-p-ethyl @ 40 g a.i ha ⁻¹ (PoE).	0.0452	0.0122
T7-Propaquizafop @ 0.75 kg a.i ha ⁻¹ (PoE)	0.0405	0.0124
T8-One hoeing at 30 DAS by wheel hoe	0.0427	0.0095
T9-Mulching with rice straw at 30 DAS	0.0371	0.0083
T10-Mulching with black plastic mulch before sowing	0.0374	0.0113
T11-Weed free check	0.0379	0.0110
T12-Weedy check	0.0302	0.0119
SEm ±	2.32	0.002
CD (p = 0.05)	NS	NS
CV%	12.0	23.9

Table 21. Net Assimilation Rate (g/g/dm²) of Chickpea as influenced by different weed management practices

Treatments	30-60 DAS	60-90 DAS
T1-Pendimethalin @ 0.75 kg a.i ha ⁻¹ (PE)	0.082403	0.048708
T2-Pendimethalin @ 0.75 kg a.i ha ⁻¹ (PE) + Quizalofop-p-ethyl @ 40 g a.i ha ⁻¹ (PoE).	0.103763	0.040776
T3-Oxyflurofen @ 100 g a.i ha ⁻¹ (PE)	0.086575	0.049129
T4-Pendimethalin @ 0.75 kg a.i ha ⁻¹ (PE) + 1 hand hoeing at 30 DAS	0.100681	0.043279
T5-Oxyflurofen @ 100 g a.i ha ⁻¹ (PE) + 1 hand hoeing at 30 DAS	0.09852	0.04273
T6- Quizalofop-p-ethyl @ 40 g a.i ha ⁻¹ (PoE).	0.103391	0.038951
T7-Propaquizafop @ 0.75 kg a.i ha ⁻¹ (PoE)	0.097334	0.039443
T8-One hoeing at 30 DAS by wheel hoe	0.103438	0.030578
T9-Mulching with rice straw at 30 DAS	0.096291	0.025646
T10-Mulching with black plastic mulch before sowing	0.123394	0.047052
T11-Weed free check	0.12707	0.04624
T12-Weedy check	0.056625	0.026704
SEm ±	0.01	0.01
CD (p = 0.05)	0.02	NS
CV%	12.1	26.6

4.2.10 Net assimilation rate (NAR) (g/m²/day)

NAR at 30-60 DAS was higher (0.12707 g/m²/day) in T₁₁ which was followed by T₈, T₆, T₂ and T₄. But there was no noteworthy variance amid treatments at 60-90 DAS which may be due to lesser vegetative growth.

4.3 Phytotoxic Effect on Crop

The herbicide phytotoxic effect on crops was shown in the form of a score card in the Table 6

Amid herbicides, pendimethalin, quizalofop-p-ethyl and propaquizafop was observed to be harmless herbicides because the crop was usual, and phytotoxic symptoms was not observed from germination to harvest throughout its growth period. Slight stunting and light orange yellow discolouration of the leaves was observed at 7 DAS i.e 4 days later oxyflorefen spraying. These symptoms, however, disappeared and the crop was usual by 14 days.

Post-harvest observations on crop

4.4 Yield parameters

4.4.1 Number of pods plant⁻¹

Number of pods plant⁻¹ of chickpea recorded at harvest differed significantly because of various weed management treatments and are shown in table 21

T₁₁ documented significantly maximum number of pods (26.7 plant⁻¹) equated to all other treatments. Amid other treatments, T₁₀, T₂, T₄ and T₅ were observed to be on equivalence with weed free check which may be because of weed free conditions by the different weed control measures at the time of crop weed competition that ultimately reflected in yield attributing characters. However, T₁₂ documented remarkably least number of pods (11.3 plant⁻¹) which may be because of heavy weed competition which influenced plant height and dry matter production resulting in lower pods per plant.

