Investigation of physiological parameters of weeds for the development of inter and intra row weeder

Kommanaboyina Raju Yadav[1*]

Farm machinery and power engineering, AEC&RI, TNAU, Coimbatore, India

Email: rajuyadav201804@gmail.com

A. Suredrakumar[1]

Farm machinery and power engineering, AEC&RI, TNAU, Kumulur, India

Email: surendrakumar@tnau.ac.in

P. Dhananchezhiyan[1]

Farm machinery and power engineering, AEC&RI, TNAU, Coimbatore, India

Email: kpdhana@gmail.com

S. D. Sivakumar[2]

Agronomy, Institute of Agriculture, TNAU, Kumulur, India

Email: rainfedsiva@yahoo.co.in

M. R. Duraisamy[2]

Physical Sciences and IT, AEC & RI, TNAU, Coimbatore, India

Email: mrd7@tnau.ac.in

Abstract

The growth and yield potential of tomato and chilli crop is highly influenced by the presence of weeds. In this study, the habitual weeds under tomato and chilli cultivation were identified and physiological parameters of crops and weeds influencing the development of inter and intra row weeder viz., height, canopy area, diameter, and root length were determined. In chilli crop broad-leaved weeds occupied a maximum area of about 54%, which is followed by grasses (29%) and sedges (17%). The same weed proportion was observed in tomato crop. In chilli crop, the maximum height, canopy area, diameter, and root length of the broad-leaved weed was found as 8.3 cm, 23 cm, 0.56 cm and 8.7 cm after 45 DAT. In tomato crop, the maximum height, canopy area, diameter, and root length of the broad-leaved weed were found as 9.1 cm 26 cm^2, 0.6 cm and 10.2 cm after 45 DAT. Similarly, the physiological parameters of grasses and sedges in chilli and tomato crop were studied. The dry matter content, moisture content and weed population were determined for weeds in both chilli and tomato crop at 15, 30 and 45 DAT. The dry matter of weeds in tomato cultivated fields was found to increase from 21.54 $g.\ m^{-2}$ to 26.08 $g.\ m^{-2}$ at 15 to 45 DAT. The dry matter content of weeds in chilli cultivated fields was found to increase from 17.8 to 23.46 $g.\ m^{-2}$ at 15 to 45 DAT. Similarly, maximum weed population was found as 63 % for tomato crop and 61% for chilli crops at 45 DAT. The moisture content shows a decreasing pattern from 15 to 45 DAT. Comparing of physiological parameters of various

weeds on 15, 30 and 45 DAT design parameters was selected for designing an inter and intra row weeder.

Keywords: canopy area, dry matter, grasses, moisture content, sedges and weed population,

INTRODUCTION

India ranks second in vegetable production in the world after china as per National Horticulture Database published by National Horticulture Board (2020-2021). The total area and production of vegetables in India are 10.86 Mha and 200.45 MT, respectively (NHB 2020-2021). Uttar Pradesh currently ranks first among all states, followed by West Bengal and Bihar.

India is the second-largest producer of tomatoes (*Lycopersicon esculentum L.*) in the world. Tomatoes are cultivated over an area of 812000 hectares in India, with an estimated production of 20573 MT (Horticulture Statistics Division 2019-2020).

India is the largest producer, consumer, and exporter of chili. In India, almost 50 varieties of chillies were cultivated with a production of 1702 MT and an area of 683000 ha (Horticulture Statistics Division 2019-2020). According to FAO 2018 report, in India, about 21% of the total dry chilies produced were exported to other countries. Major chili-producing states in India are Andhra Pradesh, Karnataka, West Bengal, Madhya Pradesh, Maharashtra, and Tamil Nadu. The growth and yield potential of tomato and chilli were highly influenced by the presence of abundance of weeds in the field.

Weed infestation in chilli is a major factor causing yield loss under irrigated conditions as it is planted at wider spacing and grows slowly during the early growth stages. Weed growth between chlli crops can be extremely competitive, reducing chili yield potential significantly. Weeds reduce yield by 30 to 80 % depending on the nature of the weed, season, variety, soil type, rainfall and duration of weed infestation (Osipitan *et al*., 2016).

The reduction in agricultural production due to weeds are estimated to cause a 5% in developed countries, a 10% in developing countries, and a 25 % loss in underdeveloped countries (weed management in horticulture crops). These weeds effectively compete with the crop for soil, nutrients, water, light and space reducing the yield from 12 to 51 % (Rao and Singh, 1997; Mukharjee and Singh, 2005; Halder and Patra, 2007). In India, yield loss due to weeds is more when compared to due to disease yield losses. The percentage of loss varies according to the type of crop and type of weed infestation. Weeds have been estimated to deprive crop growth by consuming 47% N, 42% P, 50% K, 39% Ca, and 24 % Mg of the nutrient available (weed management in horticulture crops). Poor weed control can reduce crop yield by 50-70%, and weed costs account for one-third of cultivation costs (Oni, 1990). Weed control is therefore essential to reduce production costs and increase crop yield.

