

**Effect of integrated management practices for control of
Orobanche in mustard (Brassica juncea L. Czern & Coss.)
under Gird agro-climatic conditions**

THESIS



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Rajmata Vijayaraje Scindia Krishi Vishwa Vidyalaya

In partial fulfillment of the requirements for the degree of

MASTER OF SCIENCE

In

AGICULTURE

(AGRONOMY)

by

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2016

CERTIFICATE - I

*This is to certify that the thesis entitled “**Effect of integrated management practices for control of Orobancha in mustard (*Brassica juncea* L. Czern & Coss.) under Gird agro-climatic conditions**” submitted in partial fulfillment of the requirement for the degree of **MASTER OF SCIENCE** in **Department of Agronomy** of **Rajmata Vijayaraje Scindia Krishi Vishwa Vidyalaya, Gwalior** is a record of the bona-side research work carried out by **Miss RACHANA KUMARI** under my guidance and supervision. The subject of the thesis has been approved by the student’s Advisory Committee and the Director of Instruction.*

No part of the thesis has been submitted for any other degree or diploma or has been published. All the assistance and help received during the course of the investigations has been acknowledged by the scholar.

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Place : Gwalior

Date : / /

(RACHANA KUMARI)

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Abbreviations and Acronyms

Abbreviations/ Acronyms	Meaning
Ag.	Agriculture
&	And
<i>et al.</i>	And co-workers
@	At the rate of
BCR	Benefit: cost ratio
AGR	Absolute growth rate
CD	Critical difference
CGR	Crop growth rate
Cm	Centi meter
DAS	Days after sowing
dSm ⁻¹	Deci Siemens per meter
°C	Degree centigrade
Dist.	District
E	East
EC	Electrical conductivity
F	Fertility
Fig.	Figure
FYM	Farm yard manure
G	Gram
Ha	Hectare
H. I.	Harvest index
i.e.	In reference to; that is
INM	Integrated nutrient management
Kg	Kilogram
kg ha ⁻¹	Kilogram per hectare
LAI	Leaf area index
LAR	Leaf area ratio
LAD	Leaf area duration
Max.	Maximum
Mg m ⁻³	Mega gram per cubic meter
M	Meter
mg kg ⁻¹	Milli gram per kilogram
Min	Minimum
Mm	Milli meter
M.P.	Madhya Pradesh
Mt	Metric tonnes
Viz	Namely
N	Nitrogen
NAR	Net assimilation rate
No.	Number
OC	Organic carbon
O.M.	Organic manure
%	Per cent

K	Potassium
P	Phosphorus
PSB	Phosphorus Solubilizing Bacteria
RDF	Recommended dose of fertilizer
RGR	Relative growth rate
RH	Relative humidity
Rs.	Rupees
R.V.S.K.V.V.	Rajmata Vijayaraje Scindia Krishi Vishwa Vidhyalaya
pH	Soil reaction
Q	quintal
S	Sulphur
S.E.m (d)	Standard error mean of difference
Sy.	Symbol
Temp.	Temperature
t ha ⁻¹	Tonnes per hectare
U.P.	Uttar Pradesh
VC	vermicompost
Wt.	weight
WUE	Water use efficiency
Zn	Zinc

CHAPTER - I

INTRODUCTION

Indian mustard [*Brassica juncea* (L.) Czern & Cross] is one of the important oil seed crop of the state of Madhya Pradesh. The problem of low productivity continues to be a major issue for agricultural planners and researchers.

Mustard crop is grown both in subtropical and temperate countries. India occupies the third position with respect to average production of rapeseed and mustard in the world. It is raised on 6.70 million hectares with an annual production of 7.96 million tonnes and average productivity of 1188 kg/ha in the country (Directorate of Economics and statistic, 2014). In Madhya Pradesh rapeseed and mustard is grown in 0.81 million hectares area with annual production of 0.90 million tonnes and average productivity of 1108 kg/ha. But in Gwalior district it covers an area of 58.5 thousand hectares with annual production 75.9 thousand tonnes and average productivity of 1303 kg/ha (M.P. Krishi Org.in., 2014).

Weed are considered as one of the major negative factors responsible for loss of crop produce due to their competition for nutrients, moisture, light and space which have been reported as high as 30-70%. The crop is usually found infested with grassy as well as broadleaf weeds. Weeds substantially reduce the productivity and production of mustard due to competition for various inputs. A wide range of yield reduction in the crop on account of weeds is well documented. Therefore, there is a need to create an environment that is detrimental to weeds and favourable to crop. Broomrape (*Orobancha aegyptica* pers.), a holoparasitic weed, causing heavy loss to the mustard crop in light soil of Gird region, under rainfed situation. Its infestation during early stages reflected on the crop growth and reduction in yield up to 58% (Prusty *et al.*, 1996). The reduction of 13.9 to 16.3 per cent seed yield of mustard due to *Orobancha* was observed by Sheoran *et al.* (2014). At later stages, shading caused by plant height and broad dorsiventral leaves help in suppressing weed growth (Chakaiyar and Ambasht, 1990).

Many workers have stated that glyphosate at lower rates (82 g/ha) at 30 DAS excellent control of broomrape without any toxic effect on mustard crop, but it caused some toxicity at higher rates (123 g/ha) at 60 DAS to the crop. Other herbicides like fluchloralin and pendimethalin did not control this weed (Kumar, 2002). The meagre

work on selective control of broomrape has been done so far in this region. Therefore, the present studies were proposed to be carried out with the following objectives:

- To determine the suitable methods for the control of *Orobanche* in mustard
- To find out the effect of various methods applied for control of *Orobanche* on growth and yield and quality of mustard
- To work out the economics of various methods used for the control of *Orobanche*

CHAPTER - II

REVIEW OF LITERATURE

Review of literature is a necessary step for any scientific study. It provides a theoretical framework, previous work and the basic interpretation of findings to the study. An attempt has been made to review literature, which is meaningful and had direct relevance to this study. The available relevant references have been reviewed are mentioned in this chapter:

Nemli *et al.* (1989) reported that glyphosate at 40 g/ha gave 73% control of *O. ramosa* in tobacco but caused a yield reduction. Early application of glyphosate at low rate (5 g/ha) provided 50% *O. ramosa* control with slightly increased yields.

Americanos and Vouzounis (1995) studied on the control of *Orobancha* in cabbage and found that the parasite weed was effectively controlled in the field by spraying glyphosate at 60-100 g a.i./hectare. Further, they also reported that trifluralin @ 0.9 kg a.i./ha may have a beneficial effect in reducing *Orobancha* infestation, while incorporation of organic matter into the soil did not produce any beneficial effect.

Dhanapal (1996) assessed the efficacy of 15 herbicides for control of broomrape and results indicated that 0.5 kg/ha glyphosate 60 DAS and 0.01 kg imazaquin 30 DAS gave best weed reduction (75-80%) and increased the yield of tobacco by 43%.

Dhanapal *et al.* (1998a) assessed the effect of natural oils on the control of broomrape in a naturally infested tobacco field at Agricultural Research station, Nipani, Karnatka, India. Natural oils which were less expensive and biodegradable differed in their ability to kill young broomrape spikes. Neem, coconut, sunflower, castor niger and mustard oils killed the buds of *Orobancha* within 3 to 5 days without phytotoxicity to tobacco.

Dhanapal *et al.* (1998b) reported that glyphosate at 500 g/ha applied at 60 days after transplanting (DAT) and imazaquin at 10 g/ha applied at 30 DAT reduced the number of above-ground broomrape spikes by 75 to 80%, respectively, and increased tobacco yield by 80 to >100% compared to the untreated plots. Imazethapyr and EPTC were found to be less effective for broomrape control, but they still led to substantially higher tobacco yields. None of the herbicide treatments resulted in higher yields than those in the

hand-weeded plots. Toxicity to tobacco of all herbicides was higher at the higher rates tested but it was lowest with imazaquin.

Covarelli (2002) reported that glyphosate (180-324 ml/ha) caused a reduction of 100 per cent of broomrape but it significantly depressed tobacco yield.

Kumar (2002) found that glyphosate at low rates (82 g/ha) provided excellent control of broomrape without any toxic effect on mustard crop but it caused some toxicity at higher rates (123 g/ha) to the crop. Other herbicides like fluchloralin, trifluralin and pendimethalin did not control this weed.

Anonymous (2003) reported that 2 drops of soybean oils per young shoot of *Orobanche* was the most potent killer of the weed which recorded significantly higher seed yield of mustard (1452 kg/ha).

Anonymous(2004) reported that the pre-emergence application of pendimethalin @ 1.0 kg a.i./ha produced significantly higher seed yield of mustard which was at par with pendimethalin @ 1.5 kg a.i./ha (P.E.). The direct spray of glyphosate @ 1.0% produced minimum seed yield due to its phytotoxic effect, but recorded maximum *Orobanche* control efficiency followed by two drops of soybean oil per young shoot of *Orobanche*.

Mariam and Suwanketnikom (2004) Conduced a pot experiment under natural conditions at Melkasa Agricultural Research Center, Central Ethiopia to study the effects of various levels of nitrogen, applied as ammonium nitrate(NH_4NO_3), ammonium sulfate (NH_4)₂SO₄, urea (NH_2CONH_2), chicken, cow, and goat manure on broomrape (*Orobanche ramosa*L.). Parasitism occurred most in untreated and treated pots with low N fertilizer and manure. Urea at 276 and 207 kg N/ha, ammonium nitrate, and ammonium sulfate at 207 kg N/ha and the goat manure at 20 and 30 t/ha were found to be most effective in reducing parasitism and enhancing growth of tomato plants. As nitrogen rates increased, the numbers and dry weights of shoot of branched broomrape decreased and the yields of tomato increased linearly. This result indicated that branched broomrape infestation of tomato decreased with increases level of soil nitrogen.

Dinesha and Dhanpal (2014) revealed that the broomrape spikes started emerging above-ground from 43 days after transplanting of tomato and continued up to 58 days and it took 37-50 days to complete its life cycle after the emergence above-ground. They reported that application of sulfosulfuron 75 g/ha is proved to be highly effective. Apart from higher broomrape control efficiency highest fruit yield were also recorded without causing any phytotoxicity in tomato.

Jadav *et al.* (2014) advocated that pendimethalin 1.0 kg /ha (PE) or trifluralin 1.5 kg /ha + neem oil 1% PPI could be adopted as effective weed control measure against different weeds (prominently *Orobanche*) in mustard for attaining higher seed yield and net return.

Sani and Jodaian (2014) reported that the effect of microbial herbicide (*Orocide*) was significant on germination percentage of *Orobanche ramosa*. They observed that the highest germination percentage (79%) was achieved by non-application of *Orocide* and lowest germination percentage (8%) was achieved by application of 4% *Orocide*.

Sheoran *et al.* (2014) reported that foliar spray of glyphosate twice, first 25 g/ha at 30 DAS and second 50 g/ha at 55-60 DAS is quite effective in reducing the weed infestation by inhibiting the further increase in weed seed bank and substantially increased the yield of mustard.

Pathak and Kannan (2015) reported that application of spore suspension and crude metabolite extract of *P. oxalicum* as seed treatment followed by foliar application caused a significant reduction in the stalk emergence of *O. crenata* when compared to the control. Neem cake slurry delayed the emergence of the stalks but at 150 days of observation, the emergence was near to the metabolite extract of *Fusarium oxysporum* *et.* They observed that the fungi when applied as seed treatment was able to produce a film of mycelial growth on the initial roots of tomato. This might alter the volatiles being released by the host roots and delay the preconditioning of the dormant seeds of *O. crenata* which reduces their germination and development. The reduction in emergence of the flowering stalks would reduce the development of the parasite and thus the host crop may escape the

infection during its critical stages and stalk emergence means less seed production and seed bank in the soil.

Premiet *et al.* (2015) observed that an average 135 *orobanche* colons/m² emerged under conventional (control) condition. The rate of emergence of colons was 43.0% by 90 DAS and 83.0% by 120 DAS. Application of sub lethal doses of glyphosate with or without 1% ammonium sulphate solution decreased the *Orobanche* colon counts by atleast 38% over control. Glyphosate application reduced the emergence to almost 27% by 90 DAS and 75% by 120 DAS. Reduction in colons was just 18.5% due to neem cake + pendimethalin treatment and 6.7% due to application of soybean oil drops over control. The reduction in *Orobanche* population due to various treatments was proportionally limited in the mustard seed yield. Use of neem cake + pendimethalin or soybean drops increased the seed yield of Indian mustard by at least 7.3% over control (1.43 t/ha). Application of sub-lethal doses of glyphosate significantly increased the seed yield by 20.6% over control. Addition of 1% ammonium sulphate solution did not improve the seed yield further.

Singh *et al.* (2015) reported that pre plant incorporation of pyrazosulfuron ethyl at 200 g/ha was effective for controlling *Orobanche* in mustard. *Orobanche* causes 30-35 percent reduction in yield.

CHAPTER - III

MATERIAL AND METHODS

An investigation to the study the “Effect of integrated management practices for control of *Orobanche* in mustard (*Brassica juncea*) under Gird agro – climatic conditions” was carried out during the *rabi* season of 2015-16. The material used and the methods employed during the course of investigation are dealt with this chapter.

Location, climate and weather data

Gwalior is located at 26°13' North latitude and 78°14' East longitude and 206 metres above mean sea level. It lies in the North tract of M.P. enjoying subtropical climate, with extreme hot about 48°C in summer and minimum temperature 4.0°C in the winter season. The annual rainfall ranges between 750 to 800 mm, most of which received from end of June to end of September, with few showers in winter months. The weather condition was normal during the crop season with an average maximum and minimum temperature during growing period remained as 39.5°C and 15.8°C, respectively. The total rainfall received during the rainy season from June to September 2015. The relevant meteorological data during crop season are presented in Table 3.1 and depicted Fig 3.1.

Experiment site:

The experiment was conducted in field of the Research Farm of Department of Agronomy, College of Agriculture, Gwalior (M.P.). The topography of the field was uniform with proper drainage. The soil of the experimental field was sandy clay loam. Few soil samples of the surface soil up to 15 cm, depth were taken randomly before sowing and a composite sample made after mixing all these, was analysed in the laboratory for mechanical and chemical composition. Data obtained are presented in Table 3.2 and depicted in fig.3.3.

Table 3.1: Meteorological data during crop season 2015-16

Met. Week	Temperature (°C)		Humidity (%)		Rainfall (mm)
	Max.	Min.	Morning	Evening	
45	32.1	17.3	79.2	39.2	000.0
46	31.9	11.6	85.2	28.4	000.0
47	29.2	10.3	91.4	28.3	000.0
48	29.3	12.0	84.7	44.4	000.0
49	28.2	9.0	93.0	56.3	000.0
50	29.7	9.2	93.1	24.4	000.0
51	21.9	3.9	93.7	33.2	000.0
52	23.6	5.6	88.8	28.7	000.0
02	27.0	7.7	94.2	33.1	000.0
02	26.6	8.9	89.8	38.5	000.0
03	18.9	7.0	95.0	69.4	008.0
04	23.0	5.6	92.4	39.5	000.0
05	25.7	8.4	91.4	40.7	000.0
06	25.0	7.6	91.4	36.7	000.0
07	27.1	11.1	84.1	39.4	000.0
08	29.2	11.7	87.0	31.1	000.0
09	32.0	13.0	87.1	32.3	000.0
10	31.5	16.1	84.4	39.1	022.0
11	32.1	15.6	76.5	30.1	000.0
12	34.9	16.7	68.8	17.4	000.0
13	36.0	17.8	67.0	28.2	000.0
14	40.1	22.8	50.1	20.1	000.0
15	39.3	23.0	35.1	18.1	000.0

Source :Meteorological Observatory, College of Agriculture, Gwalior

Mechanical composition of the soil

A perusal of the Table 3.2 shows that the percentage of sand was more in comparison to other fractions. Thus, the soil is categorized as sandy clay loam with low aggregation.

Table 3.2: Mechanical composition of the soil

Component	Percentage by weight	Method employed
Sand	58.80	By International pipette method (Piper, 1950)
Silt	18.40	
clay	22.80	
Textural class	Sandy Clay Loam	

Chemical composition of the soil

The chemical composition of the soil collected from 0-15 cm depth before sowing of mustard is portrayed in Table 3.3.

The data pertaining to various chemical components, presented in Table 3.3, clearly exhibit that soil of the experimental field was rich in potash content, but low in organic carbon, available nitrogen and medium in available phosphorus contents. It is slightly alkaline in reaction and had moderate cation exchange capacity.

Table 3.3: Chemical composition of the soil

S. No.	Soil component	Content	Methods used
1	Cation Exchange capacity	16.18	Ammonium Acetate method
2	pH	7.55	Blackman's Glass Electrode pH meter (Mohen <i>et. al.</i> 1965)
3	Electrical Conductivity (ds/ m) at 25°C	0.43	Solubridge method (Richard, 1954)
4	Organic Carbon (%)	0.42	Walkley and Black's Rapid Titration method (Piper, 1950).
5	Available Nitrogen (kg/ha)	205.60	Alkaline permanganate method (Subbiah and Asiza, 1956)
6	Available Phosphorus (kg/ha)	14.40	Olsen's method (Olsen <i>et al.</i> , 1954)
7	Available potassium (kg/ha)	242.50	Flame Photometer (Muhure <i>et al.</i> , 1965)

Previous cropping history of the field

The cropping history of the experimental field during the preceding three years is summarized in Table 3.4.