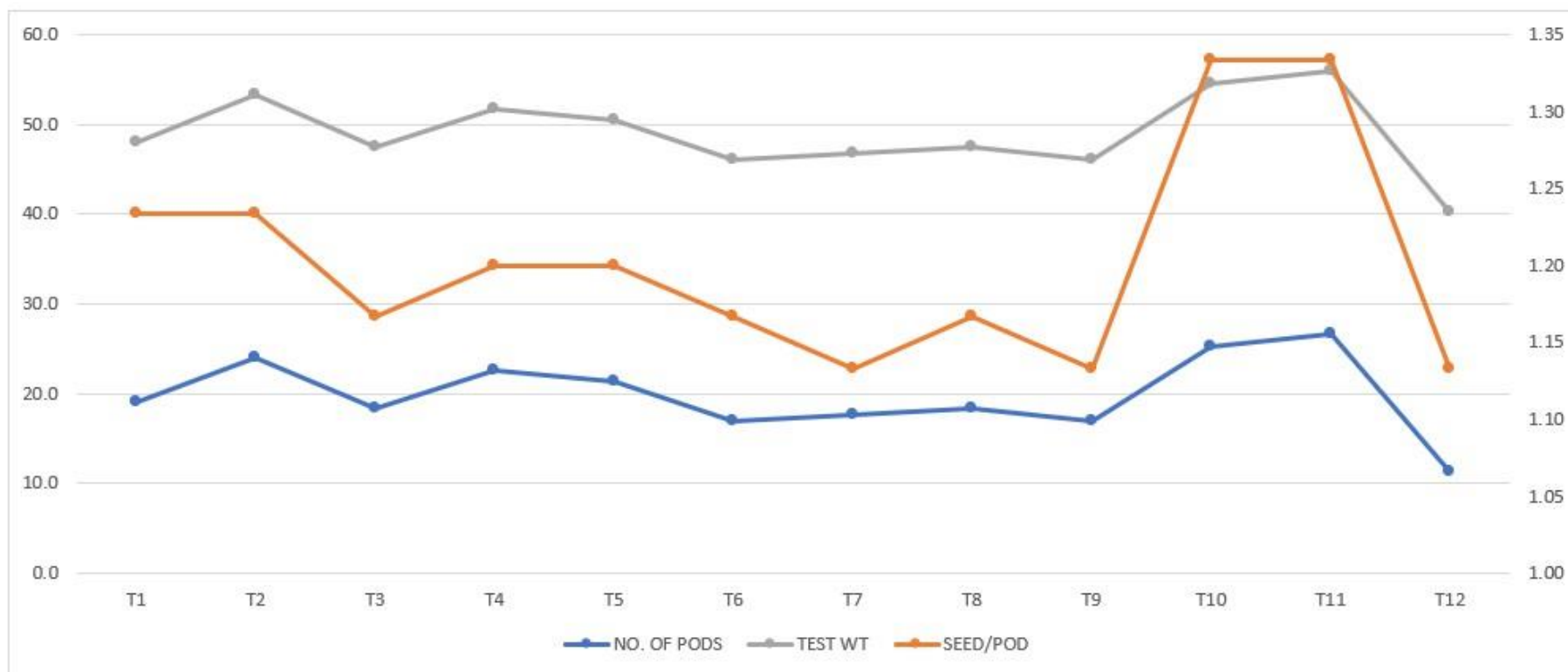
Table 22. Phytotoxic effects of different herbicidal treatments on chickpea

Treatments	Crop Injury Score			
	7 DAS	14 DAS	21 DAS	35 DAS
T1-Pendimethalin @ 0.75 kg a.i ha ⁻¹ (PE)	0	0	0	0
T2-Pendimethalin @ 0.75 kg a.i ha ⁻¹ (PE) + Quizalofop-p-ethyl @ 40 g a.i ha ⁻¹ (PoE).	0	0	0	0
T3-Oxyflurofen @ 100 g a.i ha ⁻¹ (PE)	1	0	0	0
T4-Pendimethalin @ 0.75 kg a.i ha ⁻¹ (PE) + 1 hand hoeing at 30 DAS	0	0	0	0
T5-Oxyflurofen @ 100 g a.i ha ⁻¹ (PE) + 1 hand hoeing at 30 DAS	1	0	0	0
T6- Quizalofop-p-ethyl @ 40 g a.i ha ⁻¹ (PoE).	0	0	0	0
T7-Propaquizafop @ 0.75 kg a.i ha ⁻¹ (PoE)	0	0	0	0
T8-One hoeing at 30 DAS by wheel hoe	0	0	0	0
T9-Mulching with rice straw at 30 DAS	0	0	0	0
T10-Mulching with black plastic mulch before sowing	0	0	0	0
T11-Weed free check	0	0	0	0
T12-Weedy check	0	0	0	0
SEm ±	-	-	-	-
CD (p = 0.05)	-	-	-	-
CV%	-	-	-	-

Table 23. Yield attributes of Chickpea as influenced by different weed management practices

Treatments	No. of pods/pt	No. of seeds/pod	Test weight (100 seeds)
T1-Pendimethalin @ 0.75 kg a.i ha ⁻¹ (PE)	19.0	1.23	29.10
T2-Pendimethalin @ 0.75 kg a.i ha ⁻¹ (PE) + Quizalofop-p-ethyl @ 40 g a.i ha ⁻¹ (PoE).	24.0	1.23	29.23
T3-Oxyflurofen @ 100 g a.i ha ⁻¹ (PE)	18.3	1.17	29.13
T4-Pendimethalin @ 0.75 kg a.i ha ⁻¹ (PE) + 1 hand hoeing at 30 DAS	22.7	1.20	29.03
T5-Oxyflurofen @ 100 g a.i ha ⁻¹ (PE) + 1 hand hoeing at 30 DAS	21.3	1.20	29.17
T6- Quizalofop-p-ethyl @ 40 g a.i ha ⁻¹ (PoE).	17.0	1.17	29.10
T7-Propaquizafop @ 0.75 kg a.i ha ⁻¹ (PoE)	17.7	1.13	29.07
T8-One hoeing at 30 DAS by wheel hoe	18.3	1.17	29.07
T9-Mulching with rice straw at 30 DAS	17.0	1.13	29.13
T10-Mulching with black plastic mulch before sowing	25.3	1.33	29.17
T11-Weed free check	26.7	1.33	29.23
T12-Weedy check	11.3	1.13	28.90
SEm ±	1.23	0.05	0.13
CD (p = 0.05)	3.62	NS	NS
CV%	10.7	7.3	0.7