Manual weeding by hand or using hand tools such as hand hoe and weeding hooks are widely followed in rural India. Khurpi is the most common manual weeding tool but it operation is tedious, time-consuming and highly labour intensive. Women perform this activity in bending and squatting posture for a longer time. This posture increases the fatigue and drudgery of farm women. According to Gupta et al Weeding drudgery-prone activity with a drudgery scale value of 2.01 (Gupta et al., 2002). Weeding and inter cultivation accounts about 15 to 20 % of the total man-hours (Nag, 2004) involved in crop production. Furthermore, weeding using manual tools during critical growth stages of crops is extremely difficult due to the scarcity of human labour. An estimate of 400-600 man-hours per hectare is the labour requirement of hand weeding which consumes about Rs. 2200 per hectare. To render the benefits of mechanization, it is very necessary to use proper weeding implements, which will reduce drudgery and the cost of cultivation.

Herbicides, on the other hand, seem to be inefficient for weed control due to inefficiency in killing broad-leaved weed. Moreover, prolonged and indiscriminate use of recommended herbicides results in increased accumulation of residues in soil, which has a negative impact on crop growth.

Various implements have been specially designed and manufactured to control weeds in between crop rows. During the last decade, research was successively focused on inter and intra row weeding using harrowing, torsion and finger weeder and using compressed air. New technologies are being developed to help improve field productivity by reducing weeds (Mehta et al., 2019). The possibilities for using these weeding machines vary according to crop type, crop growth stage, field and weather conditions and its efficiency depends on selectivity (i.e., higher sensitivity of the weed plants relative to the crop plants). Selectivity is to will out major on differences between weed and crop plants, for example, root anchorage forces, leaf area, and/or plant height (Fogelberg & Dock Gustavsson, 1997) which can be used as inputs for sensor-based weeder especially intra row weeders. Conditions for physical weed control on the go with sensor attachments are normally favourable when proper knowledge above physiological parameters of weeds and crops are available.

Hence it is necessary to study the nature of weed. Weeds are classified into three categories based on their lifespan: annuals, biennials, and perennials. There are again classified into broad-leaf weeds, grasses and sedges in each group (Rao., 2000). Crop-weed competition is most intense when the competing plants have similar vegetative habits and resource demands (Rao., 2000). The type of weed species infesting the area, density of infestation, and the duration of infestation affect the level of weed competition and have a major impact on designing a weeding tool (Kiran and Rao.,2013).

To overcome the constraints in crop growth due to weeds and to reduce the drudgery of labour, the development of inter and intra-row weeder is necessary which requires study of physiological parameters of predominant weeds. Hence this study is aimed to determine the physiological properties of weeds and crop that influence the design of inter and intra-row weeder.

Materials and Methods

Field observations

Chilli crop and tomato crops were cultivated in a field of size 0.2 acres each in the field of AEC&RI, TNAU, Coimbatore. After seedbed preparation with primary and secondary tillage 12 beds were formed using a broad bed former as shown in (Figure-1). (6 beds for tomato and 6 beds for chilli crop) manual dibbler was used to transplant the seedlings with 60 cm row-to-row spacing and 45 cm plant-to-plant spacing as shown in (Figure-2). The physiological parameters of crops and weeds present in the field were investigated using the methodology given below. The investigation was carried out in three stages which include 1. Study of physiological properties of chilli and tomato crop. 2. Study of types of weeds in chilli and tomato crops. 3. Investigation of the physiological parameters of weeds in chilli and tomato crops.

Physiological properties of chili and Tomato crop

The physiological parameters of both chilli and tomato crop viz., plant height (cm), canopy area (cm^2), stem diameter (cm) and root depth (cm) were measured for 20 plants from randomly selected places at 15, 30, and 45 DAT.

Plant height

The plant height plays important role in designing the height of the weeding tool. The height of the weeding tool has carefully selected as it causes damage to crops if less, hence the maximum plant height is considered for designing the weeding tool. The plant height was measured using a steel rule with a least count of 0.5 mm at 15, 30, and 45 DAT as shown in figure-3.

Crop canopy area

The canopy area is the maximum area covered by crop branches. The canopy area is an major parameter as the canopy area increases with plant growth it helps to decide the diameter of weeding tool. Canopy area is measured with the steel rule as shown in figure-4**.**

Stem Diameter

The stem diameter of both chilli and tomato crop was measured using a vernier caliper with a least count of 0.02 mm. The stem diameter vary based on the age of the seedlings and crop variety as shown in figure-5.

Root length

The root length of the seedling was measured with a steel rule with a least count of 0.5 mm.

Study of weed type in chilli and tomato crop

Weeds normally germinate along with crops in early growth stages and become more competitive for crop growth rates. Generally, weeds are classified into three types

(a) Grasses: All weeds in the *Poaceae* family are classified as grasses. They have long narrow leaves with hairy structures. *Echinocloa colonum* and *Cynodon dactylon* are the two examples.

(b) Sedges: This category includes weeds from the *Cyperaceae* family. The leaves originate from the base of the modified stem, which may or may not have tubers. *Cyperus rotundus* and *Fimbrystylis miliaceae* are the two examples.

(c) Broad-leaved weeds: this is a class of weeds that are significant among all other weed species. Dicotyledon weeds come under broad-leaved weeds. *Digera arvensis* and *Tridax procumbens* are a few examples.