Table 3.4: Previous history of the experimental field

S. No.	Year	Kharif Season	Rabi Season
1	2013-14	Guar	Wheat
2	2014-15	Guar	Mustard
3	2015-16	Guar	Present experiment

Experimental details

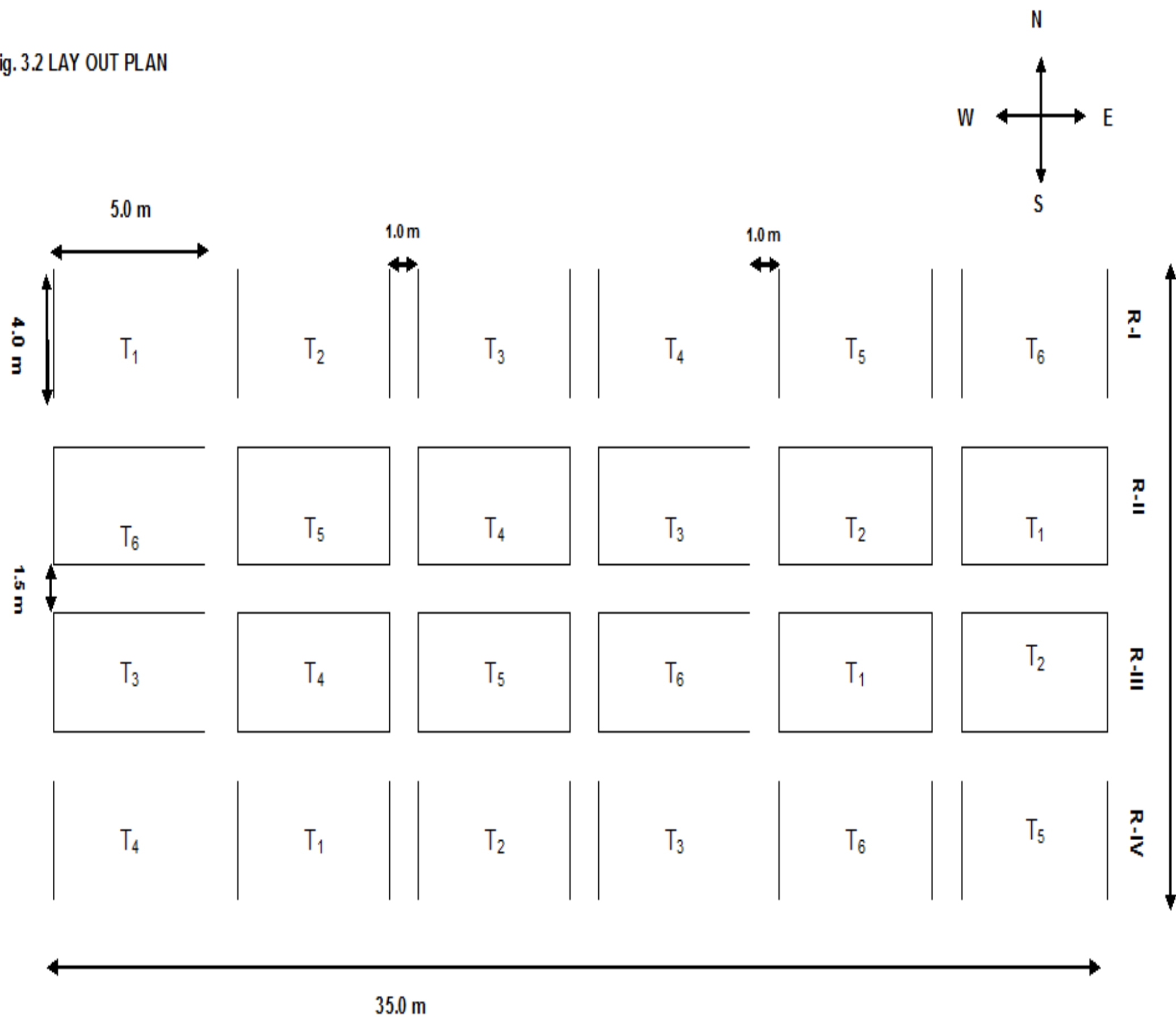
The experiment was conducted in randomized block design with four replications and 6 treatments. The details of layout are given below:

1.	Design	—	R.B.D.
2.	Treatments	—	6
3.	Replications	—	Four
4.	Number of plots	—	24
5.	Gross plot size	—	5.0 m x 4.0 m
6.	Net plot size	—	4.0 m x 3.4 m
7.	Distance between replications	—	1.5 m
8.	Distance between plots	-	1.0 m
9.	Distance between row to row	-	30 cm
10.	Distance between plant to plant	-	10 cm
11.	Fertilizer dose	—	80N: 40 P ₂ O ₅ : 20 K ₂ O kg/ha, respectively
12.	Seed rate	—	5 kg/ha
13.	Variety	-	Rohini

Table 3.5: Treatments and their details

S. No.	Treatments	Symbol
1.	Glyphosate @ 25 and 50 g/ha at 30 DAS and 55 DAS	T ₁
2.	125% of recommended fertility (N & P) + glyphosate@25 and 50 g/ha with 1% solution of NH ₄ SO ₄ at 30 DAS and 55 DAS	T ₂
3.	Neem cake 400 kg/ha at sowing followed by soil drenching of metalaxyl MZ 0.2% at 30 DAS followed by glyphosate at 40 g/ha at 45 DAS	T ₃
4.	Neem cake 400 kg/ha followed by pendimethalin (PPI) at 0.75 kg/ha followed by metalaxyl MZ 0.2% at 30 DAS	T ₄
5.	Neem cake 400 kg/ha followed by soil drenching of metalaxyl MZ 0.2% at 30 DAS	T ₅
6.	Untreated control	T ₆

Fig. 3.2 LAY OUT PLAN



Cultural operation:-

Field preparation

The experimental field was properly prepared in the 2th week of November 2015. When soil became workable, the field was ploughed with disc plough followed by two tillage operations by cultivator. Later on the fields was levelled by plankerto get a good tilth in field.

Application of fertilizer :

The nutrient were applied at the rate of 80 kg N, 40 kg P₂O₅ and 20 kg K₂O/ha. However, 25% higher N and P was applied in treatment T₂.The nitrogen was applied through urea containing 46 per cent N. The half dose of nitrogen with full dose of P₂O₅ and K₂O were given below the seed at the time of sowing as basal application. The remaining half dose of nitrogen was top-dressed after first irrigation.

Seed rate and sowing

Mustard seed (variety Rohini) was sown at the rate of 5 kg/ha on 17 November 2015. Seeds were sown in open furrows at 3-4 cm depth and uniform distance of 30 cm between row to row and 10 cm between plant to plant was maintained. Before sowing, the seeds as treated with fungicides i.e. Thirum + carbendazim @ 2 + 1 gm/kg of seeds.

Thinning operation

After fourteen days of sowing, plot wise thinning was done wherever it was observed necessary.

Harvesting

The variety took 132 days to mature. The border of 30 cm from both end and one row of mustard from each side was harvested on 29.3.16. The harvesting of the net plot was performed on 30.3.016. The green matter was left in the field for four days for sun drying and after this dry matter was transported on the threshing flour.

Threshing :

Before threshing, weight of each bundle of total produce of net plot was recorded and after that threshing was done. Seed weight was recorded in the kilogram with the help of pan balance. The difference between the total weight of produce of each plot and seed weight, showed the weight of stover.

Table 3.6: Details of pre and post sowing operations

S.No.	Operation	Date
1.	Ploughing	11.11.2015
2.	First harrowing	12.11.2015
3.	Second harrowing	13.11.2015
4.	Lay out	15.11.2015
5.	Fertilizer application	16.11.2015
6.	Pre plant incorporation of pendimethalin	17.11.2015
7.	Application of neem cake	17.11.5015
8.	Sowing	17.11.2015
9.	Thinning	02.12.2015
10.	Application of Application of glyphosate and metalaxyl as per treatments	17.12.2015
11.	Top dressing of ½ of the nitrogen dose	22.12.2015
12.	Application of glyphosate as per treatment	01.01.2016
13.	Application of gloyphosate as per treatment	11.01.2016
15.	Harvesting	29.03.2016

Sampling procedures

Following methods were used for recording various observations the field and laboratory. Five plants in each plot were selected with the help of Fisher's random table. These plot plants were tagged and numbered. Observations for each treatment were taken on these plants.

Details of observations to be recorded

The observations, recorded during the course of investigation are detailed as under:-



Plate: 1 General view of experimental plot



Plate: 2 General view of *Orobanche*

ate: 4 Treatment (T₅) Cycloxdim at 100 g a.i./ha + MSO Adjuvent @2ml/l of water at 20 DAS

I. Crop study:

A. Growth parameter:

- (i) Plant population per metre row length at 25 and harvest stage
- (ii) Plant height at 30, 60, 90 DAS and harvest stages
- (iii) Number of branches at 30, 60 90 DAS and harvest stages
- (iv) Number of leaves at 30, 60 and 90 DAS
- (v) Leaf area / plant at 30, 60 and 90 DAS
- (vi) Dry weight of infested and non infested plant (g/plant) at 30,60, 90 DAS and harvest

B. Yield attributing characters:

- (i) Number of siliqua per plant
- (ii) Length of siliqua (cm)
- (iii) Number of seed per siliqua
- (iv) Grain weight (g) per plant
- (v) Test weight (1000 –seed weight)

C. Computed yield:

- (i) Grain yield (kg/ha)
- (ii) Stover yield (kg/ha)
- (iii) Biological yield (kg/ha)
- (v) Harvest index (%)

D. Quality parameters:

- (i) Oil content in seed (%)
- (ii) Oil yield (kg/ha)

II. Weed study

- (i) Days to emergence of *Orobanche* spike
- (ii) *Orobanche* population /m² at 30, 60 and harvest
- (iii) Height of *Orobanche* stem (cm) at 30, 60 and harvest
- (iv) Dry weight (g) of 5 plant *Orobanche* at 30, 60 DAS and harvest
- (v) *Orobanche* control efficiency (%)
- (vi) *Orobanche* index (%)

III. Economics of the treatments

- (i) Cost of cultivation (Rs./ha)
- (ii) Gross and net monitory return (Rs./ha)

(iii) Benefit: cost ratio

Sampling procedures

Following methods were used for recording various observations the field and laboratory. Five plants in each plot were selected with the help of Fisher's random table. These plot plants were tagged and numbered. Observations for each treatment were taken on these plants.

I. Crop study:

A. Growth parameter:

Plant population per meter row length at 25 and harvest stage

After 25 days of sowing when the germination was complete and at harvest, one meter long row was selected randomly at different places in each plot. Later on the number of plants from each plot selected row was counted and their average was taken for calculation.

Plant height (cm)

The height of the plant was measured in centimetre by metre scale from ground level to color of the flag leaf. Height was measured at four stages 30, 60, 90 days after sowing and harvest.

Number of branches per plant :

After 30, 60, 90 day of sowing and at harvest, branches were counted from and 5 tagged plants and recorded.

Number of leaves per plant

After 30, 60 and 90 days of sowing, number of green leaves were counted from selected 5 tagged plants. Fallen leaves were ignored.

Leaf area per plant:

Leaf area per plant was determined by leaf area meter at 30, 60 and 90 days of sowing. The leaves were selected randomly at lower, middle and upper portion from plant and measure the leaf area by leaf area meter than converted leaf area per plant.

B. Yield attributing characters:

Number of siliqua per plant

Total number of seed bearing siliqua of five selected plants were counted at maturity and averaged.

Length of siliqua (cm)

The length of the twenty five siliqua from the selected five tagged plants (five siliquae from each plant) was measured by scale in cm from one end to another. The mean was calculated for each treatment separately.

Number of seed per siliqua

The number of seeds of twenty five siliquae from the tagged plants of each plot was counted. The mean seeds of twenty five siliquae were calculated to estimate the number of seed per siliqua.

Grain weight (g) per plant

Seed weight of randomly selected plants was recorded in grams and averaged to get the weight per plant.

Test weight (1000 –seed weight)

1000-seed from the mixture of 5 selected plants were counted at random and seed weight in grams was recorded.

C. Computed yield:

Grain and stover yield (kg/ha)

After threshing, grain and stover were separated and weighed in kg per plot, the yield of seed and stover was computed per hectare in kilograms by conversion factor 735.29.

Biological yield (kg/ha)

The crop was harvested when almost leaves are dropped and siliqua fully matured. The produce of each plot was tied in bundles, properly labeled and left in the field about a week for sun drying. Before threshing, sundry weight of produce was recorded with the help of spring dial balance and recorded as total dry matter production and converted into kg/ha / hectare.

Harvest index (%)

The harvest index is considered as the yield of economic part expressed as the percentage of the total biological yield in the term of dry matter.

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

D. Quality parameters:

Oil content in seed (%)

Oil content in seed was determined by Soxhlet's oil extraction method (Sadasivam and Monikam, (1998).

$$\text{Oil content (\%)} = \frac{\text{Weight of flask with oil} \times \text{weight of empty flask}}{\text{Weight of sample taken}} \times 100$$

Oil yield (kg/ha)

The grain yield obtained from each treatment was multiplied by the percent oil content in seed (grain) of respective plot for calculation of oil yield. This was reported in kg/ha.

$$\text{Oil yield (kg/ha)} = \frac{\text{Oil Content} \times \text{grain yield (kg/ha)}}{100}$$

II. Weed study

Days to emergence of *Orobanche* spike

The number of days to emergence of *Orobanche* was recorded by regular monitoring of experiment field.

***Orobanche* population /m² at 30, 60 and harvest**

The *Orobanche* population was counted randomly at three places by quadrant of one metre emerged by putting wooden sticks in each plot. The observation was taken 30, 60 days after sowing and at harvest stage.

Height of *Orobanche* stem (cm) at 30, 60 and harvest

The height of the *Orobanche* was measured in centimetre by metre scale from ground level to top. Height was measured at three stages 30, 60 days after sowing and harvest.

Dry weight (g) of 5 plant *Orobanche* at 30, 60 DAS and harvest

The 5 *Orobanche* uprooted randomly with help of *khurpi* in each plot. These were oven dried and their weight was recorded in gram.

***Orobanche* control efficiency (%)**

Orobanche control efficiency of the various treatments were worked out with the help of the following formula.

$$\text{Orobanche control efficiency} = \frac{X - Y}{X} \times 100$$

Where, X = Dry matter production of *Orobanche* in unweeded plot.

Y = Dry matter production of *Orobanche* in treated plot.

Orobanche index (%)

The *Orobanche* index was calculated by using the following formula.

$$\text{Orobanche index} = \frac{A - B}{A} \times 100$$

Where,

A = Yield from maximum *Orobanche* free plot.

B = Yield from other treated plot.

III. Economics of the treatments

Economics of the treatments

Recommendation and adoption of any practice by cultivators depends upon its economics. Therefore, it becomes essential to work out economics of the treatments tested for judging the best treatment under study, for getting higher net profit per hectare.

Cost of cultivation (Rs./ha)

For different treatments total cost was calculated on the basis of prevailing market rates of fertilizer, field preparation, sowing of seeds, labour charges, cultural and intercultural operations as well as expenditure on herbicides, harvesting and threshing of the crop produce etc.

Gross return (Rs. /ha)

For different treatments gross returns were calculated on the basis of prevailing market rate of produce.

Net return (Rs. /ha)

It was calculated treatment wise. The cost of cultivation per hectare was subtracted from the gross income for computing net returns of each treatment.

$$\text{Net profit (Rs./ha)} = \text{Gross return (Rs./ha)} - \text{Cost of cultivation (Rs./ha)}$$

Statistical analysis

All data related to pre and post harvest study of crop collected were statistically analyzed by using the analysis of variance technique (Fisher, 1958). Data so

computed were subjected to Fisher's analysis of variance for judging the effect of various treatments. The skeleton analysis of variance is presented in the Table 3.7.

Table 3.8 : Skeleton of ANOVA for the design of the experiment

S. No.	Source of variation	D.F.	S.S.	M.S.S.	F _{Cal.}	F _{Tab.}
1.	Replication	3				
2.	Treatment	5				
3.	Errors	15		V _e		
	Total	23				

The 'F' test was applied for judging the significance of various treatment effect. Comparison of mean corresponding to different significant effect was made by using critical difference at 5% level of significance.

$$\text{S.E. (m)} \pm = \sqrt{\frac{V_e}{r}}$$

$$\text{C.D.} = \text{S.E. (m)} \pm \times \sqrt{2} \times \text{'t' value at 5\% level}$$

Where,

V_e = Error M.S.

r = Replications

Data transformation

Since the data transformation is the most appropriate remedial measure for variance heterogeneity where the variance and mean are functionally related in to a new scale, resulting in a new data set that is expected to satisfy the condition of homogeneity of variance.

In the present investigation the logarithmic ($Y = \log x$) and square root ($Y = \sqrt{X+0.5}$) transformation scales, where X is the original value of *Orobanche* population, was used for satisfying the condition of homogeneity of variance.

Graphical representation

Data related to the progressive stage of growth are illustrated graphically, while those relating to yield attributing characters and yield/ha are pasteurized with the help of diagrams.

CHAPTER – IV

EXPERIMENTAL FINDINGS

The present chapter deals with the results of experiment laid out during 2015-16 at Research Farm, College of Agriculture, Gwalior (M.P.)

The observation recorded during the course of investigation were statistically analysed and finding are presented under various heads. The results of investigation have been illustrated with figures and diagrams wherever necessary.

A. Crop studies:

1. Growth characters:

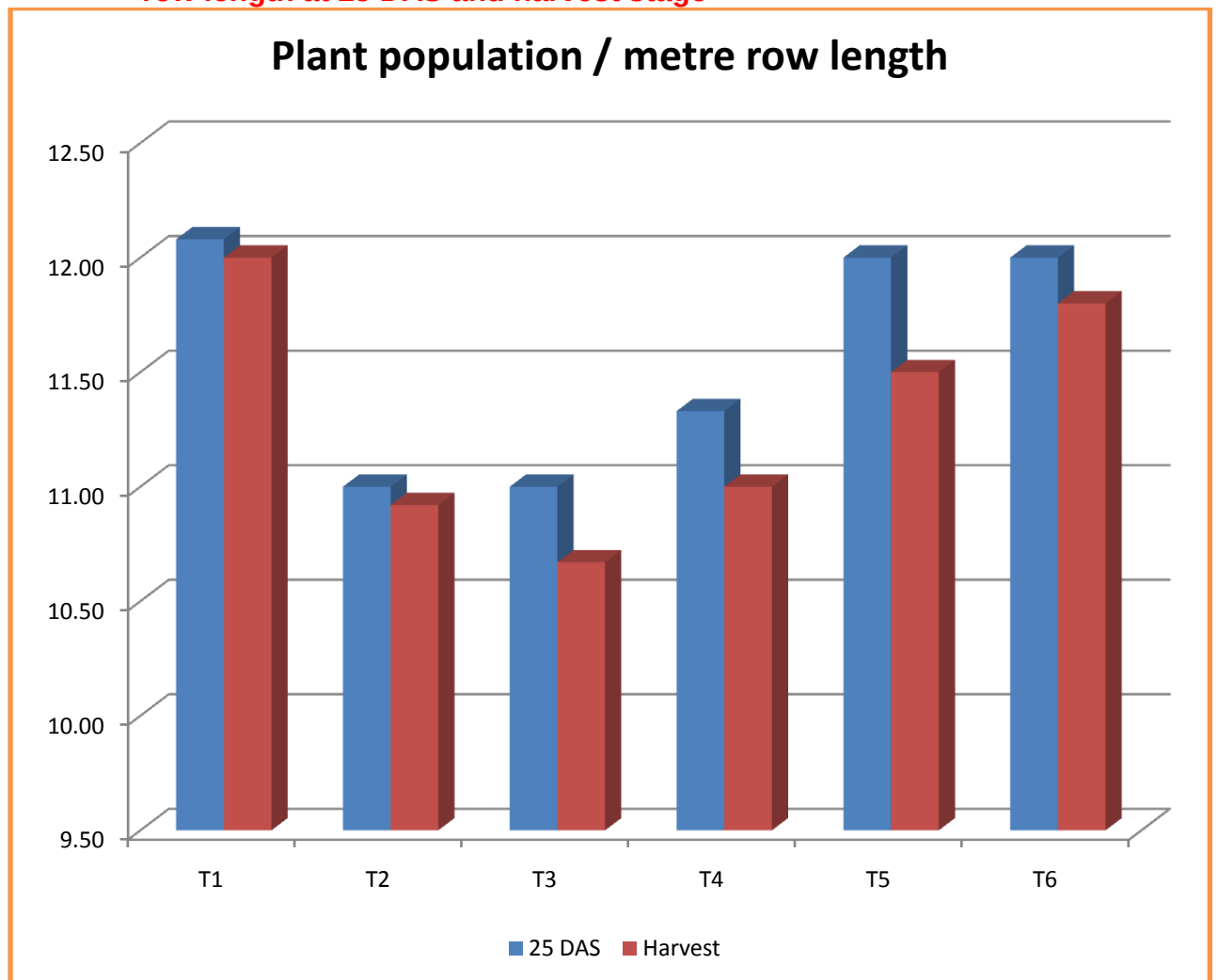
Plant population:

The plant stand recorded at 25 DAS and harvest stages are presented in Table 4.1, while the analysis of variance is given in appendix-I. The results indicated that at both stages the plant population was not affected significantly by different treatments (Fig. 4.1). The plant population range between 11.00 to 12.08 and 10.67 to 12.00 were noted at 25 DAS and harvest stage, respectively.