“Fig 15. Yield attributes of Chickpea as influenced by different weed management practices”



4.4.2 Number of seeds pod⁻¹

The difference in number of seeds pod⁻¹ because of various weed control practices was observed to be non-noteworthy. Nevertheless, the higher no. of seeds pod⁻¹ was noted with treatment T₁₁ and T₁₂ closely followed by all other treatment may be due to weed free conditions generated by the diverse weed control practices at the time of crop weed competition that ultimately reflected in yield attributing characters.

4.4.3 Test weight (100 grain weight)

The difference in 100 grain weight because of diverse weed control treatments was observed to be non-noteworthy. Nevertheless, the higher test weight of 29.23 g /100 seed was recorded with treatment T₂ and T₁₀ and closely followed by all other treatments. Mukharjee and Singh (2005) reported parallel conclusions.

4.4.5 Seed yield (kg/ha)

The statistics relating to seed yield (kg ha⁻¹) revealed that there is a noteworthy difference in yield because of various weed control measures. The maximum seed yield (1736 kg ha⁻¹) was noted with T₁₁ which is found to be statistically on equivalence with mulching with black plastic mulch followed by T₂, T₄ and T₅ and observed to be higher than other treatments.

The higher seed yield in the above treatments was because of lesser crop weed competition because of hand weeding in weed free check, application of black plastic mulch and pre and post emergence herbicidal application along with hoeing, least weed dry weight, lower WI and greater WCE. This enabled the crop to make use of maximum light, space, moisture and nutrients.

The least seed yield (736 kg ha⁻¹) was noted with T₁₂ resulted due to severe crop weed competition as weeds utilize large amount of moisture and nutrients than crop which was due to no weed management practice. These conclusions are parallel with Punia *et al.* (2011), Singh *et al.* (2003), Punia and pithia (2013) and Singh *et al.* (2014).

4.4.6 Haulm yield (kg/ha)

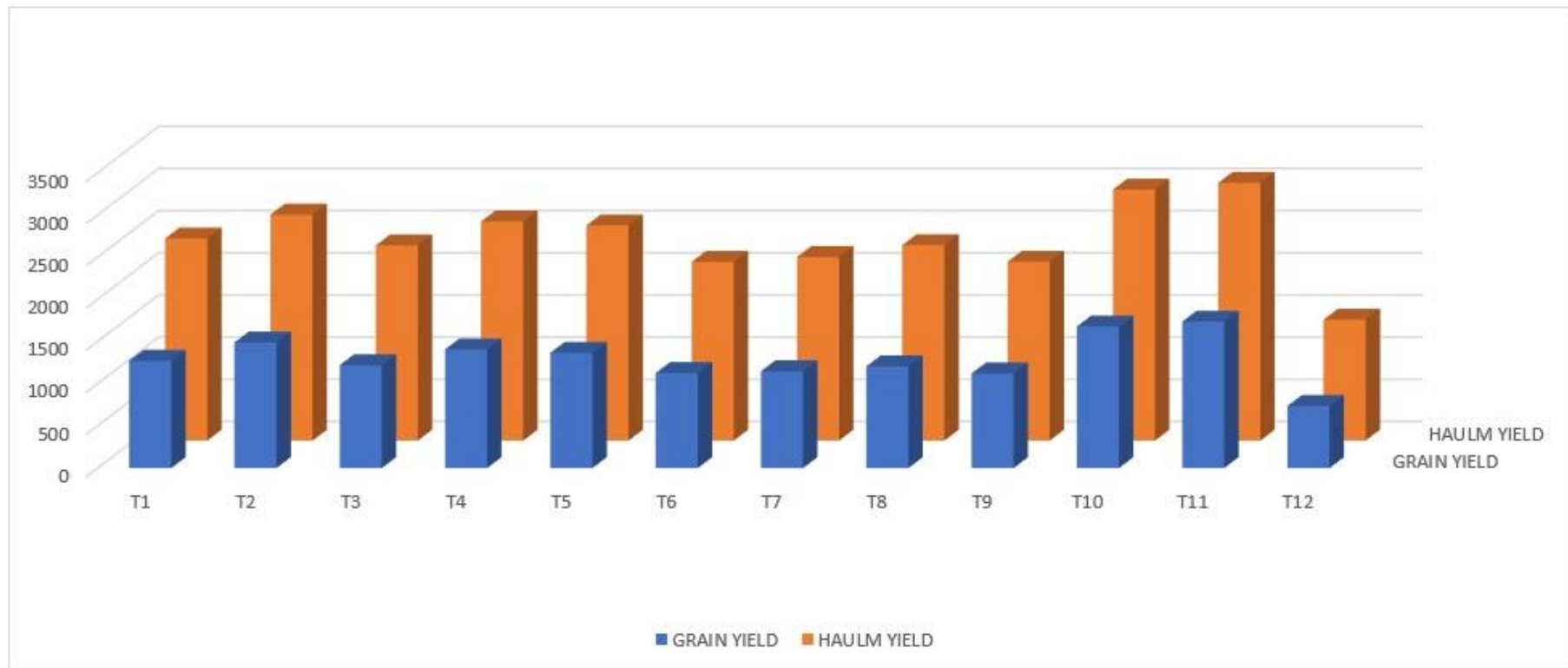
The statistics regarding haulm yield (kg ha⁻¹) of chickpea revealed that there is a noteworthy variance because of different weed management treatments. Data (Table 22) revealed that significantly higher haulm yield was documented with all weed control treatments

