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CONSERVATION TILLAGE, MOISTURE CONSERVATION AND COVER CROP MANAGEMENT ON YIELD AND YIELD ATTRIBUTES OF PIGEONPEA (*Cajanus cajan*) IN NORTHERN TRANSITION ZONE OF KARNATAKA

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ABSTRACT

Conservation agriculture has been emphasized as a holistic approach for long-term sustainability as it offers permanent soil cover, no vertical perturbation of soil and natural increase in organic matter content of the soil. Investigations worldwide stressed the beneficial impact of conservative way of crop production on the natural resources and environment. A field experiment with six tillage practices mainly conservation tillage with BBF and crop residues retained on the surface (CT_1); conservation tillage with BBF crop residue incorporation (CT_2); conservation tillage with flat bed with crop residues retained on the surface (CT_3); conservation tillage with flat bed with incorporation of crop residues (CT_4); conventional tillage with crop residues incorporation (CT_5) and conventional tillage with no crop residues (CT_6) were super imposed by two cover crop management mainly with and without cowpea cover crop under rainfed farming situation at Main Agriculture Research Station (MARS), University of Agricultural Sciences Dharwad, during *kharif* 2016 and 2017. The two years pooled data on yield and yield attributes of pigeonpea showed that, significantly higher number of pods plant^{-1} (161.78, 164.07, 161.13 and 162.22), grain weight plant^{-1} (65.88, 68.10, 68.09 and 66.43) and 100 seed weight were recorded in all the conservation tillage systems(CT_1 to CT_4) and were significantly superior to conventional tillage system with no residues. Seed yield was significantly higher in all conservation tillage (C_1, C_2, C_3 and C_4) systems (2212, 2268, 2219 and 2233 kg ha^{-1} respectively), whereas, stalk yield (4819 kg ha^{-1}) and harvest index (32.20 %) were significantly higher in conservation tillage with flat bed with incorporation of crop residues and conservation tillage with BBF and crop residues retained on the surface respectively over rest of the treatments. In pigeonpea without cowpea cover crop recorded significantly higher number pods plant^{-1}, seed yield plant^{-1}, 100 seed weight, grain yield, stalk yield and harvest index as compared to cover crop. The interaction of tillage systems and cover crop management practices differed significantly and conservation tillage with BBF and incorporation of crop residues without cowpea cover crop recorded significantly higher grain yield and stalk yield (2448 and 5006 kg ha^{-1} respectively) as compared to other combinations.

(Key words: Conservation tillage, cover crop, broad bed and furrow (BBF), and crop residues)

INTRODUCTION

The conservation of natural resources has been one of the main global concerns in recent years (Anonymous, 2018). These resources include soil, which supports plant growth and development as one of its ecological functions (Brady and Weil, 2013). However, the deforestation and inadequate conservation practices has led to soil degradation, which is considered a serious environmental problem (Lal, 1997), because it contributes to increasing CO_2 emission to the atmosphere (Six and Paustian, 2014) and aggravates the effects of global warming. According to recent population growth estimates the world's population will reach 8.6 billion people by 2030 and 9.8 billion by 2050 and impose greater pressure on the available natural resources (Anonymous, 2017). There are also limits set for the expansion of new agricultural areas in addition to this forecast.

The key option for increasing food production has been to use of agronomic techniques that allow for higher yields with less in puts and, more importantly, that avoid soil erosion as much as possible and conserve enough water. Given this possibility, the conservational tillage systems for example, the no-tillage systems (NTS), have been evolved, which aims at reduced soil disturbance and maintenance of plant residues on the surface with better

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soil physical condition (Roth *et al.,* 1988; Seben Junior *et al*., 2016). With this perspective, conservation agriculture with diversified cropping systems mimics the forest ecosystem, where the soil is covered all the time. Nonetheless, there is the action of the seeder shanks, for opening the furrow, where fertilizer and seed are deposited, and the traffic of machinery and implements for crop practices and harvest. Due to the accumulation of organic matter on the surface of the soil under NTS, the soil biological activity get promoted due to larger supply of OC (Ogle *et al*., 2012) and thus intensifies the process of soil aggregation, besides reducing CO_2 emission to the atmosphere (Six and Paustian, 2014), since C remains protected between soil aggregates.

