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Effect of Inter Cropping of Toria with Citronella, Palmarosa and Lemongrass in Different Row Ratio on Productivity and Profitability

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ABSTRACT

The experiment entitled Inter Cropping of Toria (*Brassica rapa*) with Citronella (*Cymbopogon winterianus*), Palmarosa (*Cymbopogon martinii*) and Lemongrass (*Cymbopogon citratus*) in different row ratio was conducted at the Students' Instructional Farm of Agronomy, Chandra Shekhar Azad University of Agriculture and Technology, Kanpur, Uttar Pradesh, India during *rabi* 2021-22 growing season. The experiment was laid out in Randomized Block Design (RBD) with 10 cropping systems of combination viz., T_1: Sole Toria (T), T_2: Citronella (C) + Toria (2:4:2), T_3: Citronella + Toria (3:6:3), T_4: Citronella + Toria (4:7:4), T_5: Lemongrass (L) + Toria (2:4:2), T_6: Lemongrass + Toria (3:6:3), T_7: Lemongrass + Toria (4:7:4), T_8: Palmarosa (P) + Toria (2:4:2), T_9: Palmarosa + Toria (3:6:3), T_{10}: Palmarosa + Toria (4:7:4) with three replications. The result revealed that the highest yield viz., biological yield (39.17 q ha^{-1}), grain yield (6.79 q ha^{-1}), stover yield (32.45 q ha^{-1}) and harvest index (17.15%) of toria was obtained from toria sole treatment. Among essential oil crops the highest production of citronella in 4:7:4 row ratios (52.33 q ha^{-1}) fallowed by 3:6:3 row ratio (46.33 q ha^{-1}) and 2:4:2 row ratio (32.67 q ha^{-1}) of citronella. The highest toria equivalent oil yield was found in sole toria (214.5 kg ha^{-1}) followed by C:T:C 4:7:4 (139.92 kg ha^{-1}) row ratio of citronella. The highest net income was obtained in C:T:C 4:7:4 (INR 50747 ha^{-1}) followed by P:T:P 4:7:4 (INR 45625 ha^{-1}) row ratio of palmarosa. The highest B:C ratio was found in C:T:C 4:7:4 (3.28) followed by 4:7:4 row ratio of palmarosa (3.37 and lowest B:C ratio was recorded in 2:4:2 row ratio of lemongrass (1.68).

Keywords Toria, Citronella, Palmarosa, Lemongrass, Productivity, Profitability.

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INTRODUCTION

Rapeseed and mustard are India's most important *rabi* oilseeds. They are second only to groundnut in area and production. India produces the most rapeseed and mustard in world. It produces 6.33 million tonnes of rapeseed and mustard on 6.412 M ha area and yields