under investigation over the weedy check. The maximum haulm yield was documented with T₁₁ (3056 kg ha⁻¹) which was equivalence with T₂, T₄ and T₁₀ treatments due to higher biomass produced by the crop and higher nutrient uptake by crop due to active control of weeds. The minimum haulm yield was noted with T₁₂ (1434 kg ha⁻¹). Devi *et al.* (2012) and Singh *et al.* (2014) conveyed parallel conclusions.

Table 24. Seed Yield (Kg/ha) and Haulm Yield (Kg/ha) of Chickpea as influenced by different weed management practices

Treatments	Seed Yield (Kg/ha)	Haulm Yield (Kg/ha)
T1-Pendimethalin @ 0.75 kg a.i ha ⁻¹ (PE)	1272	2396.7
T2-Pendimethalin @ 0.75 kg a.i ha ⁻¹ (PE) + Quizalofop-p-ethyl @ 40 g a.i ha ⁻¹ (PoE).	1489	2680.0
T3-Oxyflurofen @ 100 g a.i ha ⁻¹ (PE)	1220	2314.7
T4-Pendimethalin @ 0.75 kg a.i ha ⁻¹ (PE) + 1 hand hoeing at 30 DAS	1407	2598.3
T5-Oxyflurofen @ 100 g a.i ha ⁻¹ (PE) + 1 hand hoeing at 30 DAS	1367	2551.7
T6- Quizalofop-p-ethyl @ 40 g a.i ha ⁻¹ (PoE).	1127	2120.0
T7-Propaquizafop @ 0.75 kg a.i ha ⁻¹ (PoE)	1148	2176.7
T8-One hoeing at 30 DAS by wheel hoe	1205	2318.7
T9-Mulching with rice straw at 30 DAS	1122	2120.7
T10-Mulching with black plastic mulch before sowing	1679	2976.3
T11-Weed free check	1736	3056.7
T12-Weedy check	736	1434.3
SEm ±	45.13	125.66
CD (p = 0.05)	133.13	370.69
CV%	6.0	9.09

“Fig 16. Seed Yield (Kg/ha) and Haulm Yield (Kg/ha) of Chickpea as influenced by different weed management practices”



4.4.7 Seed to Haulm ratio (%)

The data on seed to haulm ratio reveal that treatments have non-significant influence on seed to haulm ratio.

4.4.8 Harvest index(HI) (%)

It is evident from the data that the HI doesn't have any influence because of diverse weed management practices. Numerically higher HI (36.22 %) was obtained from weed free check followed by T₁₀ and T₂ treatments and lowest harvest index reported from weedy check (34.23 %).

4.5 Economics

The data about the economics of various treatments was calculated and summarized in Table 24 and depicted in Fig 16

4.5.1 Cost of cultivation (₹/ha)

Statistics relating to COC indicated that amid treatments, T₁₁ documented the highest cost of cultivation (₹ 50,669/ha) followed by T₁₀ (₹ 47,181/ha), T₉ (₹ 35,181/ha), followed by T₄, T₅, T₈, T₇, T₂, T₁, T₃ and T₆. The lower cost of cultivation was documented from the weedy check (₹ 30,509/ha). The higher cost of cultivation for weed free check is due to more number of labour for weeding the plot. For T₁₀ treatment higher cost of cultivation is due to cost of black plastic mulch.

4.5.2 Gross return (₹/ha)

A scrutiny of the data exposed that various treatments had a notable influence on gross returns. The maximum gross returns (₹ 86,800/ha) were noted under T₁₁, which was statistically at equivalence with mulching with black plastic mulch before sowing (83,933/ha). Minimum gross returns were obtained from weedy check (36,816/ha). Due to maximum weed control efficiency and grain yield weed free check has recorded higher gross returns.

