



International Journal of Research in Agronomy

E-ISSN: 2618-0618
P-ISSN: 2618-060X
© Agronomy
NAAS Rating (2026): 5.20
www.agronomyjournals.com
2026; 9(2): 360-366
Received: 23-12-2025
Accepted: 28-01-2026

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Effect of tillage and weed management on growth and yield in maize-redgram cropping system

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DOI: <https://www.doi.org/10.33545/2618060X.2026.v9.i2e.4884>

Abstract

The field experiments were carried out at Annamalai University Experimental Farm, Department of Agronomy, Faculty of Agriculture, Annamalai Nagar, Tamil Nadu, India during the rabi and summer seasons of 2024 and 2025 to study the effect of tillage and weed management in maize –red gram cropping system. Experiments were conducted using split plot design with four main treatments viz., M₁-Zero tillage (ZT) in maize - CT in red gram, M₂-CT (Maize) - Zero tillage (ZT) (red gram), M₃- ZT (maize) - ZT (red gram) and M₄ CT (maize) - CT (red gram) and four sub treatments which includes weed management practices viz. S₁- Two hand weeding on 15 and 30 DAS in both maize and red gram, S₂- pre emergence application of metolachlor @ 1.25 a.i kg ha⁻¹ + hand weeding on 30 DAS in maize and Pre emergence application of pendimethalin 0.75 kg ha⁻¹ + hand weeding on 30 DAS in maize, S₃- Pre emergence application of metolachlor @ 1.25 a.i kg ha⁻¹ + post emergence application of halosulfuron methyl + atrazine @ 0.596 a.i kg ha⁻¹ in maize and pre emergence of pendimethalin 0.75 a.i kg ha⁻¹ + post emergence application of quizalopehyl + imazethapyr @ 0.10 g ai kg ha⁻¹ in redgram and S₄- unweeded control. The result of the present study demonstrates that the higher growth and yield parameters of maize and redgram were influenced by both the tillage and weed management practices. Among the given tillage practices CT-CT (M₄) resulted in the maximum values of growth and yield attributes in both the crops. In terms of weed control treatments S₂ recorded the increased growth and yield parameters in both the crops which was at par with S₃. In case of interactions M₄S₂ was recorded as best treatment which was on par with M₄S₃, where as the lowest values were obtained in M₃S₄ in both the crops.

Keywords: Maize-redgram cropping system, weed control measures, tillage practices, growth and yield

Introduction

The maize–redgram system helps in efficient utilization of residual soil moisture and nutrients from the maize crop, enabling redgram to grow well with minimal inputs. It improves soil health through biological nitrogen fixation by redgram, enhancing fertility for the next maize cycle. This system also supports better pest and weed break, lowering infestation buildup across seasons. Overall, it enhances system productivity and sustainability under rainfed conditions. (Dolijanović *et al.*, 2011, Devaraj and Isaac 2023) ^[28, 23]. Inspite of this Weed infestation is a major constraint in maize and redgram because both crops exhibit slow early growth, allowing weeds to dominate and compete for nutrients and moisture, reducing the yield by 30-40%. Continuous maize–pulse sequences also cause weed shifts toward tolerant broadleaf species, worsening management challenges.

Tillage plays a major role in crop establishment and weed management. Conventional tillage buries weed seeds to deeper layers, destroys emerging seedlings, and breaks perennial weeds, resulting in lower initial weed pressure and better crop establishment. In contrast, zero tillage leaves weed seeds on the soil surface, promoting higher grassy and broadleaf weed emergence early in the season, which reduces yield potential. The improved tilth, aeration, and root growth under conventional tillage also contribute to higher nutrient uptake and yield compared to zero tillage (Jat *et al.*, 2012) ^[32].

Weed management boosts yields and curbs weed infestation effectively. By combining cultural, mechanical, chemical, and biological tactics, IWM minimizes weed competition for resources like nutrients, water and light, preventing yield losses of 20-50% in crops like maize and

redgram. This multi-pronged approach reduces weed density and biomass by up to 70-90%, enhances crop growth during critical early stages and promotes sustainable farming with lower herbicide reliance. Overall, IWM increases grain and pod yields by 15-40% while maintaining long-term soil health (Suseendran *et al.*, 2020 and Junjariya *et al.*, 2024) [36, 37].