1089 kg ha^{-1} (Anonymous 2021). Sarson, rai, toria and lahi are all names for seeds. Sarson and toria (Lahi) are Rapeseed, while Rai, Raya, or Laha is Mustard. Different types of seeds of mustard contain 37–49% oil. Pickles and curries are seasoned with the seeds and oil of mustard and rapeseed. Northern India cooks and fries with the oil. Hair oil and medicines are made with it. Soap, grease and lubrication with mineral oils use rapeseed oil. Oil cakes feed and fertilize cattle. Young plant leaves provide enough sulfur and minerals for green vegetables. Mustard oil softens leather in tanning. Recent advances in natural extracts have expanded the green revolution beyond flavors and fragrances. India is a global partner in aromatic oil production due to essential oil-bearing plants. Agriculture and post-harvest processing are profitable. India leads the world in mints, grasses, spices, exotic flowers, roots and woody oil production. India grows mentha species and can grow citronella, lemon grass, patchouli, vetiver, rose, eucalyptus and palmarosa. India represents 20% of the essential oil industry's 14 billion US$ turnover. Global essential oil production is 1 lakh tonnes. India's 16% Medicinal and aromatic plants (MAPs) boost rural economies and national health through minor crops. 90% of Indian medicine formulations use plant-based ingredients. Medicinal plant sales exceed $60 billion worldwide. India exports nearly INR 600 crore in herbal, materials and medicine. Over 1010 lakh ha are planted with medicinal plants. Herbal drugs are worth over 4000 crore in India. India leads essential oil production (Nandy *et al.* 2006). Ceylon citronella oil from *Cymbopogon nardus* is inferior, while Java citronella oil from *Cymbopogon winterianus* is superior. Perennial grass Java citronella (*Cymbopogon winterianus*) grows from vegetative slips. It thrives in various soils. Aromatic grasses yield citronella grass oil. Geranial, citronellal, hydroxy citronella and other high-value perfumery bases are made from citronella oil. Aromatic *Palmarosa* belongs to poaceae (Germaine). It's botanically *Cymbopogan maritini* stapf vari. Motia. Rosa grass, Russ grass, Palmasosa, Grandhebel Rusaghas, Rohisah and East Indian Geranium oil are all names for this variety. Palmasosa oil comes from its floral shoots and above-ground parts. Palmarosa oil contains pinene, myrcene, limonene, 1,8-cinene, B-terpinene, n-hexanote, b-caryophyllene, nerylformate, gernayl acetate, nerol, prenyl octanoate, geranyle butyrate, and gernyl isovalerate. 6,7-geranyl expoxide, 2,3-geranyl expoxide, Caryphyllene, geranyl hexanoate, octonoate, p-mentha-1, 8 (10)-dein-g-01. Due to its long-lasting rose scent, palmarosa oil is used in perfumery to flavor tobacco and soaps. Because geraniol is stable with alvali, soap perfumery uses it. It provides high-grade geraniol. Geraniol esters, which have a permanent rose-like scent are used to make many synthetic aroma chemicals. India also grows ginger grass, or *Cymbopogon martini* stapf vari. Sofia, which produces oil with less geraniol. Ginger grass oil, a lower-grade infusive oil, costs less than palmarosa oil. Palmarosa oil is an antifungal that kills black mould, mouldy soil and plant pathogen *Penicillium funiculosum* (Verma *et al.* 2018). Tropical perennial lemongrass produces aromatic oil with 70–90% Citral. The Malabar Coast's lemon-grass oil is made from *Cymbopogon flexuous*, while the other species, *Cymbopogon citrates*, produces similar but distinct oil. *Cymbopogon flexuosus* essential oil (citraltype) contains citral-b from 14% to 35% and citral-a from 23% to 56%, while geraniol type contains 17% to 88%. Indian palm-leaf manuscripts are preserved with pesticide and preservative lemongrass oil. The Oriental Research Institute Mysore, the French Institute of Pondicherry, the Association for the Preservation of the Saint Thomas Christian Heritage in Kerala and other Indian manuscript collections use it. East Indian lemon grass (*Cymbopogon flexuosus*), also known as Cochin grass or Malabar grass is native to Cambodia, Vietnam, Laos, India, Sri Lanka, Burma and Thailand. West Indian lemon grass (*Cymbopogon citratus*) is native to South Asia and Maritime Southeast Asia. *C. citratus* is better for cooking. India uses *C. citratus* medicinally and in perfumes. Brazilian folk medicine uses *C. citratus* tea for anxiety, but a human study found no effect. In one case, tea triggered contact dermatitis. Agriculture produces essential food, pulse and oilseed crops. Forestry, dairy, fruit, poultry, beekeeping, mushroom, arbitrary are now part of agriculture. Today, agriculture includes processing, marketing and distributing crops and livestock. Thus, agriculture involves producing, processing, promoting and distributing agricultural products. Agriculture is vital to any economy. An economy relies on agriculture. Agriculture employs a large portion of the population and provides food and raw materials. India, like many agricultural nations, has farms of

all sizes. Intercropping maximises resource use and yield, income and risk management. Intercropping benefits all crops in adverse weather conditions. The experiments examined the effects of row ratio on crop yield, treatment combination on crop economics, and the best inter-cropping economic combination.

MATERIALS AND METHODS

Experimental site: The experiment was laid out in the field No. 03 at Student Instructional Farm of Agronomy at Chandra Shekhar Azad University of Agriculture and Technology, Kanpur (UP) India during *rabi* season 2021-2022. The farm is located in the main campus of university. The field was well levelled having good irrigation and drainage facilities.