CA is a resource-saving agricultural production system that aims to achieve production intensification and high yields while, enhancing the natural resource base through compliance with three interrelated principles, along with other good production practices of plant nutrition and pest management (Abrol and Sangar, 2006). An understanding of the fundamental components of conservation agriculture is imperative in order to appreciate the necessity for resource conservation technologies, as well as the difficulties associated with their development. The standardization of tillage systems, cover crop and their management for a given agro-climatic situations and in a given cropping system is a need of the hour. To that effect, the aim and purpose was to study the effect of conservation tillage systems, moisture conservation and cover crop management practices on growth and yield of pigeonpea, in Northern transition zone of Karnataka.

MATERIALS AND METHODS

The experiment was conducted at Main Agricultural Research Station (MARS), University of Agricultural Sciences (UAS), Dharwad, Karnataka on a fixed site during 2016 and 2017 in plot No. D 103 of D Block, which is located at 15^0 26N latitude and 75^0 7 E longitude and at an altitude of 678 m above the mean sea level. According to NARP Agro-climatic classification MARS, comes under the Northern Transition Zone (Zone 8) of Karnataka, which lies in between the Western high rainfall Hilly Zone (Zone 9) and low rainfall Northern Dry Zone (Zone 3) of Karnataka. The mean annual rainfall for the past 65 years at MARS, Dharwad is 711.44 mm, which is well distributed from June to October with two peaks, received one in the month of July (153.48 mm) and another during October (124.52 mm). In all the conservation tillage treatments, crop residues produced in the system were retained on the surface till April end. The treatments were imposed during first week of May. In conservation tillage with flatbed and BBF plots, rotovater was used for surface shredding and surface incorporation of crop residues and rotoslasher was used for shredding and crop residues were retained as mulch on the surface and no tillage operations were carried out later. In conventional tillage with crop residues treatment the land was ploughed with mould board plough and incorporated the crop residues and in conventional tillage without crop residues the residues were removed and land was ploughed with mould board plough. In both the treatments the clods were crushed by cultivating with cultivator and harrow and soil was brought to fine tilth. Well decomposed FYM at the rate of 5 t ha^{-1} was incorporated into the soil fifteen days before sowing. The recommended chemical fertilizers for pigeonpea were applied at the time of sowing as a basal dose. The experiment was laid out as per the plan of layout. Broad bed and furrows with a bed width of 120 cm and 30 cm furrow were made immediately after sowing of the crops. The opened furrows act as water conservation furrows and also disposal furrows to drain excess water.

Plant samples were collected at 60, 90 and 120 DAS and at harvest. At each sampling, randomly selected five plants were cut at the ground level. The samples were first air dried and then oven dried at 70 ^{0}C till they attain constant weight. The dry weight was recorded as total dry matter production and expressed in grams $plant^{-1}$. The number of pods from five randomly selected plants was counted and their mean was recorded as the number of pods $plant^{-1}$. The grains were separated from five plants and their weight was recorded. The average grain weight $plant^{-1}$ was calculated and expressed in gram $plant^{-1}$. The weight of 100 grains was recorded from the grain sample from each of the net plot and expressed in gram. Air dried plants from each net plot were threshed, cleaned, dried and weighed. The net plot seed yield was converted to yield ha^{-1} and expressed in kg ha^{-1}. From each net plot area stalk yield was recorded after complete sun drying, which was converted to ha and expressed in kg ha^{-1}. Harvest index was calculated as suggested by Donald (1962) and expressed in percentage.

$$HI\ (\%) = \frac{\text{Economic yield (kg ha}^{-1}\text{)}}{\text{Biological yield (kg ha}^{-1}\text{)}} \times 100$$

The data obtained from the experiment on various characters was subjected to statistical analysis as per the analysis of variance (ANOVA) technique for strip split block design as described by Gomez and Gomez (1984). The level of significance used in 'F' and 't' test was P = 0.05 and critical difference (CD) values were calculated where 'F' test was found significant. The mean values of each treatment separately subjected to Duncan's multiple range test using corresponding error mean sum of squares and degrees of freedom values. The mean followed by the same lower case letter do not differ significantly at the 0.05 probability level.