The interaction of tillage, cropping system, and weed management in maize-redgram systems effectively reduces weed density and biomass by disrupting seed germination through conventional tillage, enhancing crop competition via intercropping, and applying pre-emergence herbicides plus manual weeding, achieving 70-86% weed control efficiency. This targets key grassy weeds like *Echinochloa colonum*, *Dactyloctenium aegyptium*, *Digitaria sanguinalis*, *Cynodon dactylon*, and *Eleusine indica*, which compete for light and nutrients in both maize and redgram; broadleaf weeds such as *Commelina benghalensis*, *Euphorbia hirta*; as well as sedges like *Cyperus rotundus* suppressed across crops by tillage burial of rhizomes, intercropping shading and herbicide-manual combinations. Weed infestation decreases in maize during early seasons and in redgram later via niche differentiation, optimizing yield components like larger maize ears, higher kernel numbers, better pod formation in redgram, and overall grain yield gains alongside improved soil health and net returns. (Upasani *et al.*, 2017 and Vaheedet *et al.*, 2025) [38, 39].

This study seeks to explore how combining various tillage methods with integrated weed management approaches affects overall productivity in maize-redgram cropping sequences.

Materials and Methods

A field experiment was carried out during the kharif and summer seasons of 2024 and 2025 at the Experimental Farm, Department of Agronomy, Faculty of Agriculture, Annamalai University, Tamil Nadu, India, situated at 11°24' N latitude, 79°44' E longitude and an altitude of 5.79 m above mean sea level. The study was conducted in a split-plot design with three replications and four treatments. The main plot treatments comprised four different tillage practices, M₁: Zero tillage in maize-Conventional tillage in redgram; M₂: Conventional tillage in maize- Zero tillage in redgram; M₃- Zero tillage in maize-Zero tillage in redgram; M₄- Conventional tillage in maize-Conventional tillage in redgram, while the four sub-plot treatments consisted of various weed management practices *viz.*, viz. Two hand weeding on 15 and 30 DAS (S₁) in both maize and redgram, pre emergence application of metolachlor @ 1.25 a.i kg ha⁻¹ + hand weeding on 30 DAS in maize and Pre emergence application of pendimethalin @ 0.75 a.i kg ha⁻¹ + hand weeding on 30 DAS in red gram (S₂), Pre emergence application of metolachlor @ 1.25 a.i kg ha⁻¹ + post emergence application of halosulfuron methyl + atrazine @ 0.596 a.i kg ha⁻¹ in maize and Pre emergence of pendimethalin 0.75 a.i kg ha⁻¹ + post emergence application of quizalopehyl + imazethapyr @ 0.10 g ai kg ha⁻¹ (S₃) and unweeded control (S₄). The maize variety P3302 and the redgram variety VBN (Rg3) were used. Maize was sown at a spacing of 60 × 20 cm using 20 kg seed ha⁻¹ with a depth of 2-3 cm, while redgram seedlings, raised initially in polybags for 21 days, were transplanted into the main field after the harvest of maize.

Field preparation varied according to the assigned tillage treatments. Under zero tillage, seeds were dibbled into previous crop stubbles with minimal soil disturbance, whereas conventional tillage involved irrigation followed by primary tillage with a tractor-drawn cultivator and rotavator to achieve fine tilth. Fertilizer application for maize consisted of 150:75:75

kg N:P₂O₅:K₂O ha⁻¹, with 25% N and full P and K applied basally, 50% N at 25 DAS and the remaining 25% N at 45 DAS. Redgram was applied with 25:50:25 kg N:P₂O₅:K₂O ha⁻¹ as basal application. Pre-emergence herbicides metolachlor and pendimethalin were applied at 3 DAS, while post-emergence herbicides halosulfuron-methyl + atrazine for maize and quizalofop-ethyl + imazethapyr for redgram were sprayed at 25 DAS according to treatment schedules. Hand weedings were performed as per the respective treatments. Irrigations were given immediately after sowing or transplanting, followed by life irrigations and subsequent irrigations based on crop requirement. Plant protection measures were adopted based on economic threshold levels.

Maize was harvested at physiological maturity and grain yield was recorded at 12% moisture. Redgram was harvested when 80% pods turned brown, and the seed yield was recorded at 18% moisture. Weed observations included identification of dominant weed flora, total weed count and weed dry weight at 30 and 60 DAS using a 0.25 m² quadrat. Weed control efficiency, relative weed density were calculated following standard formulae.

Crop observations included plant height, dry matter production, leaf area index calculated using standard formulas, crop growth rate based on dry matter accumulation, yield attributes and yields of both crops. Economic analysis involved calculation of cost of cultivation, gross returns, net returns and benefit-cost ratio based on prevailing input costs and minimum support price of maize and redgram. Data collected from the experiment were statistically analysed using the procedures applicable to split-plot design at a 5% level of significance. Weed count data were subjected to square-root transformation $\sqrt{(X + 0.5)}$ before analysis.

Results and Discussion

Effect of tillage and weed management on growth attributes.