Weed population

The percentage of the area of grass, sedges, and broad-leaved weeds was determined in the experimental field. As population of weed increases it become competent to crop and decreases crop yields. Weeds present in both inter and intra rows at $1m^2$ area at 15, 30, and 45 DAT was determined using a frame of size $1m^2$. The frame is placed in a random area in field and the total number of weeds in both inter and intra rows were identified separately. The number of broad-leaved weeds grasses and sedges were determined as shown in figure-6.

Using the data, the percentage of population of each weed were determined. The population of weeds in both inter and intra rows helps in determining the amount of weeds to be removed by weeds.

Physiological properties of weeds

The study of physiological parameters of weeds such as broad leaf, grass, and sedge weeds. in 20 randomly selected places were carried out at 15, 30 and 45 DAT as shown in figure-7. The physiological parameters such as weed height (cm), canopy area (cm^2), stem diameter (cm), and root length (cm) are determined as per the procedure followed for crop. The population of weed, moisture content and dry matter is determined using following methods.

Moisture content and Dry matter content of weeds

A moisture analyser was used to measure the fresh weights (FW) and dry weights (DW) of weeds. For moisture, measurement weeds were collected from inter and intra rows at 5 random locations in the experimental plot at 15, 30, and 45 DAT. The sample collected was kept in a moisture analyser (IABTS110). The moisture content on a dry basis is obtained using the analyser. Crop weed competition becomes critical with increasing soil moisture stress. In general, for producing an equal amount of dry matter weeds transpire more water than field crops as shown in Figure. 8**.**

The crop growth of chili and tomato is directly affected by a dry matter of weeds. Auxiliary or complementary use of on-farm weed biomass improves soil physical, chemical, and biological properties even if there is a rise in fertilizer use efficiency (Bera and Ghosh., 2013).

Results and Discussion

Physiological parameters of chili and tomato crop

Plant height (cm)

The minimum plant height of chilli and tomato crop was found as16.6 and 14.6 cm at 15 DAT. The maximum height was observed as 39.1 and 39.8 cm for chilli and tomato crop at 45 DAT. Since the weeder has to be designed for maximum height. The height of plants at 45 DAT as shown in Figure.9. has to be incorporated while designing a weeding tool.

Canopy Area (cm^2)

The canopy area of chilli was 10.2, 16.4 and 26.1 cm^2 at 15 DAT, 30 DAT and 45 DAT respectively. Likewise, the canopy area of tomato was 11.6, 18.9 and 29.4 cm^2 at 15, 30 and 45 DAT respectively. The canopy area of chilli was more when compared to tomato. The maximum canopy area observed was 29.4 cm^2. Since the weeding tool has to be moved in a trajectory motion (cycloid or trichoid path), the diameter of the cycloid, the length of the cycle and the forward speed of the unit are decided based on the canopy area to avoid damage to plants as shown in Figure.7.

Diameter of the stem (cm)

The diameter of the stem of both crops were determined at 15, 30 and 45 days after transplanting. The results are shown in below Figure.11.

Root length

Tap root system is observed in both chilli and tomato crop. The root length of chilli was found as 3.3, 4.9 and 6.7 cm at 15, 30 and 45 DAT respectively, and for tomato, it was 3.8, 5.4 and 7.2 cm at 15, 30 and 45 DAT respectively as shown in Figure.12. The tap root length of chilli was more when compared to the tomato.

The weeding tool to be designed has to uproot the weeds in both inter and intra row. It is important to avoid damage to the roots of the crop while uprooting weeds. Hence the study of the nature of the root of crop is necessary. Since both chilli and tomato crop has a tap root system, there is less damage to the root while uprooting weeds.

Study of types of weeds

From the study it was found that the experimental field constituted grasses like *Cynodon dactylon* and *Dactyloctenium aegyptium*, *Cyperus rotundus* in sedges, *Cleome viscosa*, *Euphorbia hirta*, *Trianthema portulacastrum*, *Sida acuta*, *Amaranthus viridis*, *Boerhavia diffusa*, *Eclipta alba*, *Phyllanthus niruri* under Broad-leaved weeds.

In chili crop broad-leaved weeds occupied from Figure.13. and Figure.14. a maximum area of about 54%, which is followed by grasses 29% and sedges 17%. In tomato crop also broad-leaved weeds occupied an area of about 55%, which is followed by grasses at 30% and sedges at 14%.

In chilli crop, weed infestation in the inter-row was predominant 61% whereas in the intra row it was less 39%. In tomato crops, intra-row has the weed infestation the maximum weed infestation was found as 63%. The intra-row used to have the lowest weed infestation when compared to the inter-row. Even though the weeds in intra row is less it has more impact on crop growth.