Geography and climate: Geographically, Kanpur is situated in subtropical region. It is situated at an elevation of 125.9 meter above mean sea level, 26º20'' 35'' North latitude and belt of indo-gangetic plain in the Central Part of Uttar Pradesh, which comes into Agro-climatic zone-Central plain zone. Normally the climate of the area is semi-arid with hot dry summer and moderate to severe cold during winter. The average annual rainfall of the area varies from 800 to 900 mm with a mean annual precipitation of about 818 mm, mainly through monsoon rains confined within June to last week of September.

Experimental detail : An experiment was laid out in Randomized Block Design (RBD) with ten treatments with three replications. The treatments constituting three essential oil crops i.e. Citronella, Palmarosa and Lemongrass in 2:2, 3:3 and 4:4 row ratios and intercropping with Toria crop and one sole crop of Toria viz., T_1: Toria sole, T_2: Citronella + Toria (2:2), T_3: Citronella + Toria (3:3), T_4: Citronella + Toria (4: 4), T_5: Lemongrass + Toria (2:2), T_6: Lemongrass + Toria (3:3), T_7: Lemongrass + Toria (4:4), T_8: Palmarosa + Toria (2:2), T_9: Palmarosa + Toria (3:3), T_{10}: Palmarosa + Toria (4:4). The size of each plot was (30.24 m^2) 4.20 m length and 7.20 m breadth. Each experiment included 30 plots.

Agronomic practices: Due to rain pre sowing irrigation are not required. After removing the weed plant, individual plots of each replication should be prepared with the help of Rotavator. After field preparation layout was maintained by making ridges and irrigation channel with the help of manual labor and all the treatment were randomized. Sowing was done manually.

Seed and sowing: Citronella: Root slips of Citronella variety BIO-13 were used. After removing upper sheath the root slips was transplanted in line on 12 August, 2016 at a spacing of 60 × 60 cm. Lemongrass: Root slips of Lemongrass variety Pragathi were used. After removing upper sheath the root slips was transplanted in line on 12 August, 2016 at a spacing of 60 × 60 cm. Palmarosa: Seedling of Palmarosa variety PRC-1 was used. After cutting of levees the Seedling was transplanted in line on 12 August 2016 at a spacing of 60 cm × 15 cm. Toria : Seed of Toria variety Tapeshwari was used @ 5 kg/ha. The crop was sown with the help of Desi plough on 27 Sept. 2021, at a spacing of 40 ×15 cm row to row.

Application of fertilizer: After making the individual experiment unit recommended dose of fertilizer as per treatment was supplied through Urea, DAP, MOP and Sulfur. The full dose of P_2O_5, MOP, S and half dose of nitrogen was supplied at the time of sowing and remaining dose of nitrogen was applied in split doses. Recommended dose of fertilizer for citronella (150:80:40:0 kg), lemon grass (450:100:125:0 kg), palmarosa (60:40:40:0 kg) and toria (80:40:40:25 kg) N, P_2O_5 and K_2O.

Intercultural operation: To protect the crop from adverse effects of weeds and to pulverize the soil, the weeding and hoeing operation was performed after first and second irrigation at optimum soil moisture condition of the soil by manual labor with the help of khurpi during the experimentation time.

Harvesting and distillation of essential oil herbs (Citronella, Palmarosa and Lemongrass): The number of harvests, which can be taken during a year, depends upon the growth of the plants. The leaves are ready for harvest about 5- 6 months after planting and harvesting was done 20 cm above the ground level. The second and subsequent harvests can be taken thereafter 2.5-3 months interval. Distillation was done by the process of steam dis-

Table 1. Effect of inter cropping of toria with citronella, palmarosa and lemongrass in different row ratio on growth attributes of toria.

Treatment	Plant population/ running meter at 40 DAS	Plant height at maturity (cm)	Number of primary branches plant^{-1} at 45 DAS	Number of primary branches plant^{-1} at maturity	Number of secondary branches plant^{-1} at 45 DAS	Number of secondary branches plant^{-1} at maturity
Toria sole	13.00	110.5	6	11	17.25	25.32
C:T:C 2:4:2	13.00	109.67	7	10	17.74	25.27
C:T:C 3:6:3	14.00	113.67	6	8	16.13	24.53
C:T:C 4:7:4	13.00	107.33	7	11	18.47	26.87
L:T:L 2:4:2	14.00	109.33	6	9.33	17.33	25.73
L:T:L 3:6:3	13.00	109.33	7	9	17.13	24.63
L:T:L 4:7:4	14.00	114.67	6	8	17.07	24.57
P:T:P 2:4:2	15.00	107.67	7	9.66	17.47	24.97
P:T:P 3:6:3	13.00	109.67	6	10	18.93	25.98
P:T:P 4:7:4	14.00	109.33	7	10	17.33	24.38
SE(m)±	0.5056	1.2698	0.4676	0.5079	0.0730	0.0983
CD (5%)	N/S	3.7733	N/A	1.5095	0.2158	0.2913

tillation. The distillation equipment consists of a boiler in which steam is produced, a distillation tub for distilling the herb, a condenser and separators.