Maize

Different tillage practices did not bring about significant variation in the growth parameters and the interaction between tillage and weed management practices was also found to be non-significant. In contrast weed management practices significantly influenced the growth parameters throughout the crop growth period during maize I during second year all the growth attributes are significantly affected by both tillage and weed, management practices as the data presented in table 1. Among the assessed tillage practices higher values of growth attributes, were obtained in CT in maize I and CT-CT in maize II crop and it was on par with CT-ZT in maize II due to tillage-induced soil loosening, reduced bulk density, improved aeration and enhanced nutrient mineralization, promoting root growth, nutrient uptake and early biomass accumulation whereas the lower values of plant height, DMP and LAI were registered in maize I and in ZT-ZT in maize II as ZT systems, however, suffer higher compaction, slower N-mineralization and cooler early soils, restricting root proliferation (Kumar *et al.*, 2025; Oliveira *et al.*, 2024; Priyadarshini *et al.*, 2025) [1, 6, 11].

The application of weed management practices illustrated a significant effect on the growth attributes of maize. Among the treatments, Pre emergence application of Metolachlor @ 1.25 a.i kg ha⁻¹ + hand weeding on 30 DAS (S₂) produced the superior values of growth attributes which include plant height, DMP and LAI owing to effective early-season weed control and removal of later weed escapes, which ensured greater availability of nutrients, moisture, light and space to the crop (Kumar *et al.*, 2025) [7]. This treatment was statistically on par with pre emergence application of metolachlor @ 1.25 a.i kg ha⁻¹ + post

emergence application of halosulfuron methyl + atrazine @ 0.596 a.i kg ha⁻¹ (S₃), as the integrated chemical approach provided broad-spectrum control of grasses, sedges and broad-leaved weeds throughout the crop growth period, thereby promoting better canopy development, higher photosynthetic efficiency and greater biomass accumulation (Baruah *et al.*, 2025) [5]. In contrast, unweeded control (S₄) showed the lowest values of plant height, DMP and LAI. as a result of continuous and severe weed competition, which restricted nutrient uptake, reduced leaf expansion and suppressed overall crop growth.

The interaction effect between tillage and weed management practices was found to be non significant during maize I and statistically significant in the second year. CT-CT with pre emergence application of metolachlor @ 1.25 a.i kg ha⁻¹ + hand weeding on 30 DAS (M₄S₂) recorded the highest plant height, dry matter production and LAI this was at par with CT-CT with post emergence of metolachlor @ 1.25 a.i kg ha⁻¹ + Post Emergence application of halosulfuron methyl + atrazine @ 0.596 a.i kg ha⁻¹ (M₄S₃) whereas the lowest plant height, dry matter production and LAI were obtained in zero tillage with Un weeded control (M₃S₄). This might be due to favourable seedbed with reduced soil bulk density, improved aeration and enhanced nutrient mineralization, while simultaneously maintaining a weed-free environment during the critical period of crop–weed competition. This synergistic effect facilitated better root proliferation, higher nutrient and water uptake, enhanced photosynthetic activity and improved canopy development, resulting in higher plant height, dry matter production and leaf area index (Gathala *et al.*, 2020) [24]. In contrast, zero tillage combined with unweeded control (M₃S₄) resulted in the lowest growth attributes due to severe and uninterrupted weed competition throughout the crop growth period, the absence of weed control allowed weeds to emerge simultaneously with the crop and dominate the system. Ultimately leading to significantly lower plant height, dry matter production and leaf area index which was similar with Chauhan and Mahajan (2019) [10].

Redgram

The growth parameters of redgram viz., plant height, DMP and LAI were significantly influenced by both the tillage and weed control practices. Among the tillage practices higher values of growth parameters were recorded in CT in redgram I and CT-CT recorded the maximum parameters of growth, in redgram II. However ZT-ZT recorded the lower values of growth parameters as presented in the table 1. This might be due to which facilitated deeper root penetration, enhanced nodulation, improved nutrient mineralization and greater uptake of water and nutrients. These conditions fostered robust vegetative growth, enhanced biomass accumulation and improved canopy development in redgram (Reddy *et al.*, 2019) [4]. Improved performance under conventional tillage based cropping system can be attributed to improved soil tilth which destructed the weed seed bank and suppressed early weed emergence there by reducing crop weed competition and promoting greater plant height, dry matter accumulation and enhanced branching (Kumar *et al.*, 2022; Alhammad *et al.*, 2023) [29, 16].