Physiological properties of weeds

Physiological properties of broad leaved weeds in chili and tomato crop

The weed height, canopy area, diameter, and taproot length of broadleaf weeds were increased from 4.3 to 8.5 cm, 6.8 to 23 cm^2, 0.24 to 0.56 cm, and 3.8 to 8.7 cm, respectively at 15 to 45 DAT in chilli crop. Similarly in tomato crop the height, canopy area, diameter, and taproot length of broadleaf weeds were increased from 6.8 to 9.1 cm, 7.3 to 26 cm^2, 0.3 to 0.62 cm, and 4.1 to 10.2 cm, respectively. The maximum plant height, canopy area, diameter, and taproot length such as 9.1 cm 26 cm^2, 0.62 cm and 10.2 cm. were considered while designing an inter and intra row weeder. Since the maximum area in the experimental field was covered by broad-leaved weeds, the parameters of broad-leaved weeds have to be given importance while designing a weeding tool. The parameters of weeds in both chilli and tomato were compared in Figure.15, Figure.16, Figure.17 and Figure.18. are shown below.

Physiological properties of grass weeds in chili and tomato crop

The weed height, canopy area, diameter, and taproot length of grass weeds were increased from 8.3 to 15 cm, 7.5 to 13.8 cm, 0.19 to 0.47 cm, and 2.6 to 5.1, respectively at 15 to 45 DAT in chilli crop. Similarly, in tomato crop, the height, canopy area, diameter, and taproot length of grass weeds were increased from 5.83 to 12.6 cm, 7.28 to 12.05 cm, 0.18 to 0.46 cm, and 3.4 to 6.1 cm, respectively. The maximum plant height, canopy area, diameter, and taproot length were observed as 15 cm 13.8 cm^2, 0.46 cm and 6.1 cm. The parameter of weeds in inter and intra row of both chilli and tomato crops is shown in the above figures.

Physiological properties of sedge weeds in chili and tomato crop

The weed height, canopy area, diameter, and taproot length of sedge weeds were increased from 7.5 to 12.8 cm, 10.1 to 20.7 cm, 0.19 to 0.45 cm, and 2.5 to 5.9 cm, respectively at 15 to 45 DAT in chilli crop. Similarly in tomato crops the height, canopy area, diameter, and taproot length of sedges weeds were increased from 9.7 to 16.6 cm, 13.1 to 23.4 cm^2, 0.15 to 0.4 cm, and 3 to 5.4 cm, respectively. The maximum plant height, canopy area, diameter, and taproot length were observed as 16.6 cm 23.4 cm^2, 0.45 cm and, 5.9 cm.

Hence these parameters were considered while designing an inter and intra row weeder. The parameter of weeds in inter and intra row of both chilli and tomato crops is shown the above figures.

The moisture content and dry matter of weeds in chili and tomato crop

The moisture content of weeds in both crops were determined as per the procedure in materials and methods. The minimum and maximum moisture content of weeds in chilli crops were found as 74.12% at 15 DAT in inter row and 87.14% in intra row at 45 DAT. In the tomato crop, the moisture content of weeds was minimum 74% at 45 DAT when compared with intra 86.56% respectively at15 DAT as shown in Figure.19. and Figure.20.

Hence it shows that most of the irrigated water is utilized by weeds rather than crops. Hence effective weed control is attributed to the suppression of weeds and in turn, reduced soil moisture and nutrient losses due to weeds and making them available to crops findings are in agreement with the results of Deshpande *et al*., (2006), Kunti and Singh (2012), and Gare *et al*., (2015).

The dry matter content of weeds in both crops was determined as per the procedure in section. The dry matter content of weeds in chilli crop increased from 21.54 to 26.08 g. m^{-2} at 15 to 45 DAT in inter row and 10.84 to 14.52 g. m^{-2} at 15 to 45 DAT in intra row. In the tomato crop, the dry matter of weeds increased from 17.8 to 23.46 g. m^{-2} when compared with intra 13.44 to 14.12 g. m^{-2}, respectively, from 15 to 45 DAT. Dry matter of weed biomass shows an impact on crop growth and yield as shown in Figure.21 and Figure.22.

Conclusions

The following conclusions were drawn from the investigation of the physiological properties of the weed and crop for the design of the weeder.

1. The majority of the weeds found in both crops were broadleaf followed by grasses and sedges.

2. The physiological parameters of the crop were increased with crop robustness. Height, canopy area, diameter, and taproot length of the chili crop were increased from 16.6 to 39.1cm, 10.2 to 26.1 cm^2, 0.35 to 0.66 cm, and 3.3 to 6.7 cm, respectively to 15 to 45 DAT. Followed by the tomato crop from 14.6 to 39.8 cm, 11.6 to 29.4 cm^2, 0.41 to 0.79 cm, and 2.9 to 7.2 cm, respectively.

3. Broadleaf weed occupied a maximum area when compared with the grass and sedge weeds of 22 .7 cm^2 at 45 DAT and the area of intensification of broad leaf weed in tomato crop

found was 5.6 cm^2 at 15 DAT. The root depth of sedge in chili and tomato crops was found to be 5.7 and 5.8 cm, respectively after 45 DAT. Grass diameter was found maximum in chili and tomato crops at 45 DAT was 0.47 and 0.48 cm, respectively.