Observations recorded: In order to determine the effect of different treatments, the number of observations are recorded growth characters, yield attributes, yields, oil content and economics viz., plant population, plant height, number of primary branches at 45 DAS and at maturity, number of secondary branches at 45 DAS and at maturity, number of tillers plant^{-1}, number of siliqua plant^{-1}, number of seeds siliqua^{-1}, test weight, biological yield, grain yield, stover yield, harvesting index, oil yield of essential crops, equivalent oil yield of toria, cost of cultivation, gross income, net income and benefit : Cost ratio. Data obtained was exposed to the proper method for statistical analysis of variance difference among mean of different treatments as described by (Gomez and Gomez 1984). The treatments means were compared using the least significant differences (LSD) test at 5% level of probability by using the Randomized Block Design (RBD) model as obtained by Co. Stat 6.311, 1998–2005 as statistical program.

Table 2. Effect of inter cropping of toria with citronella, palmarosa and lemongrass in different row ratio on yield attributes.

Treatment	Number of tillers plant^{-1} essential crops	Number of siliqua plant^{-1} of toria	Number of seeds siliqua^{-1} of toria	Test weight (g) of toria
Toria sole	-	553	12.33	4.02
C:T:C 2:4:2	83	550	13.67	3.75
C:T:C 3:6:3	84.67	556	14.33	3.67
C:T:C 4:7:4	85	544.66	14.67	3.32
L:T:L 2:4:2	74	536.66	14.33	3.67
L:T:L 3:6:3	73.33	533.33	13.67	3.76
L:T:L 4:7:4	75.33	526.66	15.67	3.52
P:T:P 2:4:2	20	527.33	14	3.77
P:T:P 3:6:3	17	530.33	14.33	3.56
P:T:P 4:7:4	21.67	530	13.33	3.77
SE (m)±	0.9103	15.6929	0.5225	0.949
CD (5%)	2.7295	N/S	1.5522	0.2813

Table 3. Effect of inter cropping of toria with citronella, palmarosa and lemongrass in different row ratio on yields of toria.

Treatment	Biological yield (q/ha)	Grain yield (q/ha)	Stover yield (q/ha)	Harvest index (%)
Toria sole	39.17	6.72	32.45	17.15
C:T:C 2:4:2	26.8	3.15	23.65	11.75
C:T:C 3:6:3	26.4	3.55	22.85	13.44
C:T:C 4:7:4	27.39	4.24	23.15	15.48
L:T:L 2:4:2	26.75	3.25	23.5	12.14
L:T:L 3:6:3	26.4	3.28	23.12	12.42
L:T:L 4:7:4	26.74	3.85	22.89	14.39
P:T:P 2:4:2	25.78	3.18	22.6	12.33
P:T:P 3:6:3	25.65	3.45	22.2	13.45
P:T:P 4:7:4	26.26	4.16	22.1	15.84
SE (m)±	1.0904	0.3996	0.7257	0.2183
CD (5%)	3.2406	1.1873	2.1566	0.6483

Table 4. Effect of inter cropping of toria with citronella, palmarosa and lemongrass in different row ratio on oil yield of toria and essential oil crops.

Treatment	Herb yield of essential crops (q/ha)	Oil yield of essential crops (kg/ha)	Grain yield of toria (q/ha)	Equivalent oil yield of toria (kg/ha)
Toria sole	-	-	6.72	214.5
C:T:C 2:4:2	32.67	23.33	3.15	103.95
C:T:C 3:6:3	46.33	26.33	3.55	117.15
C:T:C 4:7:4	52.33	30.67	4.28	139.92
L:T:L 2:4:2	8.33	2.60	3.25	107.25
L:T:L 3:6:3	13.33	4.94	3.28	108.24
L:T:L 4:7:4	22.67	6.23	3.85	127.05
P:T:P 2:4:2	5.67	7.2	3.18	104.94
P:T:P 3:6:3	7.33	10.41	3.45	113.85
P:T:P 4:7:4	13.67	13.28	4.16	137.28
SE(m)±	0.3578	0.2098	0.3996	2.5549
CD (5%)	1.0730	0.6282	1.1873	7.5927

Table 5. Effect of inter cropping of toria with citronella, palmarosa and lemongrass in different row ratio on economics.