Table 4.1: Effect of *Orobanche* control measures on plant population per metre row length at 25 DAS and harvest stage

Treatments	Sy.	Plant population/metre row length	
		25 DAS	Harvest
Glyphosate 25 and 50 g/ha at 30 and 55 DAS	T ₁	12.08	12.00
125% of recommended fertility (N & P) + Glyphosate 25 and 50 g/ha with 1% solution of NH ₄ SO ₄ at 30 and 55 DAS	T ₂	11.00	10.92
Neem cake 400 kg/ha at sowing followed by soil drenching of metalaxyl MZ 0.2% at 30 DAS & glyphosate at 40 g/ha at 45 DAS	T ₃	11.00	10.67
Neem cake 400 kg/ha at sowing followed by pendimethalin (PPI) at 0.75 kg/ha & metalaxyl MZ 0.2% at 30 DAS	T ₄	11.33	11.00
Neem cake 400 kg/ha followed by soil drenching of metalaxyl MZ 0.2% at 30 DAS	T ₅	12.00	11.50
Untreated (control)	T ₆	12.00	11.80
S.E.(m)±		0.57	0.57
C.D. (at 5%)		NS	NS

Fig. 4.1: Effect of *Orobanche* control measures on plant population per metre row length at 25 DAS and harvest stage



(ii) Plant height:

Plant height a measure of growth was recorded periodically at an interval of 30 days starting from 30th day up to harvest stage. The mean data in Table 4.2 and Fig. 4.2 indicate that the plant height was found to be influenced significantly due to different treatments at all growth stages except 30 days stage. At 60 DAS, the treatment T₂ recorded significantly higher plant height (124.48 cm) but at par with T₁, T₃ and these treatments resulted in significant increase in plant height over remaining other treatments. The minimum height (101.75) was noted in treatment T₆ (control), which was comparable to T₄ and T₅.

At 90 DAS and harvest stage, the highest plant height (189.95 cm) was registered with treatments T₁ as well as T₂, which was significantly higher as compared to rest of remaining treatments except T₃. The significantly lowest plant height (150.63 cm) was recorded from treatment T₆ (control).

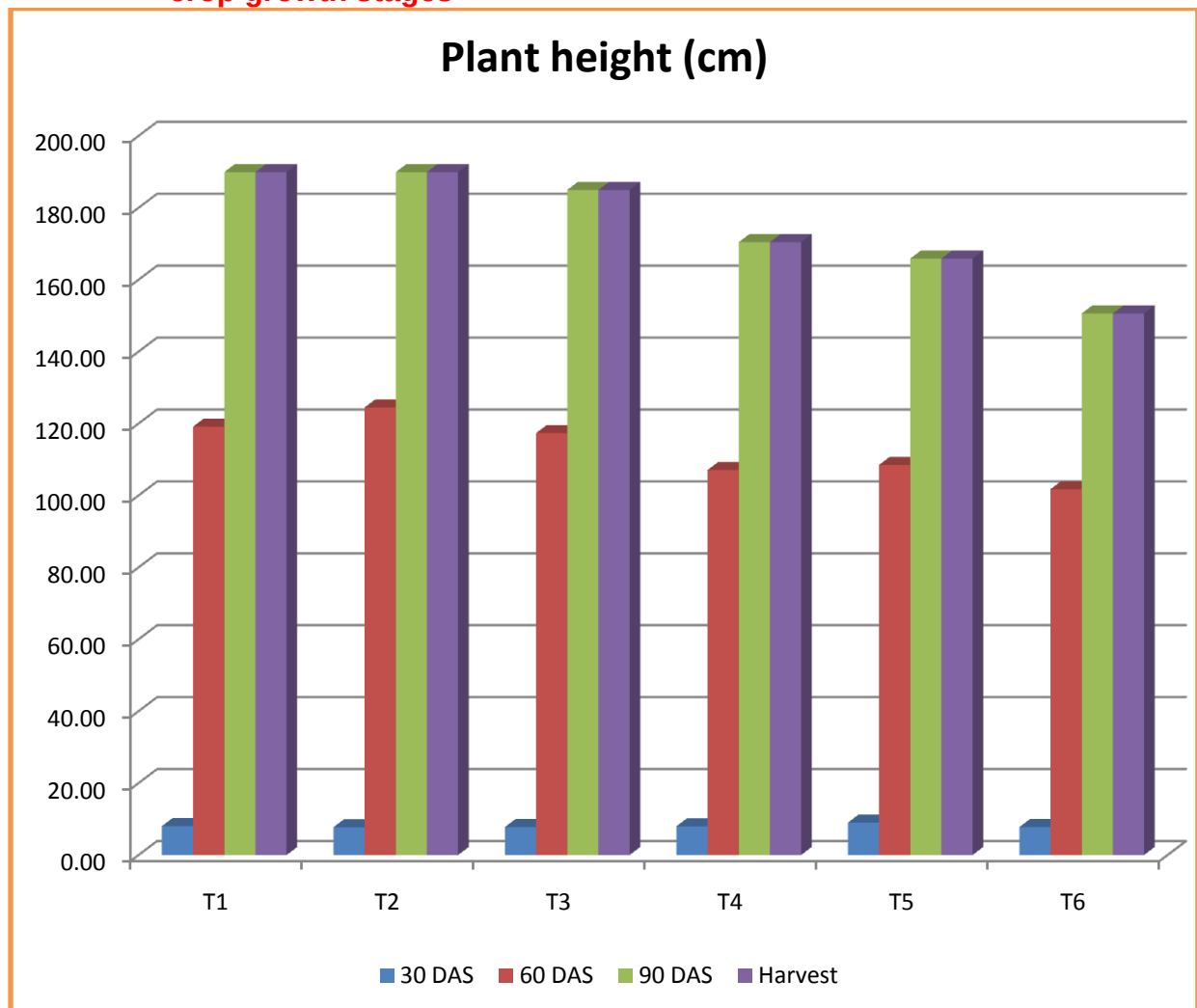
Table 4.2: Effect of *Orobanche* control measures on plant height at successive crop growth stages

Treatments	Sy.	Plant height (cm)			
		30 DAS	60 DAS	90 DAS	Harvest
Glyphosate 25 and 50 g/ha at 30 and 55 DAS	T ₁	8.05	119.15	189.95	189.95
125% of recommended fertility (N & P) + Glyphosate 25 and 50 g/ha with 1% solution of NH ₄ SO ₄ at 30 and 55 DAS	T ₂	7.73	124.48	189.95	189.95
Neem cake 400 kg/ha at sowing followed by soil drenching of metalaxyl MZ 0.2% at 30 DAS fb glyphosate at 40 g/ha at 45 DAS	T ₃	7.78	117.35	184.98	184.98
Neem cake 400 kg/ha at sowing followed by pendimethalin (PPI) at 0.75 kg/ha fb metalaxyl MZ 0.2% at 30 DAS	T ₄	8.00	107.08	170.45	170.45
Neem cake 400 kg/ha followed by soil drenching of metalaxyl MZ 0.2% at 30 DAS	T ₅	9.00	108.50	165.88	165.88
Untreated (control)	T ₆	7.78	101.75	150.63	150.63
S.E.(m)±		0.41	2.49	4.66	4.66
C.D. (at 5%)		NS	7.51	14.04	14.04

Number of branches per plant:

The data pertaining to number of branches /plant at successive growth stages of crop are exhibited in Table 4.3 and illustrated diagrammatically in Fig. 4.3. The formation of branches per plant was augmented steadily in all the treatments with the advancement of plant growth.

Fig. 4.2: Effect of *Orobanche* control measures on plant height at successive crop growth stages



upto 90 days stage. The branches were increased by more than two-fold from 60 to 90 DAS, there after constant till maturity stage in all the treatments (Table 4.3 and Appendix-III).

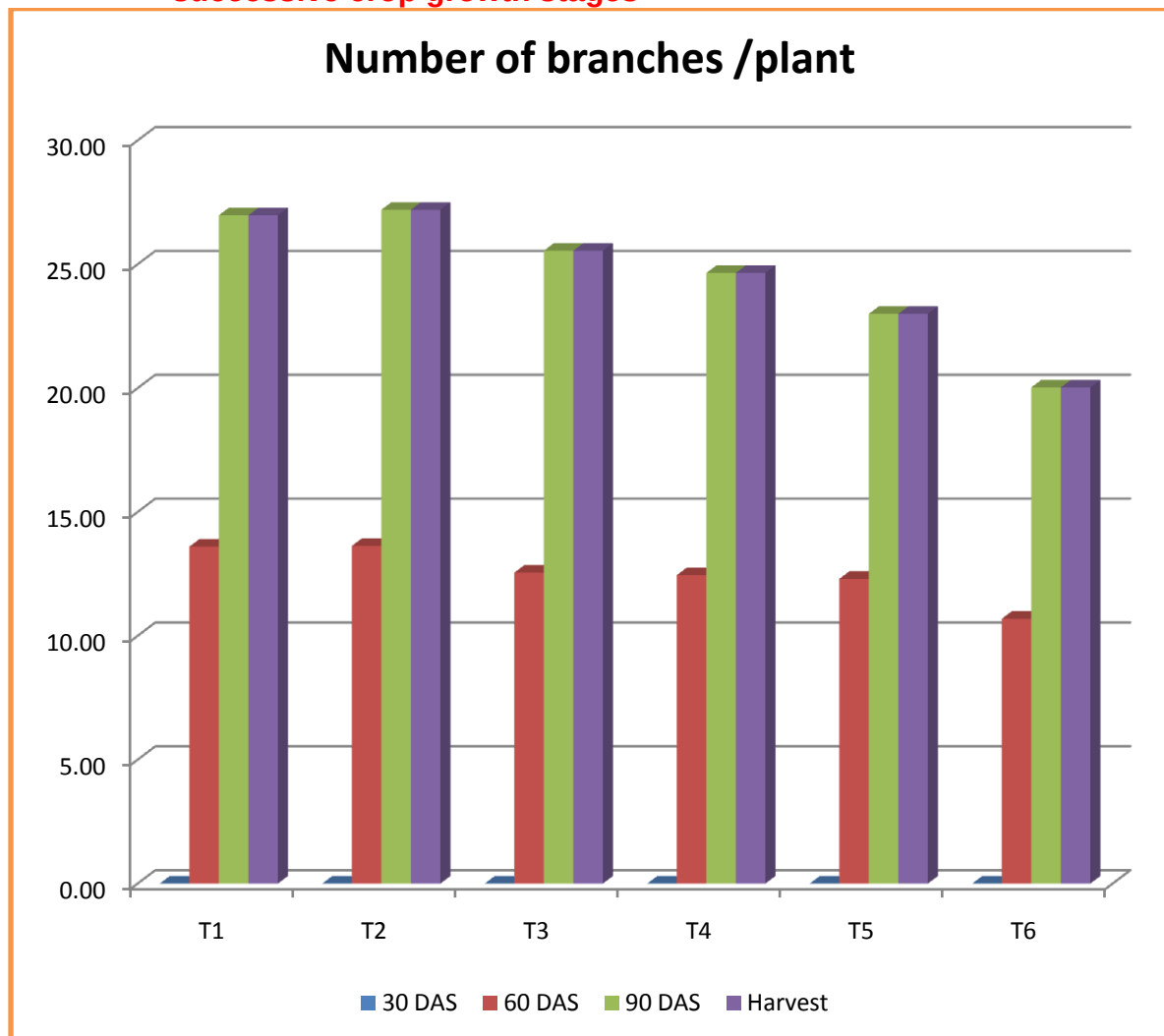
At 60 DAS, all *Orobanche* control treatments significantly increased the number of branches per plant over control (Table 4.3 & Fig. 4.3). The maximum number of branches (13.63/ plant) were recorded under T₂treatment, followed by T₁ and T₃ and all these treatment were at par. The lowest number of branches (10.69/ plant) was registered in control (T₆)

At 90 and harvest, the maximum number of branches (27.20 /plant) were observed under treatment T₂, which was significantly higher over T₃, T₄, T₅ and T₆ and at par with the rest of other treatments. The minimum number of branches (20.03 / plant) were observed in untreated plot.

Table 4.3:Effect of *Orobanche* control measures on number of branches at successive crop growth stages

Treatments	Sy.	Number of branches			
		30 DAS	60 DAS	90 DAS	Harvest
Glyphosate 25 and 50 g/ha at 30 and 55 DAS	T ₁	-	13.60	26.98	26.98
125% of recommended fertility (N &P) + Glyphosate 25 and 50 g/ha with 1% solution of NH ₄ SO ₄ at 30 and 55 DAS	T ₂	-	13.63	27.20	27.20
Neem cake 400 kg/ha at sowing followed by soil drenching of metalaxyl MZ 0.2% at 30 DAS fb glyphosate at 40 g/ha at 45 DAS	T ₃	-	12.55	25.55	25.55
Neem cake 400 kg/ha at sowing followed by pendimethalin (PPI) at 0.75 kg/ha fb metalaxyl MZ 0.2% at 30 DAS	T ₄	-	12.45	24.65	24.65
Neem cake 400 kg/ha followed by soil drenching of metalaxyl MZ 0.2% at 30 DAS	T ₅	-	12.30	23.00	23.00
Untreated (control)	T ₆	-	10.69	20.03	20.03
S.E.(m)±		-	0.38	0.47	0.47
C.D. (at 5%)		-	1.13	1.40	1.40

Fig. 4.3: Effect of *Orobanche* control measures on number of branches at successive crop growth stages



Number of leaves per plant:

The number of functional leaves per plant was recorded at 30, 60 and 90 DAS and the mean data have been presented in Table 4.4 and Fig. 4.4. The analysis of variance (Appendix IV) exhibits that the effects of *Orobanche* control measures on number of leaves per plant recorded at 60 and 90 days stage was, statistically significant. At 60 DAS, the maximum number of leaves (41.0 / plant) were recorded in treatment T₁ and it was significantly higher over T₄, and T₅ treatments including control.

The control plot recorded the minimum number of leaves (28.50 / plant), which was significantly lower compared to other treatments.

At 90 DAS, number of leaves per plant varied from 26.75 to 39.75 per plant. The maximum leaves were recorded by treatment T₁ while minimum by treatment T₆. The former treatment T₁ was found significantly superior to T₃, T₄, T₅ and T₆ and at par with T₂.

Table 4.4:Effect of *Orobanche* control measures on number of leaves at successive crop growth stages

Treatments	Sy.	Number of leaves per plant		
		30 DAS	60 DAS	90 DAS
Glyphosate 25 and 50 g/ha at 30 and 55 DAS	T ₁	7.03	41.00	39.75
125% of recommended fertility (N &P) + Glyphosate 25 and 50 g/ha with 1% solution of NH ₄ SO ₄ at 30 and 55 DAS	T ₂	7.20	40.13	39.08
Neem cake 400 kg/ha at sowing followed by soil drenching of metalaxyl MZ 0.2% at 30 DAS fb glyphosate at 40 g/ha at 45 DAS	T ₃	8.03	38.88	36.13
Neem cake 400 kg/ha at sowing followed by pendimethalin (PPI) at 0.75 kg/ha fb metalaxyl MZ 0.2% at 30 DAS	T ₄	6.68	33.75	33.25
Neem cake 400 kg/ha followed by soil drenching of metalaxyl MZ 0.2% at 30 DAS	T ₅	8.13	32.15	31.75
Untreated (control)	T ₆	7.50	28.50	26.75
S.E.(m)±		0.50	1.12	0.81
C.D. (at 5%)		NS	3.39	2.45

Fig. 4.4: Effect of *Orobanche* control measures on number of leaves at successive crop growth stages



Leaf area per plant (cm²)

The leaf area per plant of mustard was recorded from each treatment at different growth interval and the mean data after statistical analysis are depicted in Table 4.5 and exhibited through Fig. 4.5.

At 30 DAS, Leaf area per plant did not differ significantly due to different treatments. However, it varied from 742.75 to 806.50 cm²/ plant.