In respect to weed management practices higher plant height, dry matter production, LAI and no. of branches were obtained in with pre emergence application of pendimethalin 0.75 kg ha⁻¹ + hand weeding on 30 DAS (S₂). This ensured a relatively weed-free environment during the critical period of crop–weed competition, thereby improving the availability of nutrients, moisture, light and space to the crop, which promoted better root

development, enhanced photosynthetic activity and greater biomass accumulation (Choudhary and Prakash 2018) [27] the comparable performance of with the Pre emergence application of pendimethalin 0.75 kg ha⁻¹ + post emergence application of quizalopehyl + imazethapyr @ 0.10 g ai kg ha⁻¹ (S₃) may be attributed to its broad-spectrum weed control, as the herbicide combination effectively managed grasses and broad-leaved weeds/sedges throughout the crop growth period, resulting in sustained weed suppression and improved crop growth (Kumar *et al.*, 2020; Meena *et al.*, 2022) [20, 13]. The unweeded control (S₄) recorded the lowest values of plant height, dry matter production, LAI and no. of branches due to severe and continuous weed competition, which restricted nutrient uptake, reduced leaf expansion and photosynthetic efficiency, and ultimately suppressed overall crop growth.

Significant interaction effect was found between tillage and weed management practices. Among the interactions the combination of CT-CT with pre emergence application of pendimethalin 0.75 kg ha⁻¹ + hand weeding on 30 DAS (M₄S₂) produced higher plant height, greater DMP, LAI and no. of branches. The better crop growth can be due to reduced grass and annual weed seeds due to tillage operations which lead to better crop establishment (Patil and Halepyati 2018) which was at par with CT-CT with Pre emergence application of Pendimethalin 0.75 kg ha⁻¹ + post emergence application of quizalopehyl + imazethapyr @ 0.10 g a.i kg ha⁻¹ (M₄S₃) while as the premergence herbicide kills the weeds at early germination stage and post emergence herbicide controls the weeds at lateral stages (Goud *et al.*, 2021) [19]. ZT-ZT under unweeded control (M₃S₄) produced lower plant height, DMP, LAI and no. of branches due to the combined adverse effects of higher soil compaction under continuous zero tillage and severe weed competition throughout the crop growth period, which restricted root growth, nutrient absorption and vegetative development (Yadav *et al.*, 2020) [20].

Effect of tillage and weed management on yield and yield attributes

Maize

Tillage practices exerted significant influence on yield parameters of maize. Conventional tillage recorded higher yield and yield attributing characters viz., cob length, cob girth grains per cob, grain yield and stover yield under conventional tillage in maize crop I and CT-CT in maize crop II as furnished in the table 2. This may be because of improved weed suppression, better soil aeration and nutrient availability, which together reduced crop weed competition during critical growth periods and enhanced assimilate allocation to pods and seeds. Effective weed control and appropriate soil tillage create a more favourable environment for root proliferation and photosynthate accumulation, ultimately enhancing yield formation (Gathala *et al.*, 2020; Pandey *et al.*, 2019) [24, 41]. While the lower values of cob length (13.69), cob girth (10.55) and grains per cob (359.39) were obtained in ZT-ZT due to higher soil compaction, restricted root development and reduced nutrient availability, which limited kernel formation and cob development (Kassam *et al.*, 2019; Jat *et al.*, 2020) [21, 22].

The weed management practices were significantly influencing the yield attributing characters with the higher cob length of, cob girth of and grains per cob with the pre emergence application of metolachlor @ 1.25 a.i kg ha⁻¹ + hand weeding on 30 DAS (S₂) metolachlore controls annual grasses and broadleaved weeds by inhibiting cell division and shoot elongation of germinating weed seedlings and remains active in soil for 30-40 days

ensuring early season weed control the subsequent hand weeding removed late emerging weeds which caused lesser weed competition and higher availability of assimilate translocation to reproductive sinks, resulting in improved cob length, cob girth and number of seeds per cob (Sharma *et al.*, 2022) ^[14]. The next best treatment was pre emergence application of metolachlor @ 1.25 a.i kg ha⁻¹ + post emergence application of halosulfuron methyl + atrazine @ 0.596 a.i kg ha⁻¹ (S₃) may be attributed to its broad-spectrum and season-long weed control, metolachlor effectively controls early grassy and broad leaved weeds while post emergence application of halosulfuron methyl + atrazine reduced the sedges (Pandey *et al.*, 2019; Singh *et al.*, 2020) ^[25, 12]. In contrast, the unweeded control recorded the least values of yield attributes owing to continuous and severe weed competition. The interaction effect between tillage and weed management was found to be statistically significant. Regarding the interaction the treatment CT-CT with pre emergence application of metolachlor @ 1.25 a.i kg ha⁻¹ + hand weeding on 30 DAS (M₄S₂) significantly registered the maximum values of yield attributing characters viz., cob length, cob girth and seeds per cob which was at par with CT-CT with Pre emergence application of metolachlor @ 1.25 a.i kg ha⁻¹ + post emergence application of halosulfuron methyl + atrazine @ 0.596 a.i kg ha⁻¹ (M₄S₃) are due to improved soil physical conditions under conventional tillage combined with effective weed suppression throughout the crop growth period, which enhanced nutrient uptake, assimilate translocation and cob development. This was followed by S₁. The lowest values of cob length, cob girth and seeds per cob were obtained in ZT-ZT with unweeded control higher soil compaction and continuous weed competition restricted root growth, nutrient availability and cob formation (M₃S₄) this is similar with Karnataka *et al.*, 2021 ^[34]; Mishra *et al.*, 2022 ^[35].