RESULTS AND DISCUSSION

Growth of a plant is an outcome of series of internal biological events involving biochemical, physiological and morphological changes which take place during its development in accordance with the resources *viz*., light, moisture, temperature and nutrients, resulting in synthesis, accumulation and translocation of photosynthates. Yield is related to both total assimilation achieved during season and the way material acquired is portioned between harvestable storage structure and the rest of the parts and these factors are controlled by environment under which the crop is grown.

Yield and yield attributes

Two years of pooled data on seed yield of pigeonpea showed that, the conservation tillage with BBF and incorporation of crop residues CT_2 (2268 kg ha^{-1}), conservation tillage with flat bed with crop residues retained on the surface CT_3 (2219 kg ha^{-1}) and conservation tillage with flat bed with incorporation of crop residues CT_4 (2233 kg ha^{-1}) recorded significantly higher seed yield of pigeonpea over conventional tillage with crop residues incorporation CT_5 (2072 kg ha^{-1}) and conventional tillage without crop residues CT_6 (1862 kg ha^{-1}). The per cent increase in yield with CT_2, CT_4 and CT_3 over CT_6 was 21.18, 19.1 and 19.9 per cent respectively. Crop residues retention on the surface and incorporation significantly influenced the seed yield over no residues. Hence, combined application of conservation tillage with soil and water conservation practices and either crop residues retention or incorporation was found suitable for enhancing the yield. Application of pigeonpea residue which had lower C: N ratio, mineralized N in shorter period and hence enhanced the growth and yields of crop. Higher yield of pigeonpea on BBF may be ascribed to adequate supply of water during entire growth period of crop and higher availability of nutrients (Chauhan *et al.,* 2004).BBF practice of tillage and and crop cultivation in soybean during *kharif* season under rainfed situations has noticed the maximum water conservation and uptake of nutrients (Parlawar *et al*., 2018).

Among cover crop management, pigeonpea without cover crop CC_2 (2284 kg ha^{-1}) recorded significantly higher seed yield as compared to with cover crop CC_1 (2005 kg ha^{-1}). Because of initial slow growth of pigeonpea got suppressed by an aggressive vegetative growth of cowpea at initial stages, affecting its growth, development and yield. Interaction of tillage practices and cover crop management differed significantly and conservation tillage with BBF with incorporation of crop residue without cover crop CT_2CC_2 (2448 kg ha^{-1}) recorded significantly higher seed yield as compared to all other combinations. Crop residues retention on the surface and incorporation significantly influenced the seed yield over no residues. Hence, combined application of conservation tillage with soil and water conservation practices and either crop residues retention or incorporation was found suitable for enhancing the yield. Whereas significantly lower seed yield was noticed in conventional tillage without crop residues with cowpea cover crop CT_6CC_2 (1805 kg ha^{-1}). These results are in line with the findings of Seema Sepat *et al.* (2012). They reported that, on deep black soils the moisture content was 3.5 per cent more in minimum tillage than conventional tillage at all stages of pigeonpea crop had a favourable effect on yield. Conservation tillage with residue mulch and crop residue incorporation is helpful in enhancing rain water conservation, its retention, as well as its utilization, which resulted in achieving higher yields (Naveen kumar and Babalad, 2017).