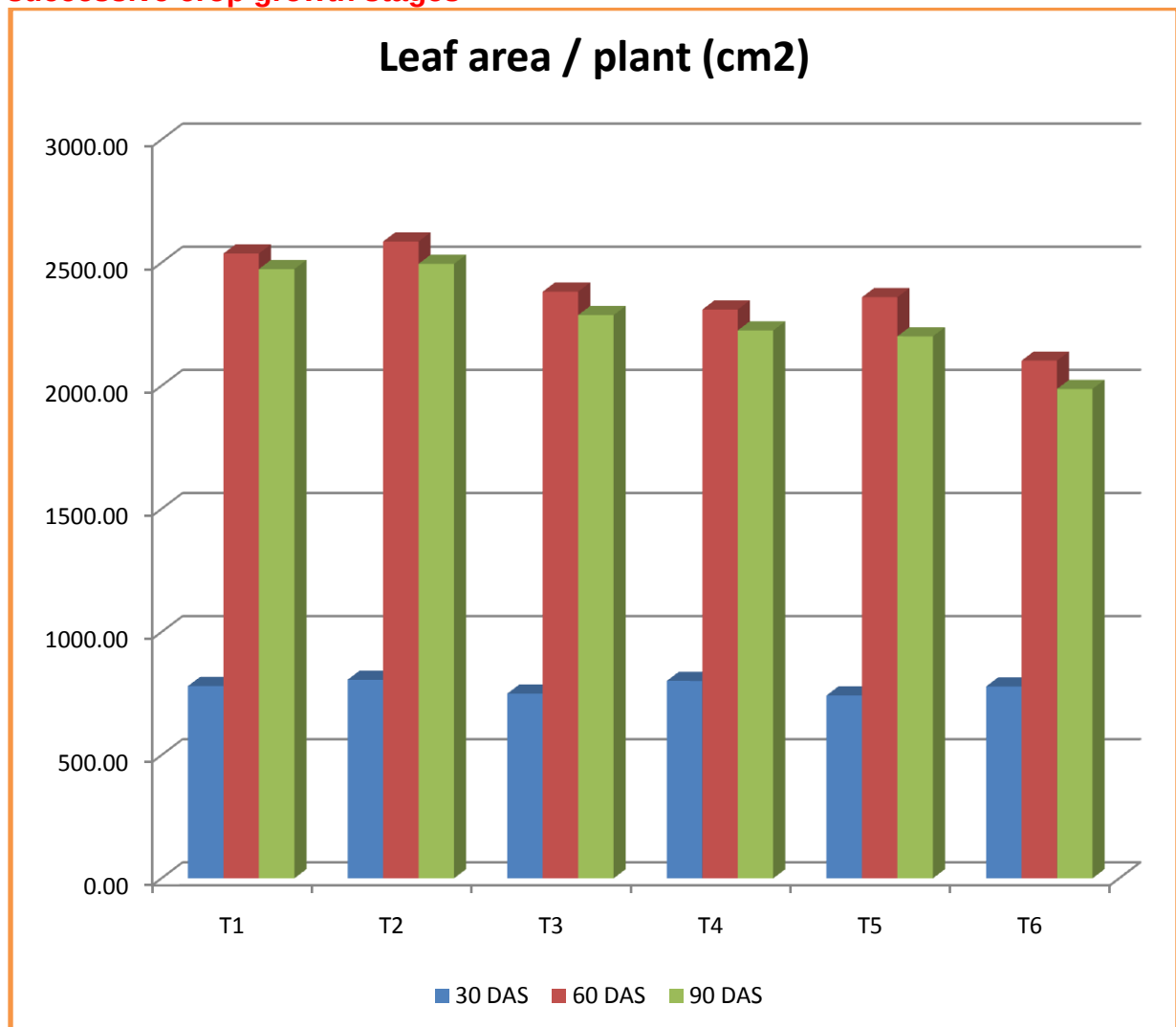
At 60 DAS, The significantly higher leaf area per plant was registered with treatment T₂ and T₁ and both these treatments were at par with each other and resulted leaf area 2586.25 and 2537.50 cm²/plant, respectively. Further, treatment T₃ also gave significantly higher leaf area (2382.50 cm² /plant) over T₆. However, it was statistically at par with T₅ and T₄ treatments. The lowest leaf area (2102.50 cm²/plant) was obtained under untreated plot (T₆).

Table 4.5: Effect of *Orobanche* control measures on leaf area per plant at successive crop growth stages

Treatments	Sy.	Leaf area per plant (cm ²)		
		30 DAS	60 DAS	90 DAS
Glyphosate 25 and 50 g/ha at 30 and 55 DAS	T ₁	781.03	2537.50	2474.50
125% of recommended fertility (N & P) + Glyphosate 25 and 50 g/ha with 1% solution of NH ₄ SO ₄ at 30 and 55 DAS	T ₂	806.50	2586.25	2495.50
Neem cake 400 kg/ha at sowing followed by soil drenching of metalaxyl MZ 0.2% at 30 DAS fb glyphosate at 40 g/ha at 45 DAS	T ₃	750.00	2382.50	2287.50
Neem cake 400 kg/ha at sowing followed by pendimethalin (PPI) at 0.75 kg/ha fb metalaxyl MZ 0.2% at 30 DAS	T ₄	802.00	2310.00	2225.25
Neem cake 400 kg/ha followed by soil drenching of metalaxyl MZ 0.2% at 30 DAS	T ₅	742.75	2360.00	2201.25
Untreated (control)	T ₆	779.25	2102.50	1987.50
S.E.(m)±		26.72	42.61	36.01
C.D. (at 5%)		NS	128.43	108.52

At 90 DAS, all *Orobanche* control treatments gave significantly higher leaf area per plant over control plot. The maximum leaf area (2495.50 cm²/ plant) was noted under treatment T₂ followed by T₁ and both these treatments were found statistically at par with each other and significantly higher over remaining treatments. Significantly lower leaf area (1987.50 cm²/ plant) was registered in treatment T₆.

Fig. 4.5: Effect of *Orobanch*e control measures on leaf area per plant at successive crop growth stages



Dry weight of infested plant (g)

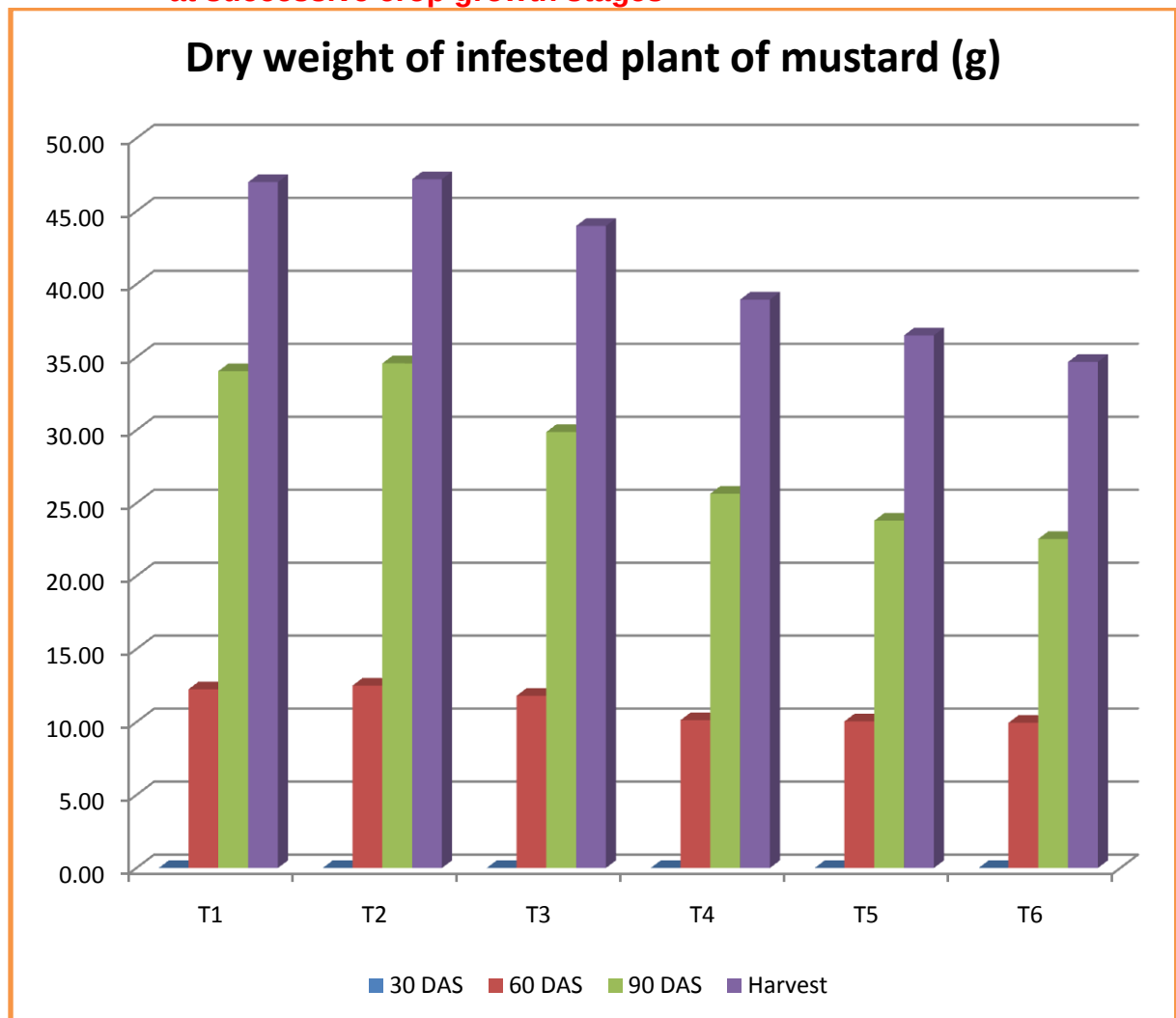
The data recorded in respect of dry weight of infested plant were analysed statistically (Appendix-VI). The mean dry weight of infested plant is presented in Table 4.6 and illustrated in Fig 4.6.

Table 4.6: Effect of *Orobanche* control measures on dry weight of infested plant at successive crop growth stages

Treatments	Sy.	Dry weight of infested plant (g)			
		30 DAS	60 DAS	90 DAS	Harvest
Glyphosate 25 and 50 g/ha at 30 and 55 DAS	T ₁	-	12.25	34.05	47.00
125% of recommended fertility (N & P) + Glyphosate 25 and 50 g/ha with 1% solution of NH ₄ SO ₄ at 30 and 55 DAS	T ₂	-	12.50	34.58	47.20
Neem cake 400 kg/ha at sowing followed by soil drenching of metalaxyl MZ 0.2% at 30 DAS fb glyphosate at 40 g/ha at 45 DAS	T ₃	-	11.80	29.88	44.00
Neem cake 400 kg/ha at sowing followed by pendimethalin (PPI) at 0.75 kg/ha fb metalaxyl MZ 0.2% at 30 DAS	T ₄	-	10.13	25.65	38.95
Neem cake 400 kg/ha followed by soil drenching of metalaxyl MZ 0.2% at 30 DAS	T ₅	-	10.05	23.80	36.50
Untreated (control)	T ₆	-	9.95	22.55	34.68
S.E.(m)±		-	0.28	0.47	0.65
C.D. (at 5%)		-	0.85	1.40	1.95

At 60, 90 DAS and harvest, all treatments produced significantly higher dry weight of infested plant over control at all these stages except T₄ and T₅ at 60 DAS and T₅ at 60, 90 DAS and harvest stages. Significantly higher but statistically equal dry weight of infested plant of mustard was found in treatments T₂ and T₁ as compared to rest of the other treatments at all the stages. Minimum dry weight of infested plant of mustard was observed in treatment T₆.

Fig. 4.6: Effect of *Orobanche* control measures on dry weight of infested plant at successive crop growth stages



Dry weight of non infested plant

The dry weight per plant of mustard was recorded from each treatment at different growth interval and the mean data after statistical analysis are depicted in Table 4.7 and exhibited through Fig. 4.7.

Table 4.7 revealed that dry weight of non infested plant of mustard significantly affected due to all treatment at all the stages.

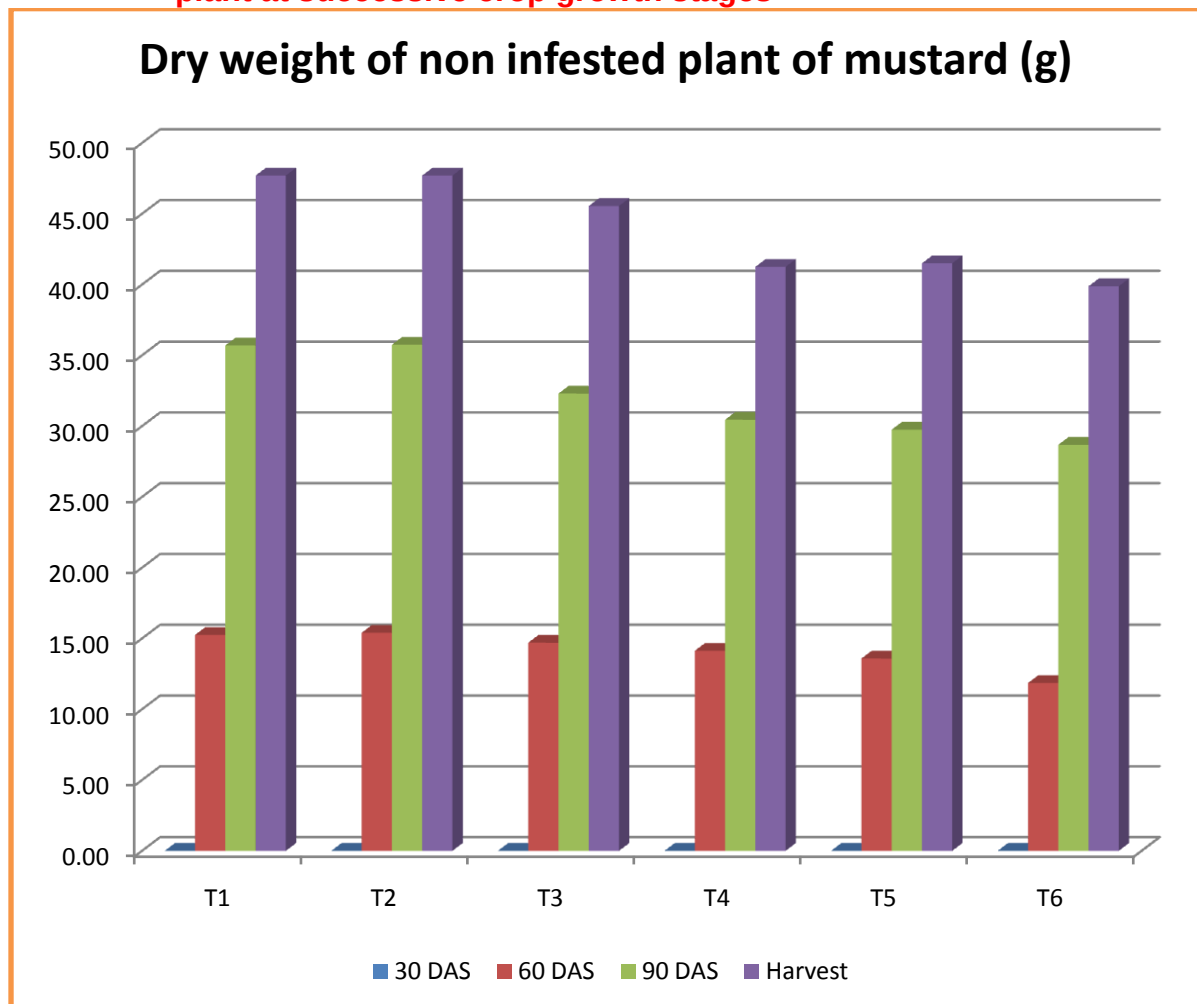
Table 4.7: Effect of *Orobanch* control measures on dry weight of non infected plant at successive crop growth stages

Treatments	Sy.	Dry weight of non infested plant (g)			
		30 DAS	60 DAS	90 DAS	Harvest
Glyphosate 25 and 50 g/ha at 30 and 55 DAS	T ₁	-	15.25	35.70	47.70
125% of recommended fertility (N & P) + Glyphosate 25 and 50 g/ha with 1% solution of NH ₄ SO ₄ at 30 and 55 DAS	T ₂	-	15.40	35.75	47.70
Neem cake 400 kg/ha at sowing followed by soil drenching of metalaxyl MZ 0.2% at 30 DAS followed by glyphosate at 40 g/ha at 45 DAS	T ₃	-	14.70	32.30	45.55
Neem cake 400 kg/ha at sowing followed by pendimethalin (PPI) at 0.75 kg/ha followed by metalaxyl MZ 0.2% at 30 DAS	T ₄	-	14.13	30.45	41.25
Neem cake 400 kg/ha followed by soil drenching of metalaxyl MZ 0.2% at 30 DAS	T ₅	-	13.58	29.75	41.50
Untreated (control)	T ₆	-	11.85	28.68	39.88
S.E.(m)±		-	0.48	0.72	0.60
C.D. (at 5%)		-	1.45	2.18	1.82

At 60 DAS, The significantly higher dry weight of non infested plant of mustard (15.40 g/plant) was registered with treatment T₂ followed by T₁, T₃, T₄ and all these treatments were at par with each other and significantly higher over control. The lowest dry weight of non infested plant of mustard (11.85 g/plant) was obtained under untreated plot.

At 90 DAS and harvest stage, all the integrated management treatments except T₄ and T₅ produced significantly higher dry weight of non infested plant of mustard over control at 90 and harvest stage. The maximum

Fig. 4.7: Effect of *Orobanche* control measures on dry weight of non infected plant at successive crop growth stages



dry weight of non infested plant of mustard (35.75 and 47.70 g/plant, at 90 DAS and harvest, respectively) was recorded under the treatment T₂, which was statistically at par with T₁ and significantly superior over rest of the treatments. The lowest dry weight of 26.68, and 39.88 g/plant was recorded with the control plot at 90 DAS and harvest stage, respectively. However, it was comparable to T₄ and T₅ at both stages.

Yield attributing characters:

Number of siliquae per plant:

The number of siliquae per plant was significantly influenced by different weed control measures are presented in Table 4.8 and depicted graphically in Fig.4.8 The analysis of variance given in Appendix-VIII. All the integrated management practices to control *Orobanche* resulted significant increase in number of siliquae per plant over control plot. The maximum number of siliquae (255.25/ plant) were recorded under treatment T₂ which was statistically superior to rest of the treatments except T₁. Minimum number of siliquae (182.10/ plant) was registered in control plot.

Length of siliqua (cm)

The data in Table 4.8 and illustrated through Fig. 4.8 revealed that the siliqua length was influenced significantly by the various treatments. The maximum siliqua length (4.40 cm) was obtained under the treatment T₂, which was significantly higher as compared to rest of the treatments. However, treatment T₁ being at par with T₃, and resulted in significantly higher siliqua length than T₄, T₅ and T₆. The lowest siliqua length (3.64 cm) was observed with treatment T₆, which was significantly inferior over rest of other treatments.

Number of seeds/siliqua

The statistical analysis of data pertaining to number of seeds per siliqua has been summarized in Appendix-VIII, where it is reviewed that the number of seed per siliqua was unaffected by different integrated management practices to control *Orobanche*. The number of seeds per siliqua ranged between 11.83 (T₆) to 12.67 (T₁).