Table 25. Seed to Haulm ratio and Harvest Index of Chickpea as influenced by different weed management practices

Treatments	Seed to Haulm ratio	Harvest Index
T1-Pendimethalin @ 0.75 kg a.i ha ⁻¹ (PE)	0.53	34.74
T2-Pendimethalin @ 0.75 kg a.i ha ⁻¹ (PE) + Quizalofop-p-ethyl @ 40 g a.i ha ⁻¹ (PoE).	0.56	35.72
T3-Oxyflurofen @ 100 g a.i ha ⁻¹ (PE)	0.53	34.60
T4-Pendimethalin @ 0.75 kg a.i ha ⁻¹ (PE) + 1 hand hoeing at 30 DAS	0.55	35.33
T5-Oxyflurofen @ 100 g a.i ha ⁻¹ (PE) + 1 hand hoeing at 30 DAS	0.54	34.85
T6- Quizalofop-p-ethyl @ 40 g a.i ha ⁻¹ (PoE).	0.53	34.73
T7-Propaquizafop @ 0.75 kg a.i ha ⁻¹ (PoE)	0.53	34.51
T8-One hoeing at 30 DAS by wheel hoe	0.52	34.23
T9-Mulching with rice straw at 30 DAS	0.53	34.63
T10-Mulching with black plastic mulch before sowing	0.57	36.12
T11-Weed free check	0.57	36.22
T12-Weedy check	0.52	34.23
SEm ±	0.03	1.47
CD (p = 0.05)	NS	NS
CV%	11.1	7.3

4.5.3 Net return (₹/ha)

Citation of the data indicated that various treatments had a noteworthy impact on net returns. The highest value of net returns obtained from T₂ (42,969/ha) which is statistically at par with T₄, T₅, T₁₀ and T₁₁. These treatments are observed to be better to other treatments. Lowest net returns are obtained from the weedy check treatment (6,309/ha). The higher net returns recorded in T₂ treatment was due to lower cost of cultivation because of herbicidal treatments and higher grain yield. Parallel observations were recorded by Choudhary *et.al.* (2015), Buttar *et al.*(2008), Pedde *et al.* (2013) and Singh *et al.* (2014).