Redgram

The application of different tillage and weed management practices significantly influenced yield attributes of redgram as enlisted in table 3. Among the tillage practices, the higher no. of seeds per pod (4.88) was recorded under CT-CT (M₄) which was at par with ZT-CT (M₁) whereas the least values were obtained in ZT -ZT. This might be due to higher weed control by conventional tillage which resulted in lower depletion of nutrients by weeds and better uptake of nutrients by maize which enhanced root growth and promoted superior flower retention and pod filling. In contrast, continuous ZT-ZT recorded the lowest values due to higher weed seed density resulted in higher weed density and higher weed dry weight which reduced yield and yield parameters (Pramodha *et al.* 2020) ^[18].

Among the assessed weed management practices higher no. of seeds per pod were obtained in Pre emergence application of pendimethalin 0.75 kg ha⁻¹ + hand weeding on 30 DAS (S₂) which was on par with pre emergence application of pendimethalin 0.75 kg ha⁻¹ + post emergence application of quizalopheyl + imazethapyr @ 0.10 g a.i kg ha⁻¹ (S₃) resulted from effective weed suppression during critical reproductive phases, minimizing crop-weed competition for moisture, nutrients, and photosynthates essential for pod filling and seed set. (Choudhary and Prakash 2018; Singh *et al.*, 2020) ^[27, 9]. This was followed by S₁ (two hand weedings on 20th and 40th DAS), while the least value of 3.55 was obtained in S₄ (unweeded

control) due to intense weed infestation causing resource depletion, poor pollination, and flower drop during seed development.

Significant interaction effect was found between tillage and weed management practices. Among the interactions CT-CT with Pre emergence application of pendimethalin 0.75 kg ha⁻¹ + hand weeding on 30 DAS (M₄S₂) was found to be superior which was at par with CT-CT with Pre emergence application of pendimethalin 0.75 kg ha⁻¹ + post emergence application of quizalopheyl + imazethapyr @ 0.10 g a.i kg ha⁻¹ (M₄S₃) which enhanced root growth and nutrient uptake, coupled with effective weed suppression that minimized crop-weed competition for resources during reproductive stages, ensuring better photosynthate allocation to pod and seed development. ZT-ZT with un weeded control recorded the least value of due to severe unchecked weed infestation depleting moisture, nutrients, and light, leading to poor pollination, higher flower drop, and reduced seed set.

Conclusion

Growth and yield attributes along with the yield of maize-redgram cropping sequence were influenced by both the tillage and weed management practices. Among the assessed tillage practices, significant increase in growth and yield attributes along with the yield of both the crops was noticed under weed management compared to weedy check. Thus, it can be concluded that CT-CT along with pre emergence application of metolachlor @ 1.25 a.i kg ha⁻¹ + hand weeding on 30 DAS or pre emergence application of metolachlor @ 1.25 a.i kg ha⁻¹ + Post Emergence application of halosulfuron methyl + atrazine @ 0.596 a.i kg ha⁻¹ in maize and CT-CT along with pre emergence application of pendimethalin 0.75 kg ha⁻¹ + hand weeding on 30 DAS or pre emergence of pendimethalin 0.75 a.i kg ha⁻¹ + post emergence application of quizalopheyl + imazethapyr @ 0.10 g a.i kg ha⁻¹ appeared to be effective for weed control and increasing the yield.

Authors' contributions

Tarannum contributed to conceptualization, data curation and writing of the original draft. J. Nambi was involved in conceptualization, supervision, funding acquisition, writing, review and editing. A. Sundari contributed to methodology, validation and writing of the original draft. A.P. Srinivasaperumal participated in writing original draft and editing. K.R. Sarvanan contributed to resources, visualization, methodology, writing, review and editing. All authors read and approved the final manuscript.

Compliance with ethical standards

Conflict of interest: On behalf of all authors, the corresponding author declares that there is no conflict of interest.