4. When crop growth of chili and tomato increased then the Dry matter of weeds also increased, the maximum dry matter of weeds was found at 26.08 g. m^{-2} in inter-row in chili crop, in tomato crop dry matter, increased from 13.44 to 14.12 g. m^{-2} in intra row. the least moisture content found in chili in inter-row was 74.12% due to the weeds being grown away from the crop at 45 DAT. The moisture content of weeds in tomato crops in intra-row was 86.56% because the weeds were rigorously growing closer to the crop and grows faster than the crop, causing competition for the crop.

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Figure 1: Beds formation by bed former

2: Transplantation of chili and tomato seedlings

a. Chili plant b. Tomato plant

Figure 3: Plant height measurement

a. Chili plant b. Tomato plant

Figure 4: Plant Canopy area measurement

a. Chili plant b. Tomato plant

Figure 5: Plant diameter measurement

a. Chilli crop

b. Tomato crop

Figure 6: Weed population in experimental plots of chilli and tomato crops

Figure 7: Broad-leaved weeds, grasses, sedges

Figure 8: Moisture content and dry matter content of weeds in chili and tomato crop

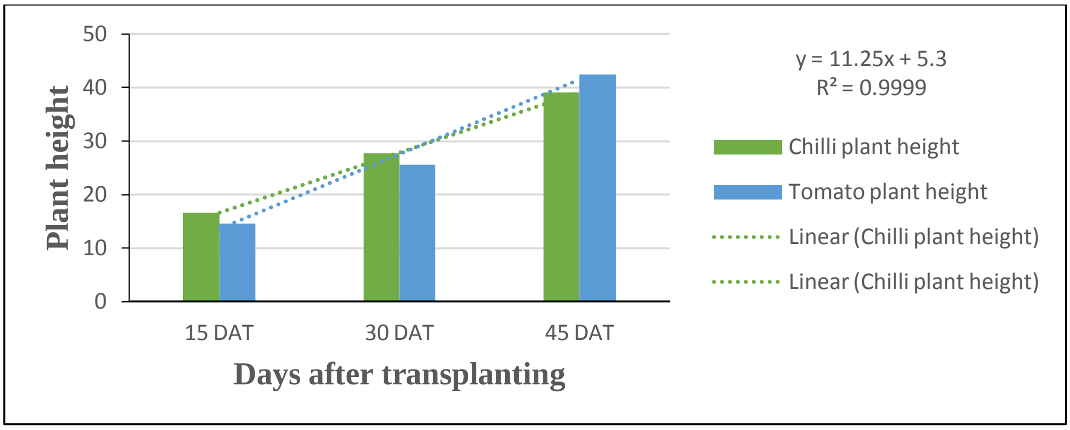