Significantly higher yields obtained under conservation tillage systems were due to positive correlation with yield attributing traits *viz.*, number of pods $plant^{-1}$ and seed weight $plant^{-1}$. Significantly higher number of pods $plant^{-1}$ (161.78, 164.07, 161.13 and 162.22) and higher seed weight $plant^{-1}$ (65.88, 68.10, 68.09 and 66.43 g) were produced in conservation tillage systems(CT_1, CT_2, CT_3 and CT_4 respectively), as compared to conventional tillage with crop residues incorporation (159.10 and 62.76 g, respectively) and conventional tillage without crop residues (149.29 and 59.02 g, respectively). Higher yield attributing characters observed due to favorable soil temperature and conserved soil moisture through reduced evaporation either by crop residues or cowpea cover crop. Thus, decreased dehydration and increased net photosynthesis which favored yield components. Further, decomposition of crop residues mineralize the nutrients and increased their availability and absorption to the plants which resulted in higher energy transformation, metabolic process, chlorophyll content, root development and yield components. Kashif *et al.* (2006) and Bahar (2013) reported that higher yield attributing characters in conservation tillage plots compared to conventional tillage plots was mainly due to higher soil organic matter and soil moisture content in residues retention plots. Increase in soil carbon over the years improves the structure of soil, especially micro-aggregates, which is active site of holding the labile carbon for longer periods. Naveen kumar and Babalad (2017) opined that in groundnut, improvement in number of pods $plant^{-1}$ and pod dry weight $plant^{-1}$ might be due to increased availability of moisture and nutrients in soil with conservation tillage and BBF system which favoured potential growth and development of crop. Conservation tillage with broad bed and furrow or flat bed had lower traffic compaction especially at lower soil depth. The deep prolific roots of pigeonpea explored deeper soil layer, so efficient nutrient recycling occurred which was reflected in yield contributing parameters and ultimately on yield (Kantwa *et al.,* 2016).

Dry matter production

In the present investigation, significant increase in yield attributing characters in conservation tillage systems might be due to significant increase in total dry matter production (TDMP) $plant^{-1}$ over conventional tillage systems. At 60 DAS all the conservation tillage systems (CT1, CT2, CT3 and CT4) recorded significantly higher TDMP (38.45, 40.60, 40.29 and 39.03 g $plant^{-1}$) as compared to conventional tillage systems and next best was CT_5 (36.24 g $plant^{-1}$). Significantly lower TDMP was observed in CT_6 (33.06 g $plant^{-1}$). Among cover crop management pigeonpea without cover crop CC_2 (38.61 g $plant^{-1}$) recorded significantly higher TDMP compared to cover crop CC_1 (37.28 g $plant^{-1}$). Interaction of tillage practices and cover crop management differed significantly and CT_2CC_2 (41.37 g $plant^{-1}$) recorded significantly higher TDMP as compared to all other combinations and was on par with CT_1CC_2 (38.72 g $plant^{-1}$), CT_2CC_1 (39.83 g $plant^{-1}$), CT_3CC_1 (39.74 g $plant^{-1}$),

Table 1. Total dry matter production of pigeonpea at different growth stages as influenced by conservation tillage practices and cover crop management in sole pigeonpea (2016-17, 2017-18 and pooled)