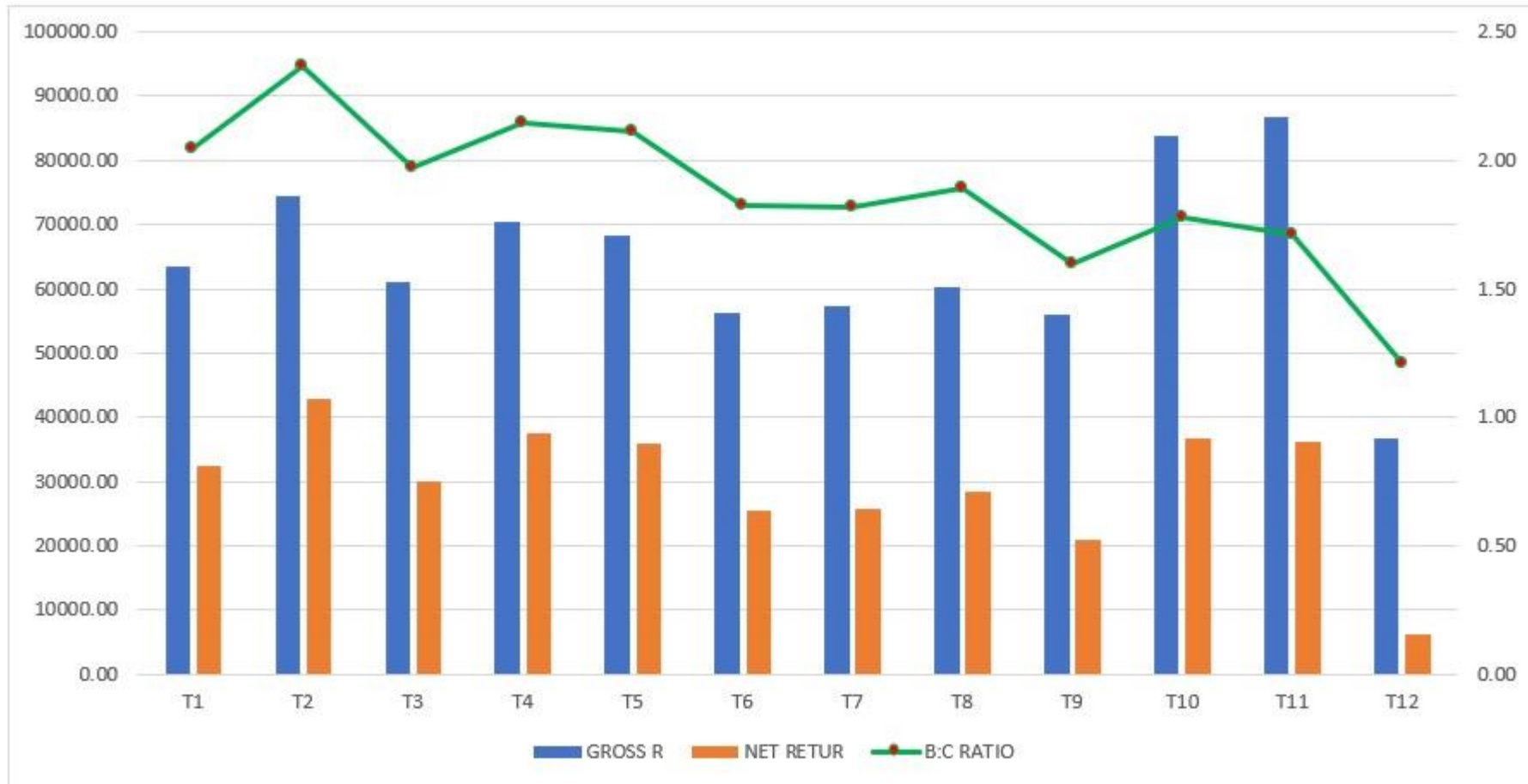
4.5.4 Benefit: Cost ratio

By looking at data it was revealed that the benefit-cost ratio showed that different treatments exerted significant influence on benefit cost ratio. The maximum B: C ratio (2.36) was attained under T₂ because of higher grain yield, gross and net returns which was found to be statistically at equivalence with T₄ and T₅. These treatments were observed to be better to other treatments. Minimum B: C ratio (1.21) was found from the weedy check. Mukesh kumar and Das (2008) conveyed parallel findings.

Table 26. Economics of different weed management practices in chickpea

Treatments	Cost of cultivation	Gross returns	Net returns	B:C ratio
T1-Pendimethalin @ 0.75 kg a.i ha ⁻¹ (PE)	31107.00	63600.00	32493.00	2.04
T2-Pendimethalin @ 0.75 kg a.i ha ⁻¹ (PE) + Quizalofop-p-ethyl @ 40 g a.i ha ⁻¹ (PoE).	31497.00	74466.67	42969.67	2.36
T3-Oxyflurofen @ 100 g a.i ha ⁻¹ (PE)	30965.00	61000.00	30035.00	1.97
T4-Pendimethalin @ 0.75 kg a.i ha ⁻¹ (PE) + 1 hand hoeing at 30 DAS	32787.00	70366.67	37579.67	2.15
T5-Oxyflurofen @ 100 g a.i ha ⁻¹ (PE) + 1 hand hoeing at 30 DAS	32309.00	68333.33	36024.33	2.11
T6- Quizalofop-p-ethyl @ 40 g a.i ha ⁻¹ (PoE).	30899.00	56333.33	25434.33	1.82
T7-Propaquizafop @ 0.75 kg a.i ha ⁻¹ (PoE)	31557.00	57400.00	25843.00	1.82
T8-One hoeing at 30 DAS by wheel hoe	31853.00	60266.67	28413.67	1.89
T9-Mulching with rice straw at 30 DAS	35181.00	56116.67	20935.67	1.60
T10-Mulching with black plastic mulch before sowing	47181.00	83933.33	36752.33	1.78
T11-Weed free check	50669.00	86800.00	36131.00	1.71
T12-Weedy check	30509.00	36816.67	6309.67	1.21
SEm ±	-	2256.47	2256.47	0.07
CD (p = 0.05)	-	6656.59	6656.59	0.20
CV%	-	6.0	13.1	6.3

“Fig 17. Economics of different weed management practices in chickpea”





CHAPTER - V



SUMMARY AND CONCLUSION



CHAPTER V

SUMMARY AND CONCLUSION

The current investigation entitled “**Effect of different weed management practices on growth and yield of chickpea (*Cicer arietinum*.L.) under riverine (*Diara*) area**” was implemented in *rabi* season of 2019-2020 at Dhab research farm, Pusa (Bihar). Some of the important parameters related to growth, yield, weed parameters and economics of chickpea production were duly studied in this experiment. The results and suitable reasons of the same are presented in the previous sections. In this section, we can get an overall idea of the result obtained for every parameter due to applied weed control treatments.

The trial consists 12 treatments which includes: T1- Pendimethalin @ 0.75 kg/ha (PE); T2- Pendimethalin @ 0.75 kg/ha(PE) + Quizalofop-p-ethyl @ 40 g/ha(PoE); T3- Oxyflurofen @ 100 g/ha(PE); T4- Pendimethalin @ 0.75 kg/ha(PE) + 1 hand hoeing at 30 DAS; T5- Oxyflurofen @ 100 g/ha(PE) + 1 hand hoeing at 30 DAS; T6- Quizalofop-p-ethyl @ 40 g/ha(PoE); T7- Propanil @ 0.75 kg/ha(PoE); T8-One hoeing at 30 DAS by wheel hoe; T9-Mulching with rice straw at 30 DAS; T10-Mulching with black plastic mulch before sowing; T11-Weed free and T12-Weedy check.

The prominent findings obtained as a result of treatments in this experiment are condensed underneath:

Effect of weed control measures on weeds

Throughout the crop growing period, T₁₀ documented significantly least count of sedges, grasses and BLW and lower weed dry weight, *fb* T₂ treatment which is on equivalence with T₁₁, but notably minimum weed count and lower weed dry weight were also detected in treatments T₄ and T₅ when compared to values of other treatments and T₆ and T₇ recorded higher weed count and T₉ recorded higher weed dry weight next to weedy check at all phases of crop development.

Significantly maximum WCE at 30, 60, 90 DAS and at harvest and lower weed index was documented in T₁₀ followed by, T₂ treatments which are on equivalence with T₁₁ which are tailed by T₄ and T₅ compared to other treatments. T₉ recorded higher weed index and lower WCE which is on equivalence with Weedy check (T₁₂).