Figure 9: plant height of two crops

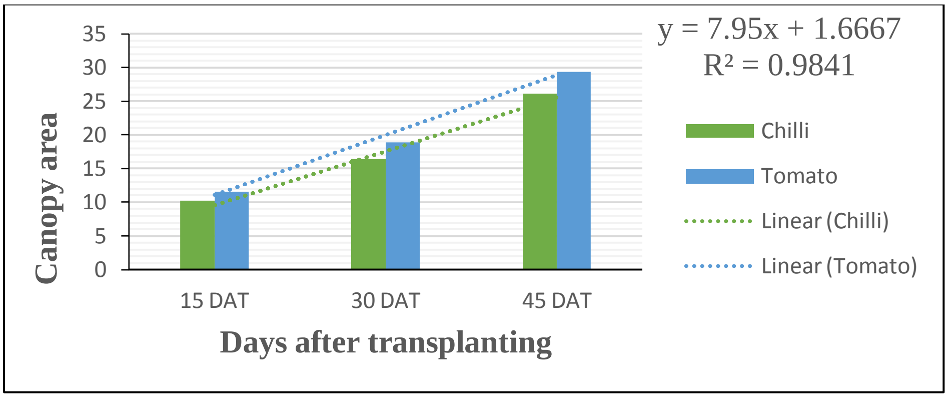

Figure 10: Canopy area of two crops

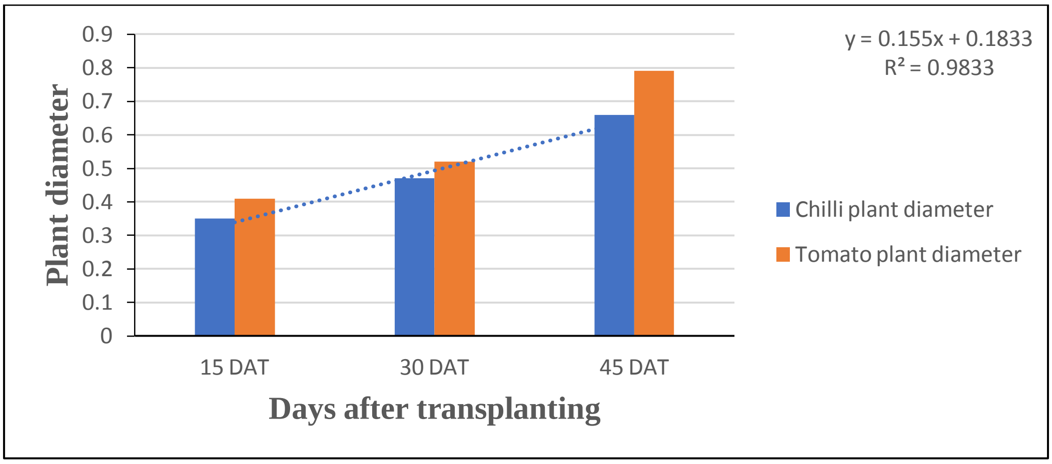

Figure 11: comparison of diameter between two crops

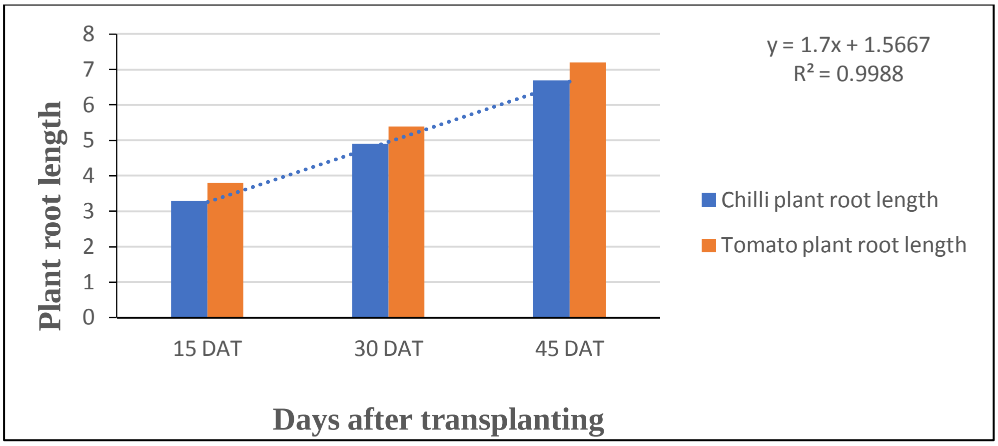

Figure 12: Comparison of plant root length two crops

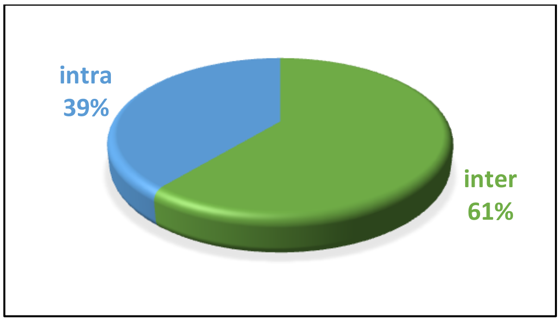

Figure 13: Weed density in chili crop

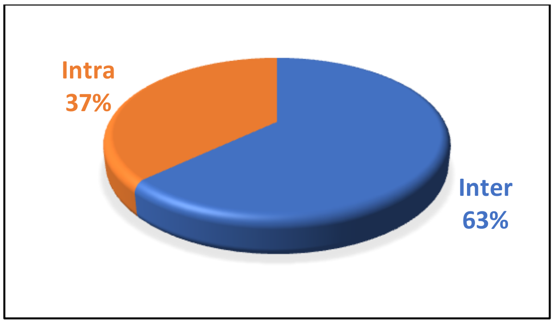

Figure 14: Weed density in Tomato crop

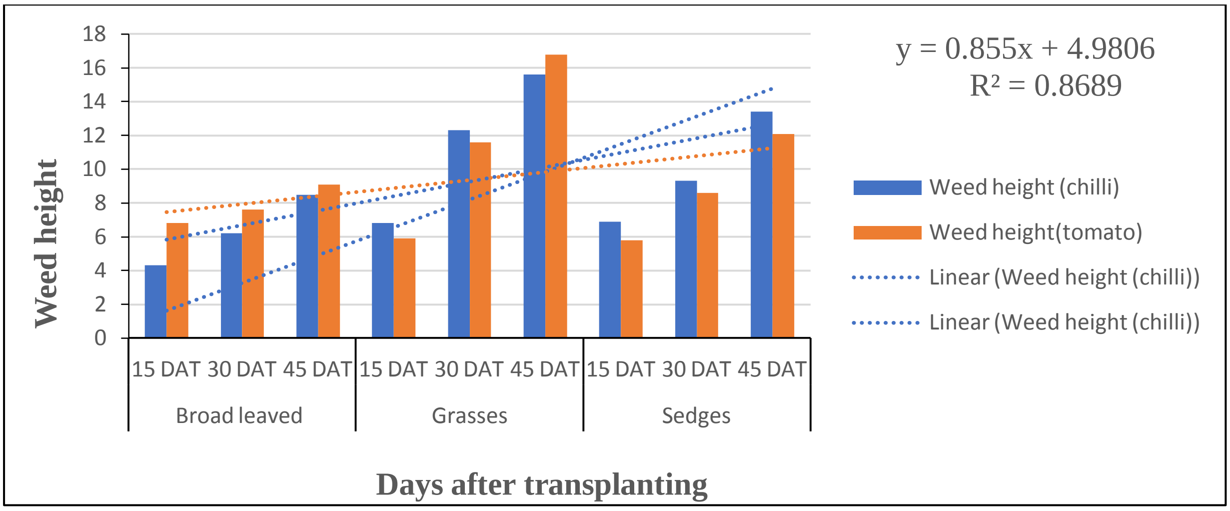

Figure 15: Comparison of weed height in two crops

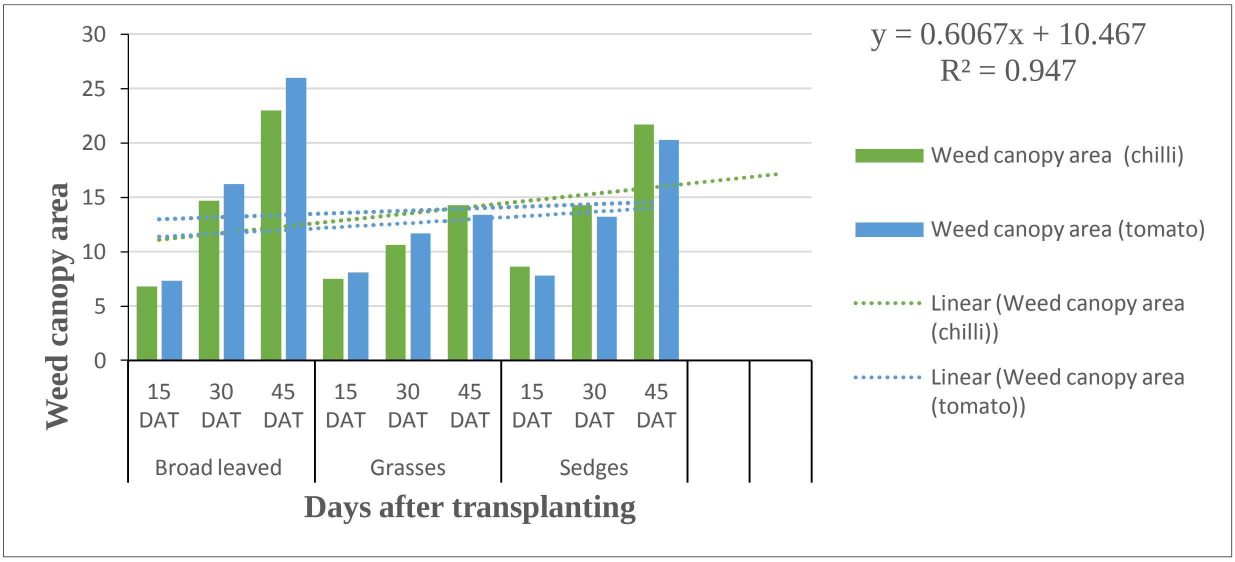