Treatments	Total dry matter production (g plant^{-1})											
	60 DAS			90 DAS			120 DAS			At Harvest		
Tillage practices	2016-17	2017-18	Pooled	2016-17	2017-18	Pooled	2016-17	2017-18	Pooled	2016-17	2017-18	Pooled
CT_1	40.72b	36.17ab	38.45a	100.58b	78.18bc	89.38c	159.50a	129.61ab	144.55ab	224.82a	171.09a	197.95a
CT_2	42.97a	38.24a	40.60a	108.83a	84.48a	96.65a	164.96a	135.10a	150.03a	237.31a	180.53a	208.92a
CT_3	42.03ab	38.54a	40.29a	107.60a	83.61ab	95.61ab	162.96a	132.12ab	147.54ab	227.10a	174.93a	201.02a
CT_4	40.72b	37.34a	39.03a	104.25ab	80.34ab	92.29bc	159.50a	127.95b	143.72b	226.48a	169.42a	197.95a
CT_5	37.82c	34.66b	36.24b	96.81c	74.23c	85.52d	146.45b	120.37c	133.41c	210.33b	157.22b	183.78b
CT_6	34.42d	31.70c	33.06c	88.12d	67.81d	77.96e	134.82c	109.56d	122.19d	184.45c	142.96c	163.70c
S Em ±	0.63	0.79	0.68	1.74	1.80	1.13	2.62	1.70	1.84	4.51	3.48	3.80
CC management												
CC_1	39.37b	35.20b	37.28b	98.78b	76.03b	87.40b	150.30b	121.41b	135.85b	211.61b	160.95b	186.28b
CC_2	40.19a	37.02a	38.61a	103.29a	80.18a	91.73a	159.10a	130.16a	144.63a	225.22a	171.10a	198.16a
S Em ±	0.26	0.43	0.37	0.41	0.84	0.48	0.84	1.56	0.81	1.57	1.40	1.46
Interactions (CT X CC)												
CT_1CC_1	41.13ab	35.22b-d	38.18bc	98.97c-e	76.16d-f	87.57de	154.45c-d	124.26cd	139.36de	218.78c-e	166.16cd	192.47de
CT_1CC_2	40.31a-c	37.12a-c	38.72a-c	102.19b-e	80.19b-d	91.19cd	164.54a-c	134.96ab	149.75bc	230.85bc	176.02bc	203.44bc
CT_2CC_1	42.86ab	36.81a-c	39.83ab	104.05b-d	81.93bc	92.99bc	157.87b-d	126.42b-d	142.15c-e	228.38b-d	173.41bc	200.89b-d
CT_2CC_2	43.07a	39.67a	41.37a	113.60a	87.02a	100.31a	172.04a	143.77a	157.91a	246.24a	187.64a	216.94a
CT_3CC_1	41.55ab	37.94ab	39.74ab	106.37b	82.66bc	94.52bc	159.42b-d	128.93b-d	144.17b-d	217.77de	171.25bc	194.51c-e
CT_3CC_2	42.51ab	39.15a	40.83ab	108.83ab	84.57ab	96.70ab	166.50ab	135.31ab	150.91ab	236.43ab	178.61ab	207.52b
CT_4CC_1	40.13bc	36.63a-c	38.38bc	102.74b-e	78.51c-e	90.63cd	157.20b-d	124.41cd	140.81de	219.89c-e	165.29c-e	192.59de
CT_4CC_2	41.31ab	38.04ab	39.68ab	105.75bc	82.18bc	93.96bc	161.79a-c	131.48bc	146.64b-d	233.08b	173.56bc	203.32bc
CT_5CC_1	37.56cd	34.26cd	35.91cd	96.15ef	72.72fg	84.44ef	143.78e	119.55de	131.67fg	208.90e	154.47ef	181.69f
CT_5CC_2	38.07cd	35.07b-d	36.57cd	97.47d-f	75.74ef	86.61de	149.13de	121.19de	135.16ef	211.76e	159.97d-f	185.86ef
CT_6CC_1	32.95e	30.35e	31.65e	84.36g	64.22h	74.29g	129.07f	104.89f	116.98h	175.94g	135.12g	155.53h
CT_6CC_2	35.89d	33.06de	34.47d	91.88f	71.40g	81.64f	140.58e	114.24e	127.41g	192.95f	150.80f	171.88g
S Em ±	0.82	0.99	0.86	2.08	1.29	1.48	3.21	2.86	2.30	3.71	3.30	2.80

CT_1: Conservation tillage with BBF and crop residues retained on the surface
CT_2: Conservation tillage with BBF and incorporation of crop residues
CT_3: Conservation tillage with flat bed with crop residues retained on the surface
CT_4: Conservation tillage with flat bed with incorporation of crop residues
CT_5: Conventional tillage with crop residues incorporation
CT_6: Conventional tillage (flat bed and no crop residues)

CC_1: With cover crop
CC_2: Without cover crop

Table 2. Yield components of pigeonpea as influenced by conservation tillage practices and cover crop management in sole pigeonpea(2016-17, 2017-18 and pooled)