Treatment	Cost of cultivation (INR ha^{-1})	Gross returns (INR ha^{-1})	Net returns (INR ha^{-1})	B:C ratio
Toria sole	25259	53300	28041	2.11
C:T:C 2:4:2	21458	57522	36064	2.68
C:T:C 3:6:3	21458	61352	39894	2.85
C:T:C 4:7:4	22290	73037	50747	3.28
L:T:L 2:4:2	19535	32930	12755	1.68
L:T:L 3:6:3	18630	36585	17955	1.96
L:T:L 4:7:4	21148	41912	20764	1.98
P:T:P 2:4:2	22156	45404	23248	2.04
P:T:P 3:6:3	22156	54664	32508	2.46
P:T:P 4:7:4	20046	65672	45625	3.27

RESULTS AND DISCUSSION

Growth indices of toria: The data regarding that the plant population of toria recorded at 40 DAS of crop were analyzed and presented in Table 1 revealed non-significant difference was observed in toria. The maximum plant population recorded in P:T:P (2:4:2) row ratio of palmarosa and toria. The perusal of data reveals that the plant height (Table 1) of toria was observed significantly better with L:T:L 4:7:4 row ratio of crop. The data pertaining to the number of primary branches $plant^{-1}$ and number of secondary branches $plant^{-1}$ were recorded at 45 DAS and maturity stage were analyzed and presented in Table 1 showed that non-significant difference was observed at 45 DAS. The significantly difference recorded at maturity, the maximum number of primary branch $plant^{-1}$ and number of secondary branches $plant^{-1}$ in C:T:C (4:7:4) row ratio and minimum number of secondary branches $plant^{-1}$ at maturity were recorded in P:T:P 4:7:4 row ratio of crop. The more and less similar finding proposed by (Sharma *et al.* 2005), (Pandey and Singh 2015), (Uttam *et al.* 2012) and (Mishra 2014).

Yield attributes of toria: The data pertaining to number of tillers $plant^{-1}$ presented in Table 2 was significantly influenced by different row ratios of toria. The highest number of tiller $plant^{-1}$ recorded in 4:4 and 3:3 row ratios of citronella and toria followed by lemongrass 2:2 row ratio while lowest number of tiller $plant^{-1}$ recorded in all the row ratio of palmarosa. The data recorded in relation to number of tillers/plant after harvesting of citronella herb which showed that were significant difference in intercropping system means number of tillers/plant in citronella which was affected by space and intercrop. Similar result reported by (Srivastava *et al.* 2016), (Ansari *et al*. 2015), (Verma *et al.* 2014), Sharma *et al.* (2002) and (Singh and Bohra 2012). The data regarding number of siliqua $plant^{-1}$ and number of grains $siliqua^{-1}$ in toria were analyzed and presented in Table 2. The maximum number of siliqua $plant^{-1}$ (556) was recorded in C:T:C 3:6:3 fallowed by Toria Sole and lowest number of siliqua $plant^{-1}$ recorded in 4:4 row ratio of lemongrass. The highest number of grain $siliqua^{-1}$ (15.67) was recorded in L:T:L 4:7:4 row ratio and lowest recorded in (12.33) in sole toria. The test weight (g) of toria observed non-significant difference in all row ratios. The maximum test weight recorded in toria sole (4.04 g) and lowest in C:T:C 4:7:4 row ratio of citronella. More and less similar result reported by (Kumar *et al.* 2008), (Mirjha and Rana 2016) and (Tripathi and Nath 2019).

Yields: The data regarding yield (q ha^{-1}) viz., biological yield, grain yield and stalk yield (q ha^{-1}) of toria of sole and intercropping treatments were analyzed and presented in Table 3 showed that significantly highest biological yield (39.17), grain yield (6.72) and stalk yield (32.45) was observed in toria sole treatment.