Ethical issues: None

Declaration of generative AI and AI-assisted technologies in the writing process

During the preparation of this article, the effects used "Quill bot" in order to improve language of readability. After that, the author carefully reviewed and edited the content as required and takes full responsibility for the content of the publications.

Table 1: Effect of tillage and weed management on growth attributes of maize-redgram

Treatment	Plant height				DMP				LAI			
	Maize-I	Redgram-I	Maize-II	Redgram-II	Maize-I	Redgram-I	Maize-II	Redgram-II	Maize-I	Redgram-I	Maize-II	Redgram-II
M ₁	231.85	124.07	247.27	116.92	12,437.8	2,913.5	11,569.69	3,103.2	2.19	1.32	2.48	1.38
M ₂	257.13	111.42	261.48	110.73	11,008.0	2,427.9	13,198.0	2,648.5	4.29	0.77	4.31	0.86
M ₃	229.69	106.83	25.02	104.65	10,257.0	2,313.1	10,700.0	2,482.1	2.15	0.47	2.27	0.51
M ₄	258.35	128.72	273.35	123.58	13,375.8	3,034.4	13,926.1	3313.11	4.35	1.46	4.82	1.51
S.Ed ±	14.12	0.71	1.89	0.60	640.22	20.62	56.41	23.52	0.02	0.006	0.01	0.003
CD (p = 0.5)	NS	1.76	3.88	1.27	NS	51.22	140.71	58.68	0.06	0.01	0.04	0.007
S ₁	230.87	115.23	244.00	116.07	12,136.9	2,405.3	13,376.9	2,578.0	3.30	0.90	3.49	0.98
S ₂	263.77	126.06	273.78	127.78	14,216.9	3,077.1	14,380.4	3,330.6	3.54	1.17	3.69	1.23
S ₃	261.84	124.84	270.68	126.17	14,063.3	3,039.0	14,164.2	3,275.6	3.46	1.15	3.64	1.19
S ₄	220.54	104.92	228.65	85.87	6,661.5	2,167.6	7,472.3	2,630.8	2.69	0.81	3.06	0.85
S.Ed ±	1.15	0.85	2.42	0.99	110.65	24.67	114.35	33.54	0.04	0.012	0.04	0.01
CD (p = 0.5)	2.16	1.77	4.97	2.03	229.74	51.45	237.42	69.63	0.04	0.02	0.08	0.02
M ₁ S ₁	221.27	119.67	240.23	119.75	13,346.7	2,509.0	12,257.1	2,620.5	2.15	1.26	2.44	1.29
M ₁ S ₂	247.4	133.67	264.08	130.45	15,171.1	3,420.3	13,569.4	3,647.1	2.38	1.45	2.65	1.50
M ₁ S ₃	245.3	132.17	261.15	128.17	15,016.6	3,377.9	13,312.8	3,608.1	2.26	1.42	2.55	1.48
M ₁ S ₄	213.46	110.79	223.60	89.318	6,217.0	2,347.0	7,139.2	2,537.2	1.99	1.18	2.27	1.25
M ₂ S ₁	240.55	110.82	248.26	111.37	11,052.7	2,306.1	14,601.9	2,525.8	4.46	0.56	4.49	0.76
M ₂ S ₂	281.27	118.54	283.82	124.42	13,180.1	2,732.6	15,248.3	2,982.2	4.7	1.01	4.67	1.12
M ₂ S ₃	279.70	117.93	279.69	123.57	13,055.0	2,706.1	15,100.5	2,933.9	4.69	0.99	4.64	1.01
M ₂ S ₄	227.031	98.37	234.13	83.54	6,744.3	1,966.6	7,841.3	2,152.1	3.33	0.53	3.45	0.57
M ₃ S ₁	219.84	107.12	229.13	104.03	10,212.3	2,194.1	11,448.7	2,368.9	2.11	0.39	2.26	0.41
M ₃ S ₂	243.74	113.60	251.32	120.09	12,556.8	2,622.2	12,603.5	2,827.0	2.33	0.61	2.47	0.65
M ₃ S ₃	242.11	112.32	247.58	118.25	12,421.1	2,578.0	12,359.4	2,764.5	2.21	0.58	2.38	0.63
M ₃ S ₄	213.07	94.27	212.06	76.25	5,837.7	1,858.3	6,388.3	1,967.8	1.97	0.33	1.99	0.38
M ₄ S ₁	241.84	123.29	258.37	129.11	13,935.9	2,611.9	15,199.7	2848.24	4.49	1.42	4.78	1.47
M ₄ S ₂	282.69	138.41	295.89	136.13	15,959.6	3,533.2	16,100.2	3,866.0	4.75	1.62	5.02	1.68
M ₄ S ₃	280.26	136.95	294.32	134.72	15,760.5	3,493.8	15,884.1	3,795.8	4.68	1.60	4.95	1.66
M ₄ S ₄	228.60	116.24	244.82	94.36	7,847.1	2,498.6	8,520.3	2742.25	3.49	1.22	4.55	1.23
S.Ed ±	11.20	1.63	4.84	1.98	860.21	47.44	205.94	62.67	0.06	0.02	0.07	0.02
CD (p = 0.5)	NS	3.52	9.95	4.07	NS	102.26	434.04	133.81	0.14	0.04	0.15	0.05