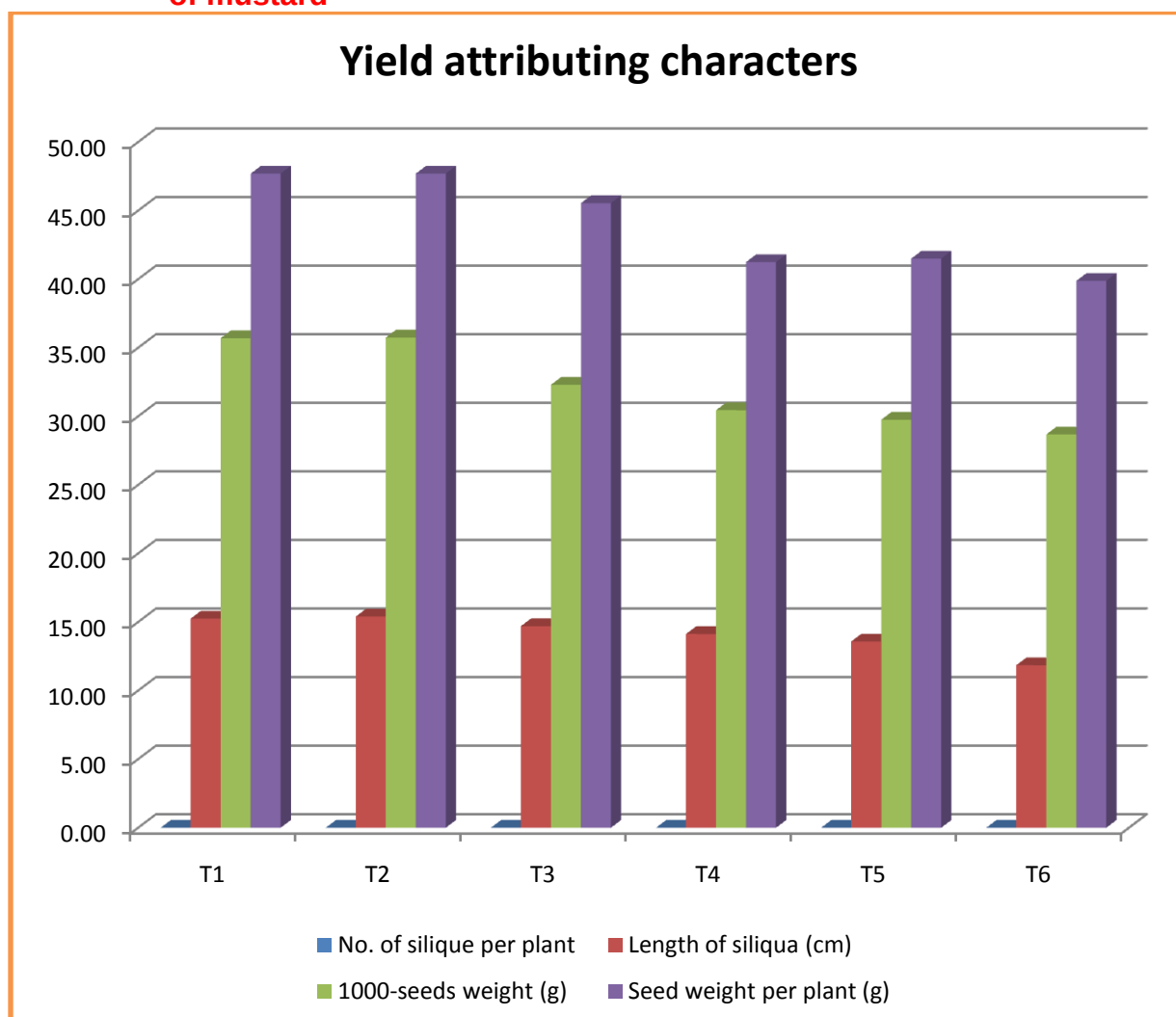
Table 4.8: Effect of *Orobanche* control measures on yield attributing characters of mustard

Treatments	Sy.	Yield attributing characters				
		No. of silique/plant	Length of siliqua (cm)	No. of seeds/siliqua	1000-seeds weight (g)	Seed weight (g/plant)
Glyphosate 25 and 50 g/ha at 30 and 55 DAS	T ₁	249.00	4.23	12.67	4.57	18.95
125% of recommended fertility (N & P) + Glyphosate 25 and 50 g/ha with 1% solution of NH ₄ SO ₄ at 30 and 55 DAS	T ₂	255.25	4.40	12.42	4.56	19.07
Neem cake 400 kg/ha at sowing followed by soil drenching of metalaxyl MZ 0.2% at 30 DAS fb glyphosate at 40 g/ha at 45 DAS	T ₃	228.00	4.18	12.58	4.24	18.35
Neem cake 400 kg/ha at sowing followed by pendimethalin (PPI) at 0.75 kg/ha fb metalaxyl MZ 0.2% at 30 DAS	T ₄	211.50	4.00	12.42	4.01	17.15
Neem cake 400 kg/ha followed by soil drenching of metalaxyl MZ 0.2% at 30 DAS	T ₅	197.00	3.98	11.84	3.88	16.20
Untreated (control)	T ₆	182.10	3.64	11.83	3.63	14.78
S.E.(m)±		4.41	0.11	0.38	0.04	0.12
C.D. (at 5%)		13.30	0.33	NS	0.11	0.35

Test weight (g)

The test weight of 1000-seed was recorded treatment wise and the data after statistical analysis are presented in Table 4.8 and illustrated diagrammatically through Fig. 4.8. The perusal of data indicated that this yield attributing parameter was influenced significantly due to different treatments. The significantly higher test weight 4.57 g and 4.56 g was recorded with treatment T₁ and T₂, respectively and both these treatments were significantly superior over rest of other treatments. However, treatments T₁ and T₂ were at par to each other. Treatment T₃ was also gave significantly higher test weight as compared to T₄, T₅ and T₆. The significantly lowest test weight (3.63 g) was noted in control (T₆) treatment.

Fig 4.8: Effect of *Orobanche* control measures on yield attributing characters of mustard



Grain weight per plant (g)

Grain weight per plant is an important parameter of grain yield of mustard. The data of grainweight per plant is presented in Table 4.8 and shown graphically in Fig. 4.8. The data were analyzed statistically and ANOVA is given in Appendix-VIII.

Grain weight per plant was significantly affected due to different treatments. The maximum grain weight per plant (19.07 g) was recorded under the treatment T₂, which was significantly higher over the remaining treatments except T₁. The treatment T₆(untreated plot) produced the lowest grain weight per plant (14.78 g) which was significantly lower than remaining treatments

Grain yield (kg/ha)

The grain yield per hectare was significantly influenced by treatments (Appendix-IX). All treatments to control of *Orobanche* increased the grain yield significantly over control (Table 4.6 and Fig. 4.9). Significantly higher grain yield of 1890 kg/ha was obtained with treatment T₂ followed by T₁ (1870 kg/ha), T₃ (1726 kg/ha). However, all integrated treatments resulted in 11.51 to 40.31 per cent increase in grain yield over control. The uncontrolled *Orobanche* in untreated plot reduced the grain yield by 28.73, 27.97 and 21.93 per cent when compared to grain yield with treatment T₂, T₁ and T₃, respectively. The minimum grain yield (1347 kg/ha) was found under control plot (T₆).

Stover yield (kg/ha)

The data pertaining to this study were analysed statistically and analysis of variance is given in Appendix-IX, where it is observed that maximum stover yield (4313 kg/ha) recorded in T₂ but at par with treatment T₁ (4292 kg/ha) and T₃ (4188 kg/ha) and significantly higher over rest of other treatments. The minimum stover yield (3463 kg/ha) was recorded under untreated plot (T₆) which was significantly inferior to rest of the treatments.

Table 4.9: Effect of *Orobanch* control measures on grain, stover and biological yield per hectare and harvest index

Treatments	Sy.	Grain yield (kg/ha)	Stover yield (kg/ha)	Biological yield (kg/ha)	Harvest index (%)
Glyphosate 25 and 50 g/ha at 30 and 55 DAS	T ₁	1870	4292	6162	30.34
125% of recommended fertility (N & P) + Glyphosate@ 25 and 50 g/ha with 1% solution of NH ₄ SO ₄ at 30 and 55 DAS	T ₂	1890	4313	6203	30.47
Neem cake 400 kg/ha at sowing followed by soil drenching of metalaxyl MZ 0.2% at 30 DAS fb glyphosate at 40 g/ha at 45 DAS	T ₃	1726	4188	5914	29.18
Neem cake 400 kg/ha at sowing followed by pendimethalin (PPI) at 0.75 kg/ha fb metalaxyl MZ 0.2% at 30 DAS	T ₄	1628	3990	5618	28.97
Neem cake 400 kg/ha followed by soil drenching of metalaxyl MZ 0.2% at 30 DAS	T ₅	1502	3738	5240	28.66
Untreated (control)	T ₆	1347	3463	4810	28.00
S.E.(m)±		41	79	117	0.25
C.D. (at 5%)		122	239	352	0.75

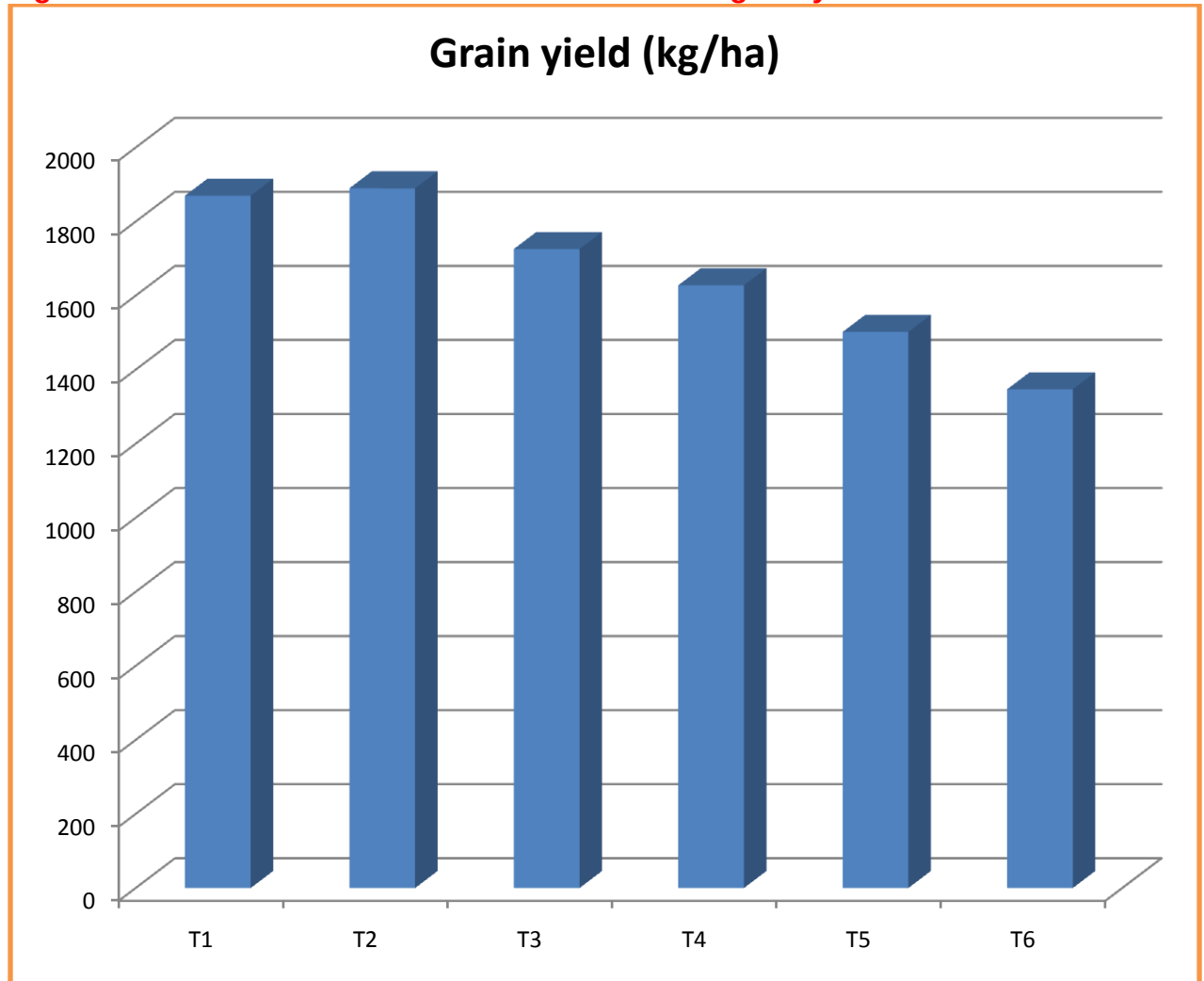
Biological yield (kg/ha)

The data is presented in Table 4.9 and analysis of variance in Appendix-IX. The significantly higher biological yield (6203 kg/ha) was noted in treatment T₂ but at par with treatment T₂ and T₃. The lowest biological yield (4810 kg/ha) was recorded by the treatment T₆ (control) which was found to be statistically inferior to rest of the treatments.

Harvest index (%)

The data of mustard crop pertaining to harvest index are presented in Table 4.9 and depicted graphically in Fig.4.10. The recorded data were analyzed statistically and ANOVA is given in Appendix-IX. The data revealed that all treatments significantly increased harvest index over control. The significantly higher value of harvest index (30.47%) was recorded with treatment T₂, followed by T₁ (30.34%) and both these treatments were at par with each other and they were significantly superior over rest of the treatments. The lowest harvest index registered with T₆ (control), which was comparable to T₅ treatment.

Fig. 4.9: Effect of *Orobanche* control measures on grain yield



Quality parameter:**Oil content (%)**

Analysis of variance (Appendix -X) revealed that oil content in grain of mustard did not differ significantly among different treatments. However, it varied from 39.75 to 40.29 per cent (Table 4.10)

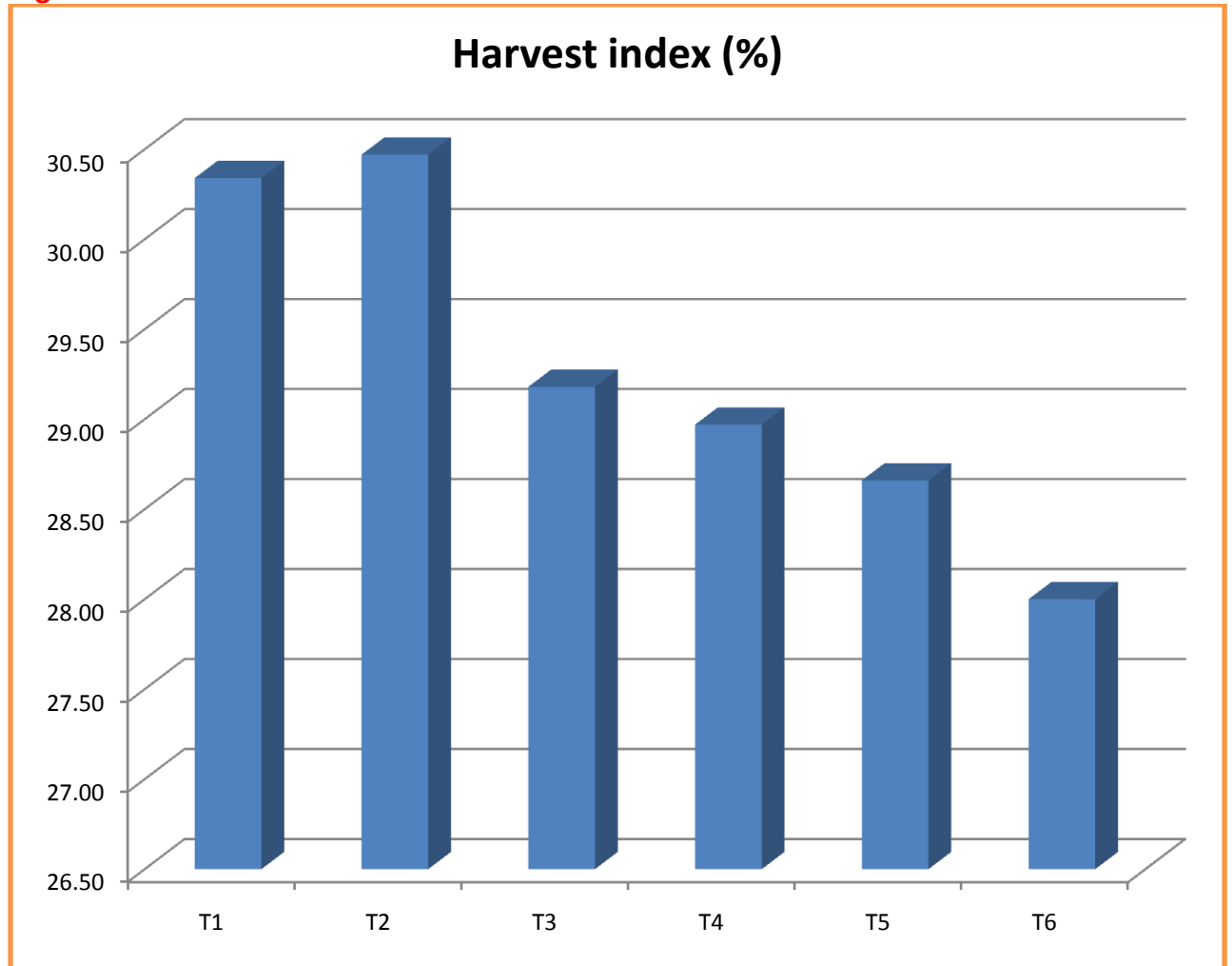
Table 4.10: Effect of *Orobanche* control measures on oil content in grain and oil yield per hectare

Treatments	Sy.	Oil content (%)	Oil yield (kg/ha)
Glyphosate 25 and 50 g/ha at 30 and 55 DAS	T ₁	40.29	753
125% of recommended fertility (N & P) + Glyphosate @ 25 and 50 g/ha with 1% solution of NH ₄ SO ₄ at 30 and 55 DAS	T ₂	40.10	758
Neem cake 400 kg/ha at sowing followed by soil drenching of metalaxyl MZ 0.2% at 30 DAS followed by glyphosate at 40 g/ha at 45 DAS	T ₃	39.85	688
Neem cake 400 kg/ha at sowing followed by pendimethalin (PPI) at 0.75 kg/ha followed by metalaxyl MZ 0.2% at 30 DAS	T ₄	39.95	650
Neem cake 400 kg/ha followed by soil drenching of metalaxyl MZ 0.2% at 30 DAS	T ₅	39.75	597
Untreated (control)	T ₆	40.25	539
S.E.(m)±		0.42	17
C.D. (at 5%)		NS	51

Oil yield (kg/ha)

Oil yield was significantly influenced by different management practices among various treatments (Appendix-X). All the treatments produced significantly higher oil yield over control (Table 4.10 and Fig 4.11). The treatment T₂ produced the maximum oil yield (758 kg/ha), which was significantly higher than T₃ (688 kg/ha), T₄ (650 kg/ha), T₅ (597 kg/ha), and T₆ (539 kg/ha) and at par with remaining treatments. The untreated plot gave significantly lower oil yield.