Figure16: Comparison of weed canopy area in two crops

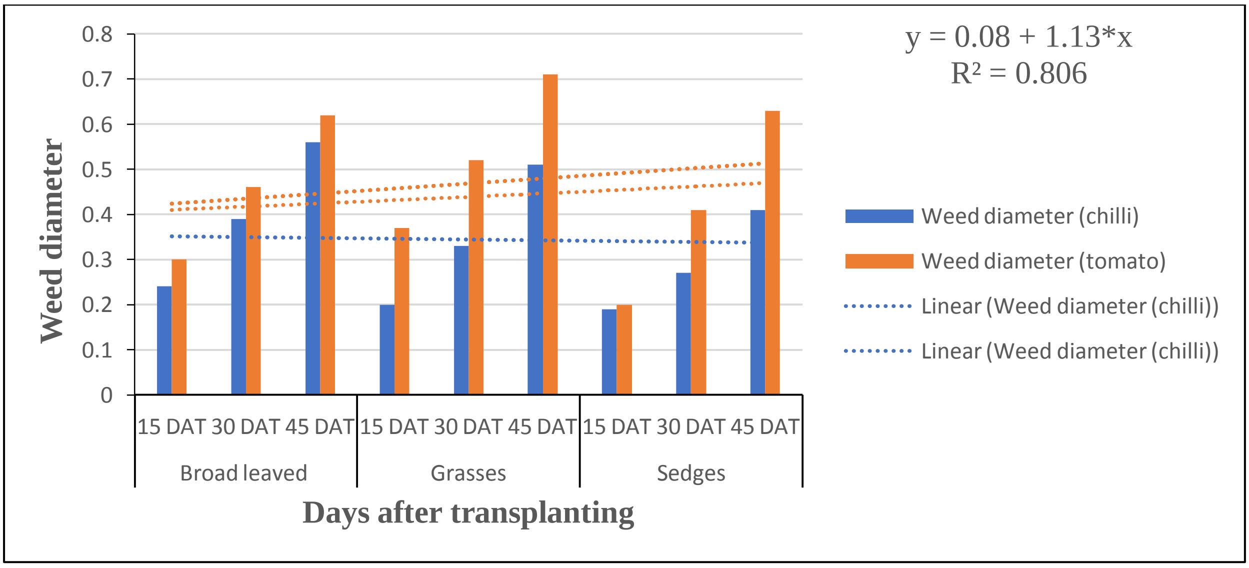

Figure 17: Comparison of weed diameter in two crops

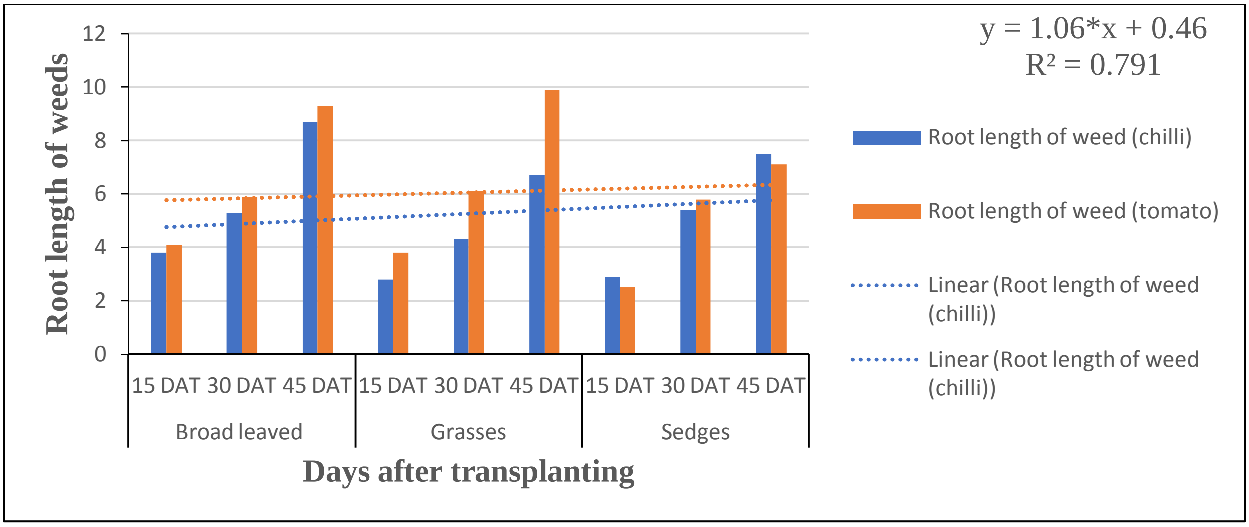

Figure 18: Comparison of weed root length in two crops

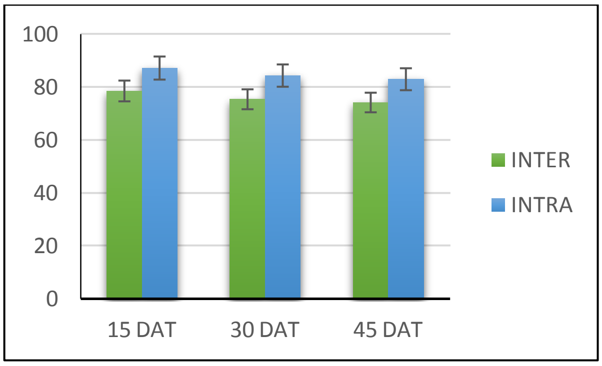

Figure.19. Moisture content of weeds in chili crop

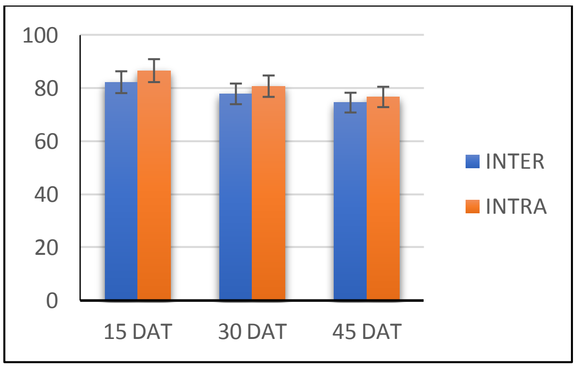

Figure.20. Moisture content of weeds in Tomato crop

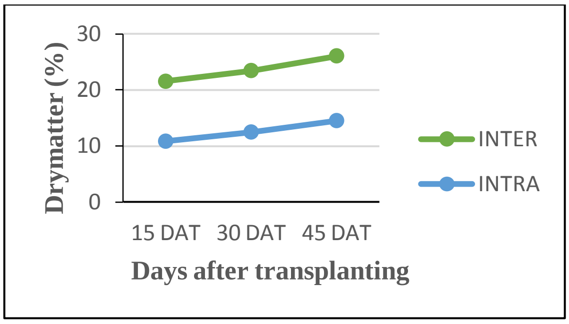

Figure 21: Dry matter of weeds in chili crop

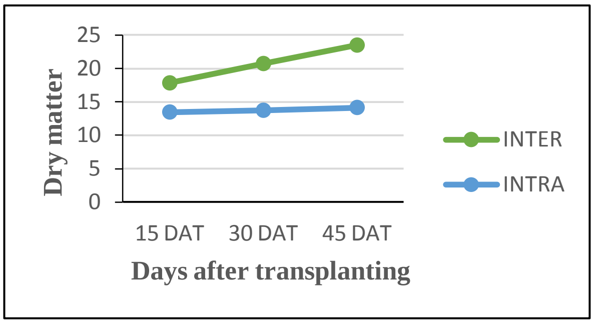

Figure 22: Dry matter of weeds in Tomato crop