Among intercropping system highest biological yield (27.39) was found in 4:4 row ratio of citronella which was significantly superior to other row ratio system. The grain yield is significantly higher in 4:4 row ratio of citronella i.e. 4.24 q/ha. The lowest grain yield was found in 2:2 row ratio of citronella (3.15 q/ha). The lowest stalk yield (22.1) is recorded in 4:4 row ratio of palmarosa and the lowest biological yield was found in 4:4 row ratio of palmarosa (26.26). The similar finding proposed by Ansari *et al.* (2014), (Kumar *et al.* 2008), (Mirjha and Rana 2016), (Tripathi and Nath 2019) and (Singh and Bohra 2012).

Oil equivalent yield of toria: The perusal of the data the oil equivalent yield of different crop sequence was computed by multiplying the oil yield of spring season crops with their respective per unit prices Table 4. The calculated total return (INR ha^{-1}) was divided by the price of oil and was added to the oil yield. There was highest (214.5 kg ha^{-1}) found in sole toria followed by 4:4 row ratio of citronella and lowest (103.95 kg ha^{-1}) in 2:2 row ratio of citronella. The more and less similar results were recorded by (Ao and Saud 2016), (Wartha *et al.* 2020) and (Shekhawat *et al.* 2012).

Herb yield and oil yield of essential oil crops: Data regarding herbage yield of essential oil crops and oil yield obtained after the extraction of herbs were presented in Table 4. It is clear from the table that higher herbage yield was found in C:T:C 4:7:4 row ratios of citronella which were significantly superior over C:T:C 3:6:3 and C:T:C 3:4:3 row ratios of citronella. The citronella intercropping system significantly gave highest oil yield 30.67 kg ha^{-1} recorded in 4:4 ratio followed by 3:3 ratios but in lemongrass and palmarosa intercropping system significantly higher oil recovery found in 4:4 ratio fallowed by 3:3 row ratio. The lowest oil recovery found in 2:2 row ratio of all essential oil cropping system. The similar finding proposed by Kalita *et al.* (2012), Verma *et al.* (2014), Ansari *et al.* (2014), Ansari *et al.* (2015), Mani *et al*. (2015) and Tomar *et al.* (2015).

Profitability: The profitability parameter viz., cost of cultivation, gross income, net income and benefit cost ratio were influenced by different treatments Table 5. The cost of cultivation is highest in sole toria (INR 25259 ha^{-1}) and lowest cast of cultivation in 3:3 row ratio of lemongrass and toria (INR 18630 ha^{-1}). The highest gross income (INR 73037 ha^{-1}) and net income (Rs 50747) were found in C:T:C (4:7:4) and the lowest gross income (INR 50747 ha^{-1}) and net income (INR12755 ha^{-1}) were found in L:T:L2: 4:2 treatments. The highest B:C ratio was found in C:T:C 4:7:4 (3.28) and lowest B:C ratio was observed in 2:4:2 row ratio of lemongrass (1.68). The similar finding proposed by Srivastava *et al.* (2016), Mishra *et al*. (2018), Behera *et al.* (2015), Ansari *et al.* (2015) and Mani ram *et al.* (2015).

CONCLUSION

On the basis of experimental result conducted during *rabi* season (2021-22) at student instructional farm under irrigated condition following conclusion can be done. Cultivation of citronella + toria 3:6:3 intercropping system was superior over other treatment. Sole toria (214.5 kg ha^{-1}) gave the highest toria oil equivalent yield followed by C:T:C 4:7:4 (139.92 kg ha^{-1}), P:T:P 4:7:4 (137.28 kg ha^{-1}) and lowest oil equivalent yield of toria recorded in C:T:C 2:4:2 (103.95 kg ha^{-1}) row ratio. From economic point of view the highest net return found in C:T:C 4:7:4 (INR 50747) followed by P:T:P 4:7:4 row ratio of palmarosa (INR 45625) and lowest net income obtained in 2:4:2 row ratio of lemongrass (INR 12755). The highest B:C ratio was found in C:T:C 4:7:4 (3.28) followed by 4:7:4 row ratio of palmarosa (3.27) and other treatments and the lowest B:C ratio was observed in 2:4:2 row ratio of lemongrass (1.68).

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