Fig. 4.10: Effect of *Orobanche* control measures on harvest index



Days to emergence of *Orobanche*

The data (Table 4.11) reveals that the days to emergence of *Orobanche* was not influenced by different treatments. However it's ranged from 51.25 days. with T₅ to 59.00 days in treatment T₂.

Table 4.11:Effect of *Orobanche* control measures on days to emergence of *Orobanche* spike

Treatments	Sy.	Days to emergence of <i>Orobanche</i> spike
Glyphosate 25 and 50 g/ha at 30 and 55 DAS	T ₁	53.50
125% of recommended fertility (N &P) + Glyphosate 25 and 50 g/ha with 1% solution of NH ₄ SO ₄ at 30 and 55 DAS	T ₂	59.00
Neem cake 400 kg/ha at sowing followed by soil drenching of metalaxyl MZ 0.2% at 30 DAS fb glyphosate at 40 g/ha at 45 DAS	T ₃	57.50
Neem cake 400 kg/ha at sowing followed by pendimethalin (PPI) at 0.75 kg/ha fb metalaxyl MZ 0.2% at 30 DAS	T ₄	57.25
Neem cake 400 kg/ha followed by soil drenching of metalaxyl MZ 0.2% at 30 DAS	T ₅	51.25
Untreated (control)	T ₆	53.75
S.E.(m)±		4.08
C.D. (at 5%)		NS

Orobanche population/m²

The perusal of data in Table 4.12 and Appendix-XI, revealed that population of *Orobanche* /m² was significantly influenced by different treatments at 60DAS and harvest stage.

At 60DAS, the significantly lower population *Orobanche* (2.00 /m²) was observed in treatment T₁ as well as T₂. However, they were statistically at par to each other. Maximum population of *Orobanche* was observed in control plot, which was comparable to T₅ treatment.

At harvest, treatment T₂ gave lowest population of *Orobanche*. However, it was found statistically at par with treatment T₁ and significantly lower over remaining treatments. Highest population *Orobanche* (5.75 /m²) was recorded at under control, which was comparable to treatment T₅.

Fig. 4.11: Effect of *Orobanche* control measures on oil yield

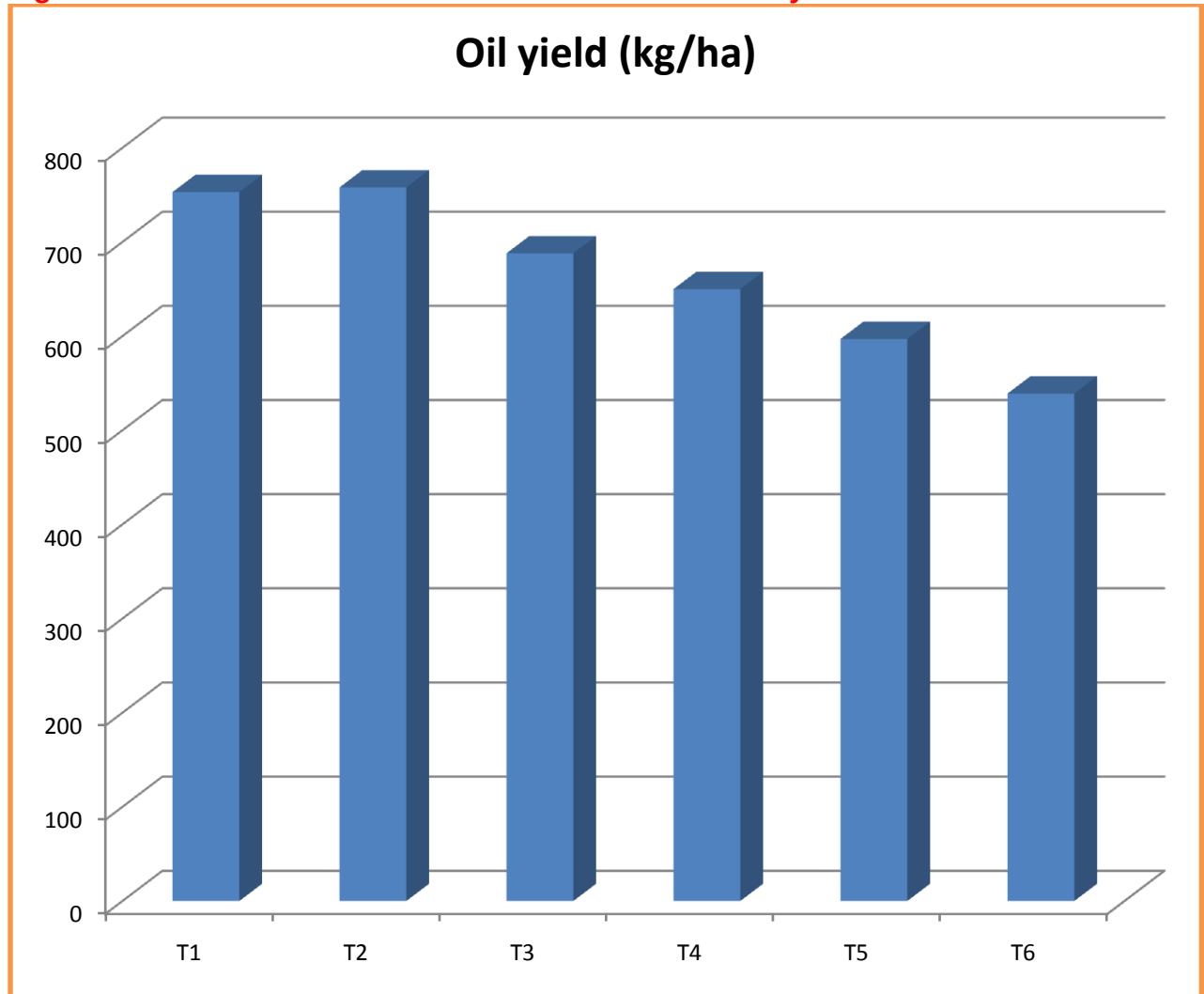


Table 4.12:Effect of *Orobanche* control measures on *Orobanche* population at 30, 60 DAS and harvest stages

Treatments	Sy.	<i>Orobanche</i> population /m ²		
		30 DAS	60 DAS	Harvest
Glyphosate 25 and 50 g/ha at 30 and 55 DAS	T ₁	-	1.39 (2.00)	1.10 (0.75)
125% of recommended fertility (N &P) + Glyphosate 25 and 50 g/ha with 1% solution of NH ₄ SO ₄ at 30 and 55 DAS	T ₂	-	1.39 (2.00)	0.97 (0.50)
Neem cake 400 kg/ha at sowing followed by soil drenching of metalaxyl MZ 0.2% at 30 DAS fb glyphosate at 40 g/ha at 45 DAS	T ₃	-	1.80 (3.25)	1.56 (2.00)
Neem cake 400 kg/ha at sowing followed by pendimethalin (PPI) at 0.75 kg/ha fb metalaxyl MZ 0.2% at 30 DAS	T ₄	-	2.10 (4.50)	1.98 (3.50)
Neem cake 400 kg/ha followed by soil drenching of metalaxyl MZ 0.2% at 30 DAS	T ₅	-	2.24 (5.00)	2.22 (4.50)
Untreated (control)	T ₆	-	2.45 (6.00)	2.49 (5.75)
S.E.(m)±		-	0.11	0.14
C.D. (at 5%)		-	0.34	0.42

Height of *Orobanche* stem (cm)

The data presented in Table 4.13 and Appendix-XII, showed that the height of *Orobanche* stem significantly reduced due to different treatments at 60 DAS and harvest stage.

At 60 DAS, treatment T₂ gave lowest height of *Orobanche* stem followed by treatment T₁ and both were found statistically at par with each other. Significantly higher height of *Orobanche* stem (5.45 cm) was registered in treatment T₆ (Fig. 4.12). However, treatment T₅ also gave statistically similar plant height as registered in T₆.

At harvest, all treatment except T₅ reduced height of *orobanche* stem over control. Lowest height of *Orobanche* stem was noted in treatment T₂ followed by T₁ and both were found statistically at par with each other. Maximum height of *Orobanche* stem (29.10 cm) was observed with untreated plot.

Fig. 4.12: Effect of *Orobanche* control measures on height of *Orobanche* stem at 30, 60 DAS and harvest stages

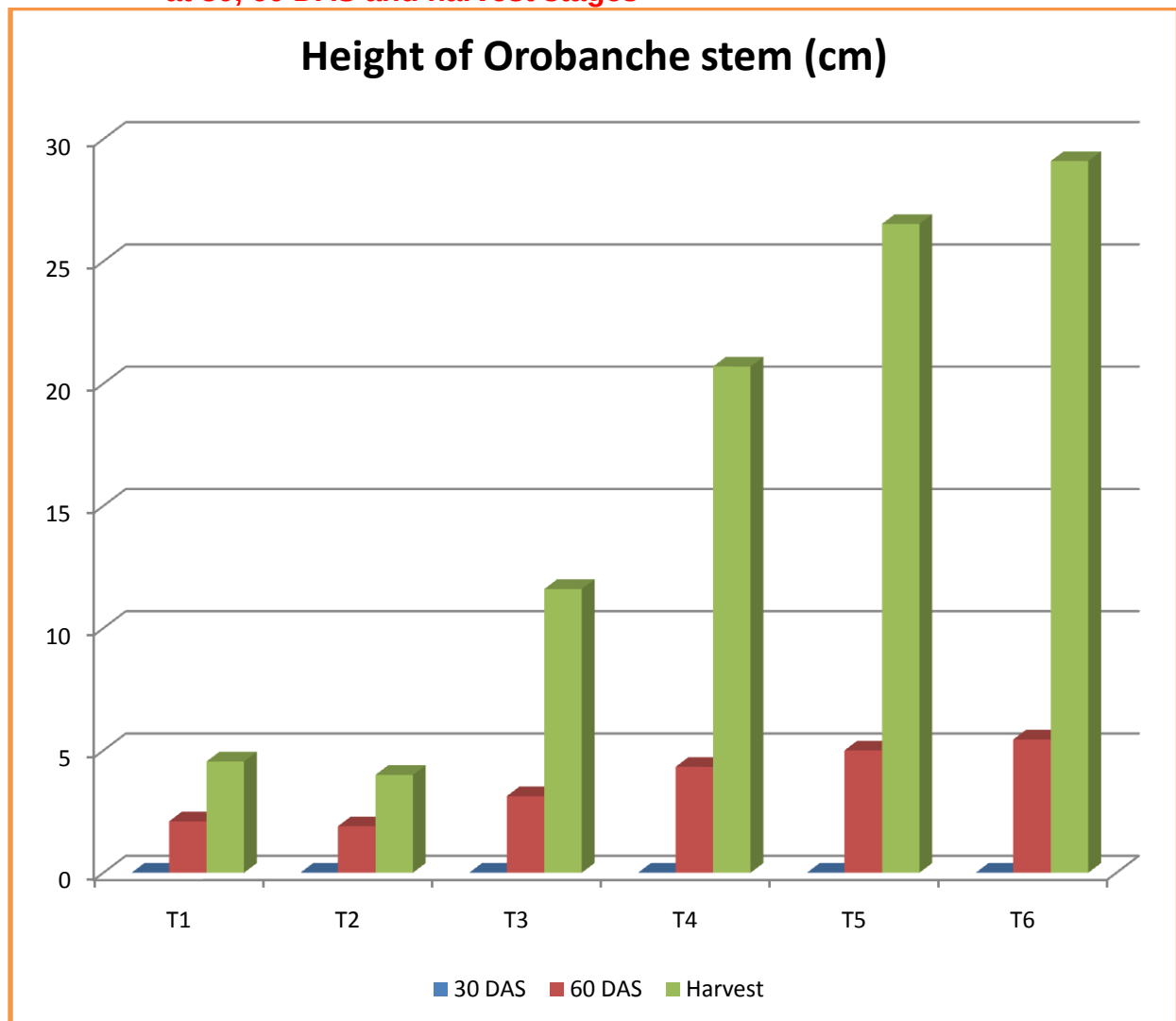


Table 4.13: Effect of *Orobanche* control measures on height of *Orobanche* stem at 30, 60 DAS and harvest stages

Treatments	Sy.	Height of <i>Orobanche</i> stem (cm)		
		30 DAS	60 DAS	Harvest
Glyphosate 25 and 50 g/ha at 30 and 55 DAS	T ₁	-	2.10	4.55
125% of recommended fertility (N & P) + Glyphosate 25 and 50 g/ha with 1% solution of NH ₄ SO ₄ at 30 and 55 DAS	T ₂	-	1.90	4.00
Neem cake 400 kg/ha at sowing followed by soil drenching of metalaxyl MZ 0.2% at 30 DAS fb glyphosate at 40 g/ha at 45 DAS	T ₃	-	3.13	11.60
Neem cake 400 kg/ha at sowing followed by pendimethalin (PPI) at 0.75 kg/ha fb metalaxyl MZ 0.2% at 30 DAS	T ₄	-	4.33	20.70
Neem cake 400 kg/ha followed by soil drenching of metalaxyl MZ 0.2% at 30 DAS	T ₅	-	5.00	26.53
Untreated (control)	T ₆	-	5.45	29.10
S.E.(m)±		-	0.25	0.91
C.D. (at 5%)		-	0.76	2.73

Dry weight of 5 plant of *Orobanche* (g)

The dry weight of 5 plant of *Orobanche* was significantly influenced by different treatments at 60 DAS and harvest (Table 4.14 and Fig.4.13). The dry weight of 5 plant of *Orobanche* was lowest (0.62 and 0.0.70 g) in T₂ treatment at 60 and harvest stage, respectively. The next effective treatment was T₁ which recorded significantly lower dry weight of 5 plants of *Orobanche* as compared to treatment T₃, T₄, T₅, and T₆ and found statistically identical to T₂ at both stages. Significantly higher dry weight of 5 plant of *Orobanche* was obtained in control plot at both stages except T₅ at harvest.

Fig. 4.13: Effect of *Orobanche* control measures on dry weight of 5 plant of *Orobanche* at 30, 60 DAS and harvest stages

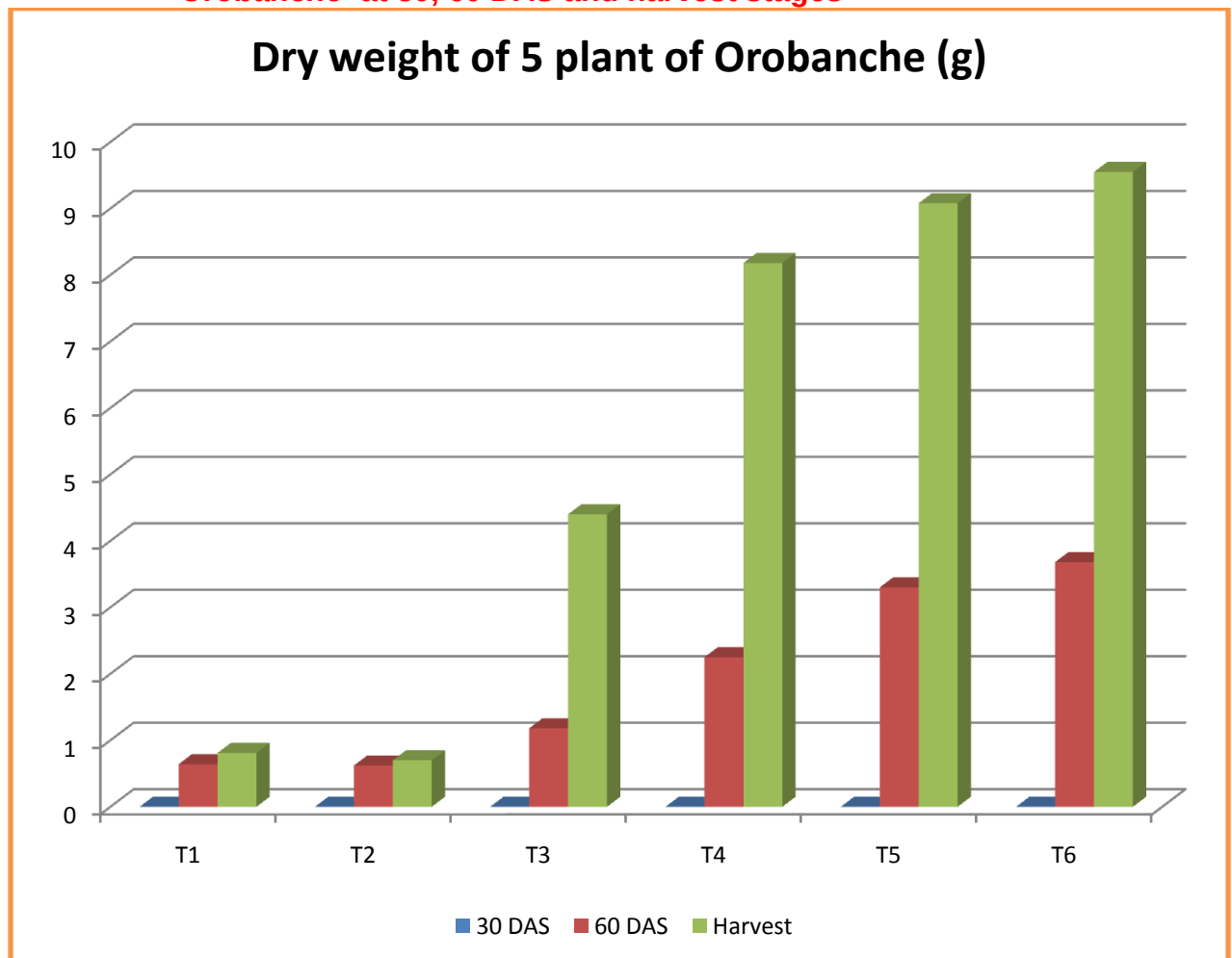


Table 4.14: Effect of *Orobanche* control measures on dry weight of 5 plant of *Orobanche* at 30, 60 DAS and harvest stages