Table 2: Effect of tillage and weed management on yield attributes and yield of maize

Treatment	Cob length		Cob Girth		Seeds per cob		Grain yield		stover yield	
	Maize-I	Maize-II	Maize-I	Maize-II	Maize-I	Maize-II	Maize-I	Maize-II	Maize-I	Maize-II
M ₁	14.21	15.68	10.56	12.05	344.93	381.68	4616.37	4564.47	6,323.81	6691.87
M ₂	19.30	21.29	12.09	14.09	369.64	394.15	5275.99	5377.57	7,328.30	7851.87
M ₃	13.01	13.69	9.57	10.55	329.79	359.39	4354.25	4322.00	6,040.00	6178.78
M ₄	20.73	23.23	13.11	15.13	379.56	417.52	5477.98	5612.92	7,837.20	8232.37
S.Ed ±	0.11	0.10	0.20	0.14	1.59	3.19	32.32	24.05	50.24	65.72
CD (p = 0.5)	0.29	0.26	0.47	0.35	3.97	7.96	80.62	49.40	116.73	164.01
S ₁	14.53	15.97	10.12	12.18	357.32	384.27	5005.49	5,441.11	7,157.12	8068.91
S ₂	20.26	21.95	13.08	15.27	368.14	395.18	5952.60	5,892.22	8,285.69	8476.21
S ₃	19.51	21.56	12.70	14.44	365.35	393.34	5889.26	5,826.69	8,204.36	8321.54
S ₄	12.94	14.41	9.43	9.93	333.10	379.13	2877.24	2717.34	3,882.14	4027.50
S.Ed ±	0.19	0.24	0.22	0.17	2.20	4.19	38.96	40.98	56.22	82.97
CD (p = 0.5)	0.40	0.49	0.51	0.36	4.57	8.71	80.89	84.18	125.32	172.27
M ₁ S ₁	11.91	12.98	9.72	10.70	355.32	373.44	4533.06	4,864.23	6,519.72	7227.64
M ₁ S ₂	17.38	19.11	12.00	14.53	357.25	392.14	5580.35	5,482.33	7,599.80	7891.76
M ₁ S ₃	16.69	18.69	11.56	13.64	354.58	387.01	5530.56	5,398.98	7,524.49	7772.41
M ₁ S ₄	10.84	11.94	8.97	9.33	312.59	374.12	2821.53	2512.63	3,651.21	3875.68
M ₂ S ₁	17.11	18.82	10.37	13.58	366.65	390.75	5505.04	6,012.05	7,841.71	8859.24
M ₂ S ₂	22.80	24.98	14.19	16.47	378.83	388.90	6355.05	6,347.00	8,982.85	9048.84
M ₂ S ₃	22.30	24.58	13.87	15.52	376.22	397.51	6288.79	6,288.08	8,900.53	8889.89
M ₂ S ₄	14.97	16.80	9.94	10.81	356.85	396.22	2955.06	2863.15	3,588.12	4276.14
M ₃ S ₁	10.79	11.80	8.74	9.60	330.91	357.03	4261.91	4,633.39	6,192.00	6815.33
M ₃ S ₂	16.14	16.51	10.85	12.58	346.93	372.06	5322.01	5,198.80	7,324.81	7404.75
M ₃ S ₃	15.45	16.02	10.56	11.90	344.80	365.17	5256.96	5,115.58	7,246.08	7243.86
M ₃ S ₄	9.66	10.44	8.15	8.13	296.54	343.31	2576.15	2341.56	3,397.11	3268.84
M ₄ S ₁	18.31	20.29	11.64	14.82	376.43	415.86	5721.97	6,254.79	8,075.07	9373.43
M ₄ S ₂	24.72	27.21	15.29	17.52	389.57	427.63	6552.99	6,540.76	9,235.29	9559.49
M ₄ S ₃	23.59	26.96	14.83	16.71	385.79	423.68	6480.73	6,504.13	9,146.33	9380.01
M ₄ S ₄	16.29	18.45	10.67	11.47	366.44	402.89	3156.23	3152.02	4,892.12	4689.33
S.Ed ±	0.35	0.42	0.44	0.33	4.13	7.94	74.82	72.45	109.57	158.95
CD (p = 0.5)	0.75	0.90	0.96	0.71	8.84	17.02	161.18	154.96	237.14	339.58