Phytotoxicity rating

Oxyfluorfen treatments T₃ and T₅ (100 g/ha) have shown little phytotoxic effect at 4 days after spraying on crop at 7DAS, but phytotoxicity symptoms disappeared at 14 DAS i.e 10 days after application of herbicide.

Effect of weed control treatments on chickpea

Significantly maximum plant height, higher amount of branches, maximum dry matter accumulation and root dry weight were noticed in T₁₀ followed by T₂ treatments which are on equivalence with T₁₁ tailed by T₄ and T₅ which are better than other treatments. Nevertheless, weedy check (T₁₂) has documented minimum plant height, quantity of branches, dry matter accumulation and root dry weight.

RGR AND NAR obtained at 30, 60 and 90 DAS seems to be non-significant. Various weed management treatments doesn't exerted any influence on RGR AND NAR.

Among yield attributing characters, significantly higher count of pods per plant, number of seeds per pod and 100 seed weight were detected in T₁₀ followed by T₂ treatments which are on equivalence with T₁₁ tailed by T₄ and T₅ which are better than other treatments. Nevertheless, T₆ and T₉ has documented lower number of pods per plant, number of seeds per pod and 100 seed weight next to weedy check (T₁₂)

Significantly higher grain yield and haulm yield, seed to haulm ratio and harvest index were detected in T₁₀ followed by T₂ treatments which are on equivalence with T₁₁ tailed by T₄ and T₅ which are better than other treatments. Nevertheless, T₉ has documented lower grain yield and haulm yield next to weedy check (T₁₂) and T₈ has documented lower seed to haulm ratio and harvest index next to weedy check (T₁₂)

Economics

Significantly higher gross returns were detected in weed free check (T₁₁) (86,800 ha⁻²) but significantly (T₂) Pendimethalin @ 0.75 kg ha⁻¹ (PE) + Quizalofop-p-ethyl @ 40 g ha⁻¹ (POE) documented maximum net returns (42,969.67 ha⁻²) and higher B:C ratio (2.36) than other weed management treatments. However weedy check (T₁₂) documented minimum gross returns, net returns and B:C ratio.

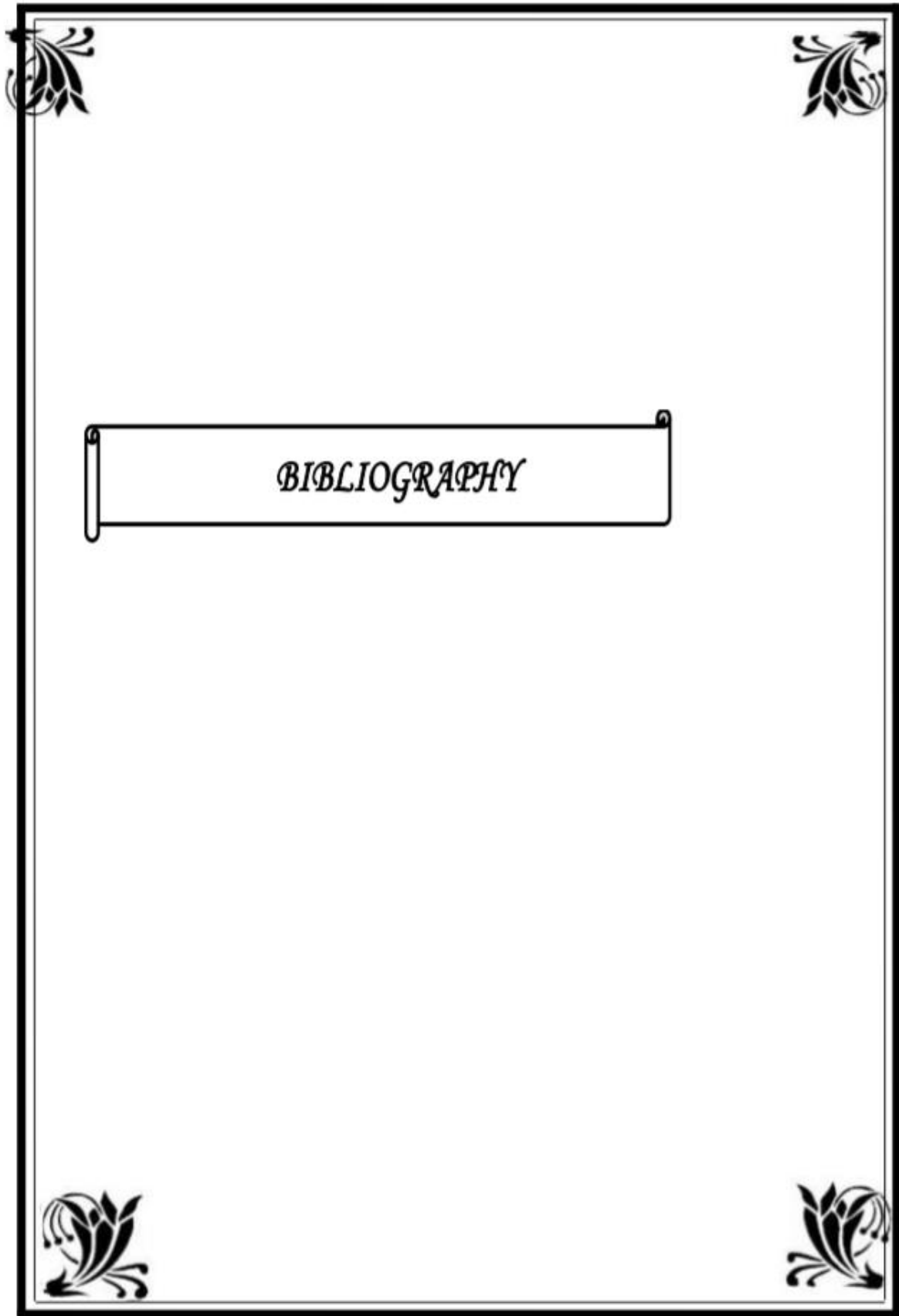
CONCLUSIONS:

In consideration of the objectives of current experimentation, undermentioned key inferences could be drawn:

Amid different weed control measures, Pendimethalin @ 0.75 kg ha⁻¹ (PE) + Quizalofop-p-ethyl @ 40 g ha⁻¹ (POE) at 30 DAS was observed to be higher in case of growth parameters, seed yield, haulm yield, net returns and B:C ratio. Hence T₂ treatment can be recommended for controlling the weeds in chickpea cultivation under riverine area.

Amid different treatments under investigation Oxyfluorfen treatments T₃ and T₅ (100 g/ha) have shown little phytotoxic effect at 4 days after spraying on crop at 7DAS, but phytotoxicity symptoms disappeared at 14 DAS i.e. 10 days after application of herbicide.

Thus, applying Pendimethalin @ 0.75 kg ha⁻¹ (PE) + applicaton of Quizalofop-p-ethyl @ 40 g ha⁻¹ (PoE) at 30 DAS aids in effective control of weeds with higher WCE and net returns.



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APPENDIX



APPENDIX-I
COMMON COST OF CULTIVATION

Sl. No.	Particulars	Quantity	Rate (₹/unit)	Cost (₹/ha)
1	Layout	2 mandays	336/ manday	672
2	Seed	80kg	150/kg	12000
3	Sowing and fertilizer application	6 mandays	336/ manday	2016
4	Cost of top dressing	2 mandays	336/manday	672
5	Nutrient management			
	12:32:16 N:P:K	50 kg	1185/50kg	1185
6	Irrigation	1	900/irrigation	900
	Cost of application of irrigation	2 mandays	336/ manday	672
7	Harvesting	10 mandays	336/manday	3360
8	Threshing and winnowing	8 mandays	336/manday	2688
9	Cleaning, drying and storage	4 mandays	336/manday	1344
10	Land rent	6 months	10000/ha/year	5000
Total		30509		

APPENDIX-II

Variable cost of cultivation of Different weed management treatments

Treatments	Particulars	Quantity		Rate	Cost (₹)
T ₁	Pendimethalin 30% EC	750 ml/ha	1 manday	262/750ml & 336/manday	598
T ₂	Pendimethalin 30% EC & Quizalofop-p- ethyl 5% EC	750 ml/ha & 40 ml/ha	2 mandays	262/750 ml + 54/40ml & 336/manday	988
T ₃	Oxyfluorfen 23.5% EC	100 ml/ha	1 manday	120/ 100ml & 336/manday	456
T ₄	Pendimethalin 30% EC & Hand hoeing	750 ml/ha	5 mandays	262/ 750ml & 336/manday	2278
T ₅	Oxyfluorfen 23.5% EC & Hand hoeing	100 ml/ha	5 mandays	120/ 100ml & 336/manday	1800
T ₆	Quizalofop-p- ethyl 5% EC	40 ml/ha	1 manday	54/ 40 ml & 336/manday	390
T ₇	Propaquizafop 10% EC	750 ml/ha	1 manday	712 /750 ml & 336/manday	1048
T ₈	Hoeing by wheel hoe		4 mandays	336/manday	1344
T ₉	Rice straw	20 q/ha	2 mandays	200/quintal & 336/manday	4672
T ₁₀	Black plastic mulch	133 kg/ha	2 mandays	120/kg & 336/manday	16672
T ₁₁	Hand weeding at 15, 30 & 45 DAS		60 mandays	336 /manday	20160
T ₁₂	-----	-----		-----	-----

APPENDIX-III

Total cost of cultivation per hectare for different treatments

Treatments	Common cost(₹/ha)	Variable cost (₹/ha)	Total (₹/ha)
T1	30509	598	31107.00
T2	30509	988	31497.00
T3	30509	456	30965.00
T4	30509	2278	32787.00
T5	30509	1800	32309.00
T6	30509	390	30899.00
T7	30509	1048	31557.00
T8	30509	1344	31853.00
T9	30509	4672	35181.00
T10	30509	16672	47181.00
T11	30509	20160	50669.00
T12	30509	-----	30509.00