Treatments	Sy.	Dry weight of 5 plant of <i>Orobanche</i> (g)		
		30 DAS	60 DAS	Harvest
Glyphosate 25 and 50 g/ha at 30 and 55 DAS	T ₁	-	0.64	0.81
125% of recommended fertility (N & P) + Glyphosate 25 and 50 g/ha with 1% solution of NH ₄ SO ₄ at 30 and 55 DAS	T ₂	-	0.62	0.70
Neem cake 400 kg/ha at sowing followed by soil drenching of metalaxyl MZ 0.2% at 30 DAS fb glyphosate at 40 g/ha at 45 DAS	T ₃	-	1.18	4.40
Neem cake 400 kg/ha at sowing followed by pendimethalin (PPI) at 0.75 kg/ha fb metalaxyl MZ 0.2% at 30 DAS	T ₄	-	2.25	8.18
Neem cake 400 kg/ha followed by soil drenching of metalaxyl MZ 0.2% at 30 DAS	T ₅	-	3.30	9.08
Untreated (control)	T ₆	-	3.68	9.55
S.E.(m)±		-	0.08	0.17
C.D. (at 5%)		-	0.25	0.50

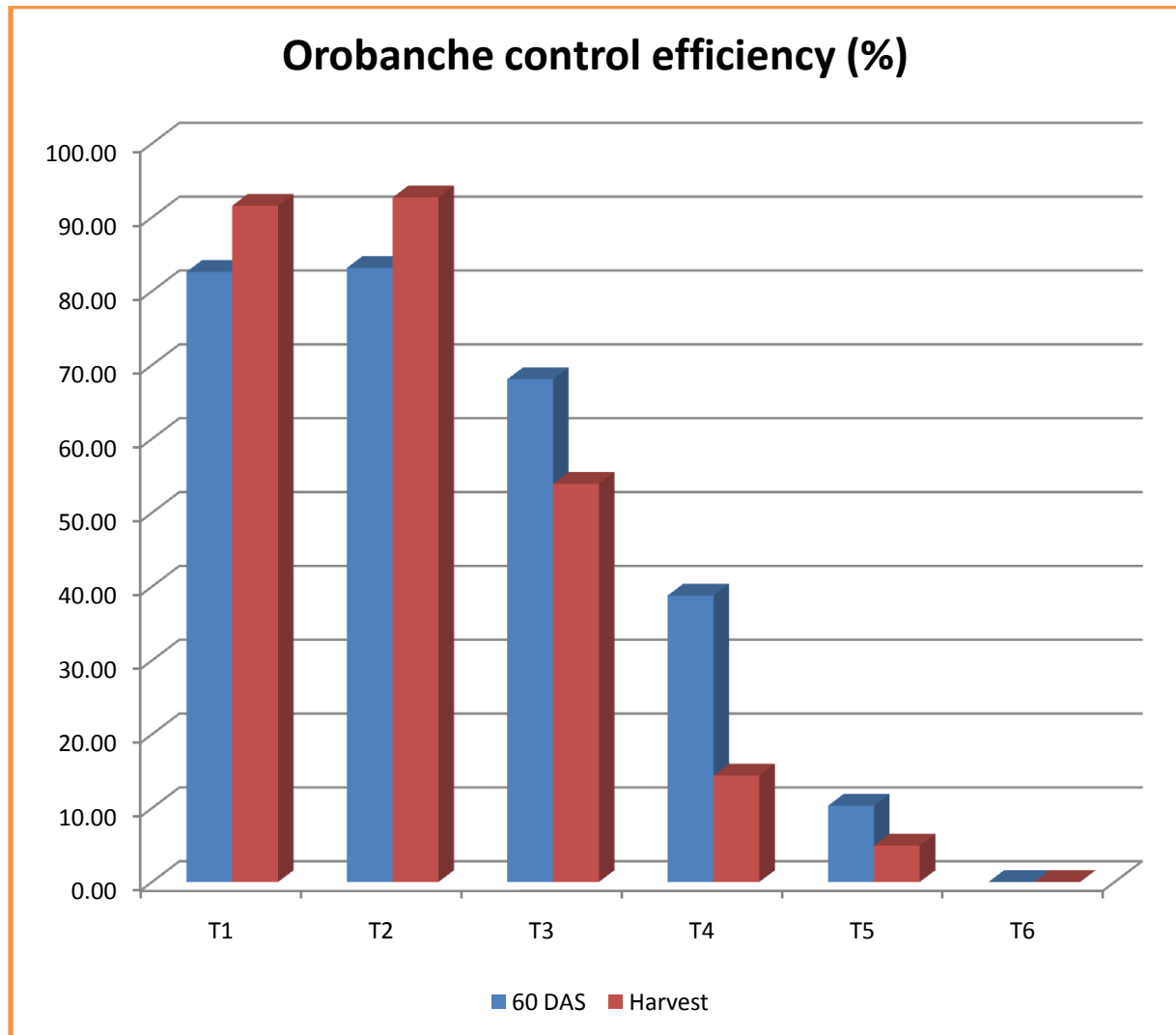
***Orobanche* control efficiency (%)**

The data on *Orobanche* control efficiency at 60 DAS and harvest is presented in table 4.15 and depicted graphically in Fig. 4.14. Data revealed that maximum *Orobanche* control efficiency (83.15 and 92.70%) was recorded in T₂, respectively at 60 and harvest stages. The next effective *Orobanche* control treatment T₁ followed by T₃.

***Orobanche* index (%)**

Orobanche index may be termed as the competition index. It indicates the reduction in yield due to *Orobanche* competition and is presented in percentage. Perusal of data presented in Table 4.15 and shown graphically in Fig 4.15, reveals that the different *Orobanche index* control treatments varied from 0.00 to 28.73 per cent in *Orobanche* index. Maximum *Orobanche* index was observed under control (28.73%). Treatment T₂ was most effective to

Fig. 4.14: Effect of *Orobanche* control measures on *Orobanche* control efficiency at 60 DAS and harvest stages



control of *Orobanche* among the all treatments understudy. The lowest *Orobanche* index (1.06%) was noted with T₁ treatment followed by T₃ (8.68%).

Table 4.15: Effect of *Orobanche* control measures on *Orobanche* control efficiency and *Orobanche* index

Treatments	Sy.	Orobanche control efficiency (%)		Orobanche index (%)
		60 DAS	Harvest	
Glyphosate 25 and 50 g/ha at 30 and 55 DAS	T ₁	82.61	91.57	1.06
125% of recommended fertility (N & P) + Glyphosate 25 and 50 g/ha with 1% solution of NH ₄ SO ₄ at 30 and 55 DAS	T ₂	83.15	92.70	0.00
Neem cake 400 kg/ha at sowing followed by soil drenching of metalaxyl MZ 0.2% at 30 DAS fb glyphosate at 40 g/ha at 45 DAS	T ₃	68.07	53.93	8.68
Neem cake 400 kg/ha at sowing followed by pendimethalin (PPI) at 0.75 kg/ha fb metalaxyl MZ 0.2% at 30 DAS	T ₄	38.79	14.40	13.86
Neem cake 400 kg/ha followed by soil drenching of metalaxyl MZ 0.2% at 30 DAS	T ₅	10.33	4.92	20.53
Untreated (control)	T ₆	-	-	28.73

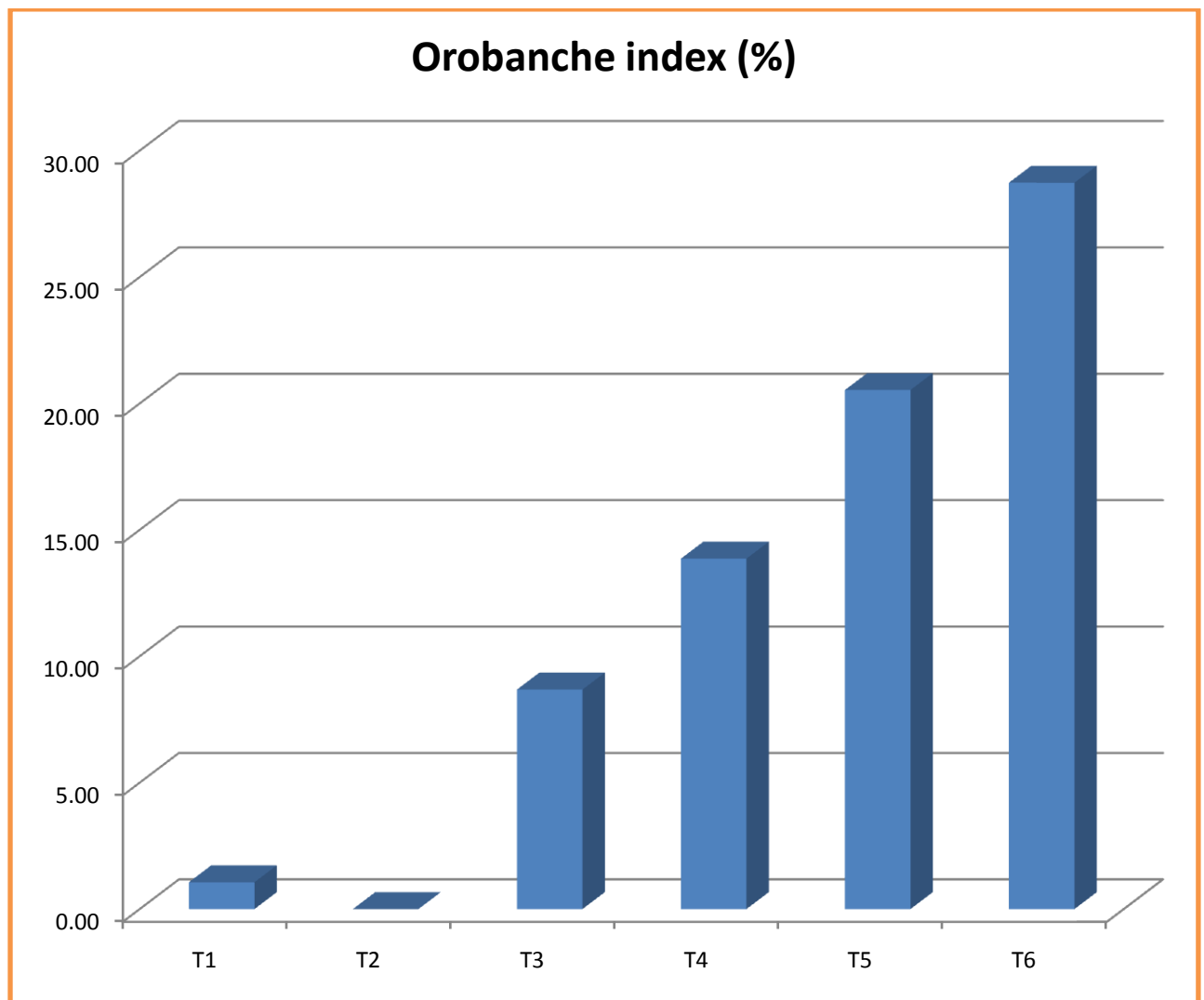
Cost of Cultivation (Rs./ha)

Cost of cultivation of Rs. 17316/ha was common for all the treatments. But the cost of integrated management practices for controlling *Orobanche* varied from treatment to treatment. The highest total cost of cultivation (Rs. 23545/ha) was incurred under treatment T₄.

Table 4.16: cost of cultivation (Rs./ha) excluding treatment cost

S.No.	Particular of expenditure	Cost of cultivation (Rs./ha)
1	One ploughing by tractor (4 hrs. @ Rs.600/hrs.)	2400
2	Two harrowing by tractor (3 hrs. @ Rs. 600/hrs.)	1800
3	Seed cost (5 kg/ha, 50Rs./kg)	250
4	Sowing charge (3 hrs. @ Rs. 500/hrs.)	1500
5	Fertilizer cost	3066
6	Two irrigation @ Rs.1500/ha	1500
7	Harvesting 20labour @ Rs.200/labour	4000
8	Threshing charge (3 hrs. @ Rs.500/hour + 3 labour @ Rs. 100/labour	1800
9	Miscellaneous	1000
	Total cost	17316

Fig. 4.15: Effect of *Orobanche* control measures on *Orobanche* index



Gross income (Rs./ha)

Data embodied in Table 4.17 revealed that all treatments gave more income over control. The maximum gross income of Rs. 69169/ha was obtained under treatment T₂, which was 39.549 per cent higher than control. The treatment T₂, T₃ were next in order to higher income resulting Rs. 68454, Rs. 63341 gross income per hectare, respectively.

Net Income (Rs./ha)

Data encompassed in Table 4.17 observed that all integrated management practices for controlling *Orobanche* gave more net returns over control. The maximum net return of Rs. 50355 /ha was found with treatment T₂, which was Rs 18002 higher than control. The treatment T₂ and T₃ were the next best treatments recording Rs. 50265 and Rs. 40783 per hectare in respect to net income respectively.

Benefit: Cost Ratio

Table 4.17 show that the maximum benefit cost ratio of 3.76 was recorded with treatment T₁, followed by T₂ (3.68). The minimum B:C ratio was recorded in treatment T₅ (2.49) plot.

Table 4.17: Cost of cultivation, gross return, net income and B:C ratio under different treatments for controlling of *Orobanche* in mustard

Treatments		Seed yield (kg/ha)	Stover yield (kg/ha)	Cost of cultivation (Rs./ha)	Treatment cost (Rs./ha)	Total cost of cultivation (Rs./ha)	Gross return (Rs/ha)	Net income (Rs/ha)	B:C Ratio
Glyphosate 25 and 50 g/ha at 30 and 55 DAS	T ₁	1870	4292	17316	873	18189	68454	50265	3.76
125% of recommended fertility (N &P) + Glyphosate 25 and 50 g/ha with 1% solution of NH ₄ So ₄ at 30 and 55 DAS	T ₂	1890	4313	17316	1498	18814	69169	50355	3.68
Neem cake 400 kg/ha at sowing followed by soil drenching of metalaxyl MZ 0.2% at 30 DAS fbglyphosate at 40 g/ha at 45 DAS	T ₃	1726	4188	17316	5242	22558	63341	40783	2.81
Neem cake 400 kg/ha at sowing followed by pendimethalin (PPI) at 0.75 kg/ha fbmetalaxyl MZ 0.2% at 30 DAS	T ₄	1628	3990	17316	6229	23545	59756	36211	2.54
Neem cake 400 kg/ha followed by soil drenching of metalaxyl MZ 0.2% at 30 DAS	T ₅	1502	3738	17316	4804	22120	55186	33066	2.49
Untreated (control)	T ₆	1347	3463	17316	0	17316	49569	32253	2.86

Selling: seed – Rs. 3500/q., stover- Rs. 70/q.

Fertilizer cost: (1) SSP- Rs. 300 /50 kg, (1) Urea- Rs.287.50/50kg, (3) MOP Rs. 850 /50kg

Herbicides cost: (1) Glyphosate - Rs. 390 /lit. (2) pendimethalin - Rs. 410/kg

Neem cake cost: Rs. 1050/q

Metalaxyl cost: Rs.120/100g

CHAPTER-V

DISCUSSION

The finding obtained from the present investigation entitled “**Effect of integrated management practices for control of *Orobanche* in mustard (*Brassica juncea* L. Czern&Coss.) under Gird agro-climatic conditions.**” has been presented in the previous chapter. The experimental results are being discussed in this chapter and critically corroborated in the light of research work done in the past.

Effect on *Orobanche*

Orobanche population /m² was recorded at 30, 60 DAS and at harvest stages. At 30 DAS *Orobanche* did not emerge. Dinesha and Dhanpal (2014) also reported that the *Orobanche* spikes started emerging above-ground from 43 days after transplanting of tomato. At the crop was advanced in age from 60 DAS to harvest the population of *Orobanche* significantly influenced by different *Orobanche* control measures. At 60DAS and harvest stages, the significantly lower population *Orobanche* (2.00 and 0.50 /m²) was observed under the application of 125% of recommended fertility (N &P) + Glyphosate 25 and 50 g/ha with 1% solution of NH₄SO₄ at 30 and 55 DAS (T₂) followed by treatment T₁ (Glyphosate 25 and 50 g/ha at 30 and 55 DAS). However, they were statistically at par to each other. Maximum population of *Orobanche* was observed in control plot, which was comparable to T₅ (Neem cake 400 kg/ha followed by soil drenching of metalaxyl MZ 0.2% at 30 DAS) treatment. Kumar (2002) also reported that glyphosate foliar application controlled broomrape in mustard. Dhanpal (1996), Dhanpal *et al.* (1998a) and also reported that glyphosate foliar application controlled broomrape in tobacco. Premi *et al.* (2015) observed that application of sub lethal doses of glyphosate with or without 1% ammonium sulphate solution decreased the *Orobanche* colon over control.

Height of *Orobanche* stem significantly reduced due to different treatments at 60 DAS and harvest stage. Lowest height of *Orobanche* stem was noted in treatment T₂ followed by T₁ and both were found statistically at par with each other it may be possibly due to better control of *Orobanche* by glyphosate application. Maximum height of *Orobanche* stem (29.10 cm) was observed with untreated plot.

Dry weight of *Orobanche* (g/m²)

All *Orobanche* control treatments gave lower dry weight of 5 plant of *Orobanche* when compared with untreated plot at 60 DAS and harvest stage of observations except T₅. The significantly lowest dry weight of 5 plant of *Orobanche* was recorded with application of 125% of recommended fertility (N &P) + Glyphosate 25 and 50 g/ha with 1% solution of NH₄SO₄ at 30 and 55 DAS (T₂) followed by T₁ (Glyphosate 25 and 50 g/ha at 30 and 55 DAS) and both these treatments were at par with each other at both stages of observation it might be due to least population of *Orobanche*, while highest dry weight of 5 plant of *Orobanche* was registered in control. It might be due to more density and unsuppressed *Orobanche* growth. Minimum dry weight of *Orobanche* under application of Glyphosate 25 and 50 g/ha at 30 and 55 DAS has also been reported by Sheoran *et al.* (2014).

Among all *Orobanche* management practices, application of 125% of recommended fertility (N &P) + Glyphosate 25 and 50 g/ha with 1% solution of NH₄SO₄ at 30 and 55 DAS (T₂) and Glyphosate 25 and 50 g/ha at 30 and 55 DAS (T₁) demonstrated a very effective mortality of *Orobanche* resulting decline trend in dry matter accumulation and proved best of all the treatments for *Orobanche* control.

***Orobanche* control efficiency and *Orobanche* index**

Higher *Orobanche* control efficiency (83.15 and 92.70% at 60 Das and harvest stage, respectively) was recorded in application of 125% of recommended fertility (N &P) + Glyphosate 25 and 50 g/ha with 1% solution of NH₄SO₄ at 30 and 55 DAS followed by Glyphosate 25 and 50 g/ha at 30 and 55 DAS (T₁). The higher *Orobanche* control efficiency under these treatments was reflected due to lower growth of *Orobanche*.