Table 3: Effect of tillage and weed management on yield attributes and yield of redgram

Treatment	No. of branches		No. of seed pod ⁻¹		No. of pod plant ⁻¹		Seed yield		Stover yield	
	Redgram-I	Redgram-II	Redgram-I	Redgram-II	Redgram-I	Redgram-II	Redgram-I	Redgram-II	Redgram-I	Redgram-II
M ₁	9.66	9.65	4.53	4.57	159.37	154.28	776.94	837.11	2,029.37	2,211.07
M ₂	6.63	6.48	3.94	4.05	151.28	165.48	708.72	773.95	1,649.37	1,860.10
M ₃	5.94	6.10	3.55	3.42	138.76	149.39	672.65	721.75	1,556.08	1,741.64
M ₄	10.27	10.09	4.88	5.28	168.86	170.85	803.39	882.65	2,130.71	2,359.66
S.Ed ±	.007	0.04	0.04	0.12	0.97	0.70	2.64	3.54	13.20	6.24
CD (<i>p</i> = 0.5)	0.17	0.11	0.11	0.25	2.42	1.75	6.59	8.83	32.94	15.58
S ₁	7.14	7.32	3.91	4.42	143.13	145.67	721.62	780.28	1,629.37	1,814.80
S ₂	9.55	9.55	4.79	4.96	171.98	175.45	899.93	985.17	2,136.98	2,363.83
S ₃	9.35	8.86	4.66	4.77	169.28	174.86	889.49	976.31	2,111.34	2,327.84
S ₄	6.46	6.58	3.55	3.16	133.88	144.02	450.67	473.70	1,487.86	1,666.01
S.Ed ±	0.10	0.10	0.07	0.13	1.66	2.10	4.95	7.36	16.20	24.77
CD (<i>p</i> = 0.5)	0.22	0.22	0.15	0.28	3.45	4.36	10.28	15.29	33.65	51.30
M ₁ S ₁	8.26	8.82	4.18	4.74	150.79	132.31	750.47	793.66	1,655.56	1,844.94
M ₁ S ₂	11.44	11.45	5.20	5.25	174.05	170.45	934.13	1017.53	2,435.71	2,636.17
M ₁ S ₃	11.26	10.65	5.07	5.04	171.72	173.94	923.93	1010.26	2,407.09	2,610.75
M ₁ S ₄	7.68	7.68	3.69	3.25	140.91	140.43	499.25	526.99	1,619.14	1,752.42
M ₂ S ₁	5.95	5.95	3.75	4.10	137.21	155.66	694.71	769.94	1,584.35	1,799.18
M ₂ S ₂	7.83	7.83	4.38	4.69	169.72	180.82	864.22	952.64	1,841.22	2,061.10
M ₂ S ₃	7.64	7.02	4.22	4.44	167.34	176.79	854.72	946.31	1,820.69	2,026.49
M ₂ S ₄	5.12	5.12	3.41	2.97	130.87	148.66	421.25	426.92	1,351.21	1,553.62
M ₃ S ₁	5.49	5.63	3.22	3.48	122.62	129.42	666.35	716.65	1,504.17	1,659.20
M ₃ S ₂	6.99	6.99	4.05	4.04	160.57	166.21	838.17	905.19	1,742.57	1,952.77
M ₃ S ₃	6.76	6.79	3.87	3.81	157.85	168.73	830.53	896.19	1,721.41	1,922.86
M ₃ S ₄	4.54	5.02	3.09	2.35	114.01	133.21	355.55	368.99	1,256.19	1,431.75
M ₄ S ₁	8.89	8.89	4.48	5.36	161.91	165.31	774.96	840.86	1,773.39	1,955.89
M ₄ S ₂	11.96	11.96	5.53	5.89	183.6	184.32	963.19	1065.33	2,528.41	2,805.27
M ₄ S ₃	11.74	10.99	5.47	5.79	180.21	179.99	948.78	1052.47	2,496.16	2,751.26
M ₄ S ₄	8.52	8.52	4.02	4.08	149.72	153.81	526.63	571.92	1,724.90	1,926.24
S.Ed ±	0.19	0.19	0.13	0.24	3.04	3.71	8.97	13.23	31.02	43.36
CD (<i>p</i> = 0.5)	0.42	0.40	0.29	0.50	6.44	7.76	18.95	27.88	66.76	90.40

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