Orobanche index is indirectly related to the reduction in yield due to *Orobanche* population and *Orobanche* dry weight. Minimum reduction in grain yield of mustard due to least *Orobanche* competition was found in application of 125% of recommended fertility (N &P) + Glyphosate 25 and 50 g/ha with 1% solution of NH₄SO₄ at 30 and 55 DAS (T₂) and Glyphosate 25 and 50 g/ha at 30 and 55 DAS (T₁). The infestation of *Orobanche* throughout the crop growth period caused 28.73%

reduction in grain yield of mustard. Drastic reductions in grain yield of mustard due to higher *Orobanch*e competition in control have been reported by Singh *et al.* (2015).

Crop studies:-

Plant population / m row length

Uniform plant density is an important requisite for obtaining higher precision when it is not a variable factor as the treatments. The data in Table 4.1 indicate that the plant population per metre row length remained statistically unchanged (non-significant) under the various *Orobanch*e control measures without giving any definite trend. It obviously reflects the fact that the sowing of mustard was done properly, uniformly in each treatment using healthy and viable seeds to maintain the better germination, emergence and crop stand per unit area. Thus, the crop stand remained almost uniformly sufficient in all *Orobanch*e control measures. There was no harmful effect of herbicides on mustard crop.

Plant growth, yield attributes and yield of mustard

All growth parameters, viz., plant height and number of branches /plant, number of leaves per plant, leaf area per plant, dry weight of infested and non infested plant were significantly influenced by *Orobanch*e control measures treatments at all crop growth stages except 30 DAS. Application of 125% of recommended fertility (N & P) + Glyphosate 25 and 50 g/ha with 1% solution of NH_4SO_4 at 30 and 55 DAS (T_2) being at par with Glyphosate 25 and 50 g/ha at 30 and 55 DAS (T_1) at all the stages and found most effective *Orobanch*e control treatments to enhance plant height and number of branches per plant number of leaves per plant, leaf area per plant, dry weight of infested and non infested plant over other *Orobanch*e control treatments. This may be because of the fact that there was very lower population of *Orobanch*e was available for competition for different growth factors, which provided better opportunity to the crop to utilize nutrients, moisture, light and space in better way for its proper growth and development.

Yield attributing characters, viz., number of silique /plant, length of silique, number of seeds per silique, 1000-seed weight and seed yield per plant were significantly influenced by *Orobanch*e control measures. All these yield attributing characters were significantly increased over control by all *Orobanch*e control treatments. Significantly higher values of these yield

attributing parameters was recorded with application of 125% of recommended fertility (N & P) + Glyphosate 25 and 50 g/ha with 1% solution of NH_4SO_4 at 30 and 55 DAS (T_2) and Glyphosate 25 and 50 g/ha at 30 and 55 DAS (T_1) over other treatments. This might be due to less population of *Orobanche* under these treatments, where there was less competition between crop and *Orobanche* for moisture, light, space and nutrients utilized provided congenial condition to the crop for proper development of its reproductive phase which resulted in the enhancement of all these yield contributing characters.

All the *Orobanche* control treatments significantly increased the grain and stover as well as biological yield over control. The highest grain, stover and biological yield recorded with application of 125% of recommended fertility (N & P) + Glyphosate 25 and 50 g/ha with 1% solution of NH_4SO_4 at 30 and 55 DAS (T_2) followed by Glyphosate 25 and 50 g/ha at 30 and 55 DAS (T_1). The highest grain and stover as well as biological yield were due to effective suppression of *Orobanche*, which was evidenced from maximum growth parameters and yield attributes under these treatments. The superiority of these treatments over control in increasing yield has also been reported by Dhanapal (1996) and Premiet *et al.* (2015).

Orobanche management practices did not exert significant influence on oil content in seed. Similar results were also reported by Sharma and Singh (2003).

Oil yield was significantly influenced by differed among various treatments. All the treatments produced significantly higher oil yield over control. Treatment T_2 produced the maximum oil yield (758 kg/ha), followed by T_1 (753 kg/ha) probably due to the higher grain yield under these treatments. The untreated plot gave significantly lower oil yield.

Economics

The choice of any *Orobanche* control method ultimately depends on economics and *Orobanche* controlling efficiency.

Out of the different *Orobanche* control treatments, combined application of 125% of recommended fertility (N & P) + Glyphosate 25 and 50 g/ha with 1% solution of NH_4SO_4 at 30 and 55 DAS (T_2) gave highest net return

of Rs.50.355/ha closely followed by Glyphosate 25 and 50 g/ha at 30 and 55 DAS (T₁). recording Rs.50265, per hectare, Minimum net return (Rs.32253/ha) was received in control. Application of Glyphosate 25 and 50 g/ha at 30 and 55 DAS performed the highest benefit cost ratio of 3.76, whereas, minimum BCR was obtained in application of Neem cake 400 kg/ha followed by soil drenching of metalaxyl MZ 0.2% at 30 DAS. Similar findings were also reported by Jadav *et al.* (2014)

Chapter – VI

SUMMARY, CONCLUSION AND SUGGESTIONS FOR FURTHER WORK

An investigation on “**Effect of integrated management practices for control of *Orobanche* in mustard (*Brassica juncea* L. Czern & Coss.) under Gird agro-climatic conditions**” was carried out during *Rabi* 2015-16 at Research Farm, College of Agriculture, Gwalior (M.P.) The trial was laid out in a randomized block design replicated four times with 5 treatments excluding control namely T₁ (Glyphosate 25 and 50 g/ha at 30 and 55 DAS) T₂ (125% of recommended fertility (N &P) + Glyphosate with 1% solution of NH₄SO₄ at 25 and 50 g/ha at 30 and 55 DAS), T₃ (Neem cake 400 kg/ha at sowing followed by soil drenching of metalaxyl MZ 0.2% at 30 DAS fb glyphosate at 40 g/ha at 45 DAS), T₄ (Neem cake 400 kg/ha at sowing followed by pendimethalin (PPI) at 0.75 kg/ha fb metalaxyl MZ 0.2% at 30 DAS), T₅ (Neem cake 400 kg/ha followed by soil drenching of metalaxyl MZ 0.2% at 30 DAS) and T₆ (Untreated (control)).

The magnitude of *Orobanche* competition in mustard had been critically investigated in the present study. The various parameters that had been considered in the present investigation for evaluation of different treatments on plant population, growth characters, yield and yield attributing characters, *Orobanche* studies, quality parameter, and economics of the treatments. The data on *Orobanche* population were subjected to square root transformation $\sqrt{x}$ and $\sqrt{x+0.5}$, to normalize their distribution before statistical analysis. This result of the investigation had been summarized here under:

Studies on *Orobanche*

- Days to emergence of *Orobanche* was not influenced by different treatments.
- Significantly lower population of *Orobanche* was observed in treatment T₁ as well as T₂. However, they were statistically at par to each other at both (60 DAS and harvest) stages.. Maximum population of *Orobanche* was observed in control plot, which was comparable to T₅ treatment.
- Height of *Orobanche* stem significantly influenced by different treatments. At 60 DAS and harvest stages, treatment T₂ gave lowest

height of *Orobanche* stem followed by treatment T₁ and both were found statistically at par with each other. Significantly higher height of *Orobanche* stem (5.45 cm) was registered in treatment T₆. Which was comparable to treatment T₅ at both stages.

- The dry weight of 5 plant of *Orobanche* was significantly influenced by various different treatments at 60 DAS and harvest. The dry weight of 5 plant of *Orobanche* was lowest (0.62 and 0.70 g) in T₂ treatment at 60 and harvest stage, respectively. The next effective treatment was T₁.
- Maximum *Orobanche* control efficiency (83.15 and 92.70%) was recorded in T₂, respectively at 60 and harvest stages. The next effective *Orobanche* control treatment T₁ followed by T₃.
- Maximum *Orobanche* index was observed under untreated control (28.73%). Treatment T₂ was most effective to control of *Orobanche* among the all treatments under study. The lowest *Orobanche* index (1.06%) was noted with T₁ treatment followed by T₃ (8.68%).

Studies on crop

- The highest plant height was registered with treatments T₁ as well as T₂, which was significantly higher as compared to rest of remaining treatments except T₃. The significantly lowest plant height was noted from treatment T₆ (control).
- The maximum number of branches was observed under treatment T₂, which was significantly higher over T₃, T₄ and T₅ and at par with the rest of other treatments. The minimum number of branches was observed in untreated plot.
- The maximum leaves were recorded by treatment T₁ while minimum by treatment T₆.
- Dry weight of non infested plant of mustard significantly influenced due to different treatments of *Orobanche* control at 60,90 DAS and harvest stage. The maximum dry weight of non infested plant of mustard (35.70 and 47.70 g/plant, at 90 DAS and harvest, respectively) was recorded under the treatment T₂, which was statistically at par with T₁ and significantly superior over rest of the treatments.

- The maximum dry weight of non infested plant of mustard was recorded under the treatment T₂, followed by T₁.
- Yield attributing characters of mustard viz., number of silique /plant, siliqua length, 1000-seed weight, seed yield /plant significantly influenced due to *Orobanche* control treatments. The maximum values of number of silique /plant and siliqua length were recorded with treatment T₂, followed by T₁, while 1000-seed weight and seed yield /plant was obtained with treatment T₁ followed by T₂ and both these treatments were at par with each other.
- Significantly higher grain yield of 1890 kg/ha was obtained with treatment T₂ followed by T₁ (1870 kg/ha), T₃ (1726 kg/ha). However, all integrated treatments resulted in 11.51 to 40.31 per cent increase in grain yield over control.
- Maximum stover yield (4313 kg/ha) recorded in T₂ but at par with treatment T₁ (4292 kg/ha) and T₃ (4188 kg/ha) and significantly higher over rest of other treatments.
- The significantly higher biological yield (6203 kg/ha) was noted in treatment T₂ but at par with treatment T₂ and T₃.
- The significantly higher value of harvest index (30.47%) was recorded with treatment T₂, followed by T₁ (30.34%) and both these treatments were at par with each other and they were significantly superior over rest of the treatments.
- Treatment T₂ produced the maximum oil yield (758 kg/ha), which was significantly higher than T₃ (688 kg/ha), T₄ (650 kg/ha), T₅ (597 kg/ha), and T₆ (539 kg/ha) and at par with remaining treatments.

Economics

- Maximum gross income (Rs. 69169 /ha), net income (Rs. 50355/ha) and was recorded with treatment T₂ followed by T₁.
- Highest benefit: cost ratio (3.76) was observed with treatment T₁ closely followed by T₂ (3.68).

Conclusion

- On the basis of above findings, it may be concluded that significantly highest grain yield (1890 kg/ha) was obtained from T₂ (125% of recommended fertility (N &P) + Glyphosate with 1% solution of NH₄SO₄ at 25 and 50 g/ha at 30 and 55 DAS), followed by T₁ (Glyphosate 25 and 50 g/ha at 30 and 55 DAS) 1870 kg/ha.
- Treatment T₂ gave lowest population of Orobanche with higher Orobanche control efficiency closely followed by T₁.
- Benefit: cost ratio obtained higher (3.76) in Glyphosate 25 and 50 g/ha at 30 and 55 DAS, followed by T₂.

Suggestions for further work

The experiment may be repeated under different agro-climatic conditions to confirm the result obtained from the present investigation.

Indian mustard [*Brassica juncea* (L.) Czern& Cross] is one of the important oil seed crop of the state of Madhya Pradesh. The problem of low productivity continues to be a major issue for agricultural planners and researchers.

Mustard crop is grown both in subtropical and temperate countries. India occupies the third position with respect to average production of rapeseed and mustard in the world. It is raised on 6.70 million hectares with an annual production of 7.96 million tonnes and average productivity of 1188 kg/ha in the country (Directorate of Economics and statistic, 2014). In Madhya Pradesh rapeseed and mustard is grown in 0.81million hectares area with annual production of 0.90 million tonnes and average productivity of 1108 kg/ha. But in Gwalior district it covers an area of 58.5 thousand hectares with annual production 75.9 thousand tonnes and average productivity of 1303 kg/ha(M.P. Krishi Org.in., 2014).

Weed are considered as one of the major negative factors responsible for loss of crop produce due to their competition for nutrients, moisture, light and space which have been reported as high as 30-70%. The crop is usually found infested with grassy as well as broadleaf weeds. Weeds substantially reduce the productivity and production of mustard due to competition for

various inputs. A wide range of yield reduction in the crop on account of weeds is well documented. Therefore, there is a need to create an environment that is detrimental to weeds and favourable to crop. Broomrape (*Orobancha aegyptica* pers.), a holoparasitic weed, causing heavy loss to the mustard crop in light soil of Gird region, under rainfed situation. Its infestation during early stages reflected on the crop growth and reduction in yield up to 58% (Prusty *et al.*, 1996). The reduction of 13.9 to 16.3 per cent seed yield of mustard due to *Orobancha* was observed by Sheoran *et al.* (2014). At later stages, shading caused by plant height and broad dorsiventral leaves help in suppressing weed growth (Chakaiyar and Ambasht, 1990).

Many workers have stated that glyphosate at lower rates (82 g/ha) at 30 DAS excellent control of broomrape without any toxic effect on mustard crop, but it caused some toxicity at higher rates (123 g/ha) at 60 DAS to the crop. Other herbicides like fluchloralin and pendimethalin did not control this weed (Kumar, 2002). The meagre work on selective control of broomrape has been done so far in this region. Therefore, the present studies were proposed to be carried out with the following objectives:

- To determine the suitable methods for the control of *Orobancha* in mustard
- To find out the effect of various methods applied for control of *Orobancha* on growth and yield and quality of mustard
- To work out the economics of various methods used for the control of *Orobancha*

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APPENDIX – I

Value of mean sum of squares for plant population per metre row length

Source of variation	d.f.	Population / metre row length at	
		25 DAS	Harvest
Replication	3	0.483	0.776
Treatment	5	1.071 ^{NS}	1.132 ^{NS}
Error	15	1.316	1.285

^{NS} – Non significant

APPENDIX – II

Value of mean sum of squares for plant height

Source of variation	d.f.	Plant height (cm) at		
		30 DAS	60 DAS	90 DAS /Harvest
Replication	3	0.108	42.531	179.909
Treatment	5	0.929 ^{NS}	296.259**	995.247**
Error	15	0.677	24.823	86.854

^{NS} – Non significant
p=0.01

** Significant at

APPENDIX – III

Value of mean sum of squares for number of branches per plant

Source of variation	d.f.	Number of branches per plant at		
		30 DAS	60 DAS	90 DAS /Harvest
Replication	3	-	0.495	0.049
Treatment	5	-	4.624**	29.432**
Error	15	-	0.563	0.867

** Significant at p=0.01

APPENDIX – IV

Value of mean sum of squares for number of leaves per plant

Source of variation	d.f.	Number of leaves per plant at		
		30 DAS	60 DAS	90 DAS
Replication	3	1.189	2.834	0.988
Treatment	5	1.303 ^{NS}	100.792**	96.245**
Error	15	1.005	5.059	2.646

^{NS} – Non significant
p=0.01

** Significant at

APPENDIX – V

Value of mean sum of squares for leaf area per plant

Source of variation	d.f.	Leaf area per plant (cm) at		
		30 DAS	60 DAS	90 DAS
Replication	3	4119.08	59245.49	14567.17
Treatment	5	2734.83 ^{NS}	119726.04 ^{**}	145806.07 ^{**}
Error	15	2854.97	7263.82	5186.27

^{NS} – Non significant
p=0.01

^{**} Significant at

APPENDIX – VI

Value mean sum of squares for dry weight of infested plant

Source of variation	d.f.	Dry weight of infested plant (g) at			
		30 DAS	60 DAS	90 DAS	Harvest
Replication	3	-	0.108	1.274	0.342
Treatment	5	-	5.722 ^{**}	108.138 ^{**}	117.598 ^{**}
Error	15	-	0.318	0.868	1.666

^{**} Significant at p=0.01

APPENDIX – VII

Value mean sum of squares for dry weight of non infested plant

Source of variation	d.f.	Dry weight of non infested plant (g) at			
		30 DAS	60 DAS	90 DAS	Harvest
Replication	3	-	0.301	1.136	1.469
Treatment	5	-	6.957 ^{**}	37.038 ^{**}	48.464 ^{**}
Error	15	-	0.931	2.093	1.456

^{**} Significant at p=0.01

APPENDIX – VIII

Value mean sum of squares for yield attributing characters

Source of variation	d.f.	Number of silique/ plant	Length of silique	No. of seeds /silique	1000- seeds weight (g)	Seed yield (g/plant)
Replication	3	154.06	0.037	0.126	0.008	0.041
Treatment	5	3347.10 ^{**}	0.267 ^{**}	0.540 ^{NS}	0.573 ^{**}	11.575 ^{**}
Error	15	77.87	0.049	0.568	0.005	0.054

^{NS} – Non significant
p=0.01

^{**} Significant at

APPENDIX – IX

Value of mean sum of squares for seed, stover and biological yield per hectare

Source of variation	d.f.	Grain yield (kg/ha)	Stover yield (kg/ha)	Biological yield(kg/ha)	Harvest index (%)
Replication	2	3915.7	17880.9	37225.2	0.079
Treatment	11	180275.4**	460630.0**	1209805.6**	3.739*
Error	22	6596.8	25178.3	54442.6	0.246

* Significant at p= 0.05
p=0.01

** Significant at

APPENDIX – X

Value of mean sum of squares for oil content and oil yield

Source of variation	d.f.	Oil content in seed (%)	Oil yield (kg/ha)
Replication	3	0.669	219.8
Treatment	5	0.145 ^{NS}	30255.3**
Error	15	0.683	1136.9

^{NS} – Non significant
p=0.01

** Significant at

APPENDIX – XI

Value of mean sum of squares for day to emergence of Orobanche and population of Orobanche

Source of variation	d.f.	Days to emergence of Orobanche	Population of Orobanche/m ² at		
			30 DAS	60 DAS	harvest
Replication	2	101.153	-	0.708	1.000
Treatment	5	35.475 ^{NS}	-	10.842**	17.767**
Error	15	66.586	-	0.642	0.900

^{NS} – Non significant
p=0.01

** Significant at

APPENDIX – XII

Value of mean sum of squares for height of *Orobanche* stem

Source of variation	d.f.	Height of <i>Orobanche</i> stem (cm) at		
		30 DAS	60 DAS	Harvest
Replication	3	-	0.052	5.825
Treatment	5	-	9.007**	479.120**
Error	15	-	0.255	3.286

** Significant at p=0.01

APPENDIX – XIII

Value of mean sum of squares for dry weight of 5 plant of *Orobanche*

Source of variation	d.f.	Dry weight of 5 plant of <i>Orobanche</i> (cm) at		
		30 DAS	60 DAS	Harvest
Replication	3	-	0.008	0.039
Treatment	5	-	7.180**	66.142**
Error	15	-	0.028	0.112

**** Significant at p=0.01**

VITA

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