Treatments	Number of pods $plant^{-1}$			Grain weight (g $plant^{-1}$)			100 seed weight (g)		
Tillage practices	**2016-17**	**2017-18**	**Pooled**	**2016-17**	**2017-18**	**Pooled**	**2016-17**	**2017-18**	**Pooled**
CT_1	176.18a	147.37a	161.78a	73.46ab	58.30ab	65.88ab	13.33a	12.80a	13.06a
CT_2	178.79a	149.34a	164.07a	75.40a	60.80a	68.10a	13.65a	13.10a	13.38a
CT_3	176.31a	145.95a	161.13a	75.23a	60.95a	68.09a	13.60a	13.06a	13.33a
CT_4	176.68a	147.77a	162.22a	74.52a	58.33ab	66.43ab	13.36a	12.83a	13.10a
CT_5	170.63b	140.58b	159.10b	70.50b	55.02b	62.76b	13.36a	12.82a	13.09a
CT_6	162.81c	135.76b	149.29b	63.86c	50.18c	59.02c	13.21a	12.68a	12.95a
S Em ±	2.10	2.56	2.22	1.15	1.47	1.21	0.23	0.12	0.16
CC management									
CC_1	171.39b	142.14b	156.76b	69.99b	54.89b	62.44b	13.30b	12.77b	13.03b
CC_2	177.02a	148.12a	162.57a	74.34a	60.97a	67.65a	13.54a	13.00a	13.27a
S Em ±	0.74	1.30	0.89	0.70	0.17	0.44	0.14	0.07	0.09
Interactions (CT X CC)									
CT_1CC_1	175.63b	146.35b-d	160.99bc	71.25cd	55.36cd	63.30d-f	13.12a	12.59b	12.86ab
CT_1CC_2	181.73ab	151.74ab	166.73ab	75.68a-c	61.24ab	68.46a-c	13.54a	13.00ab	13.27ab
CT_2CC_1	171.62bc	142.81b-d	157.22bc	72.16b-d	57.18bc	64.67c-f	13.46a	12.92ab	13.19ab
CT_2CC_2	182.63a	152.53a	167.58a	78.65a	64.41a	71.53a	13.84a	13.29a	13.56a
CT_3CC_1	173.43b	142.40b-d	157.91bc	74.12a-d	58.14bc	66.13b-d	13.64a	13.09ab	13.37ab
CT_3CC_2	179.20ab	149.50a-c	164.35ab	76.35a-c	63.77a	70.06ab	13.56a	13.02ab	13.29ab
CT_4CC_1	174.63b	145.46a-c	160.04bc	71.69b-d	55.11cd	63.40d-f	13.22a	12.69ab	12.95ab
CT_4CC_2	178.73ab	150.09a-c	164.41ab	77.36ab	61.55ab	69.45a-c	13.51a	12.97ab	13.24ab
CT_5CC_1	171.62bc	142.81b-d	157.22bc	68.36de	51.36d	59.86fg	13.25a	12.72ab	12.98ab
CT_5CC_2	175.63b	146.35a-c	160.99b	72.65b-d	58.69bc	65.67b-e	13.47a	12.93ab	13.20ab
CT_6CC_1	161.42d	132.98d	147.20d	62.36f	52.22d	57.29g	13.11a	12.58b	12.85b
CT_6CC_2	164.19cd	138.55cd	151.37cd	65.36ef	56.15cd	60.75e-g	13.31a	12.78ab	13.04ab
S Em ±	1.65	3.34	2.21	1.66	1.43	1.46	0.33	0.17	0.22

CT_1: Conservation tillage with BBF and crop residues retained on the surface

CT_2: Conservation tillage with BBF and incorporation of crop residues

CT_3: Conservation tillage with flat bed with crop residues retained on the surface

CT_4: Conservation tillage with flat bed with incorporation of crop residues

CT_5: Conventional tillage with crop residues incorporation

CT_6: Conventional tillage (flat bed and no crop residues)

CC_1: With cover crop

CC_2: Without cover crop

Table 3. Seed yield, stalk yield and harvest index of pigeonpea as influenced by conservation tillage practices and cover crop management in sole pigeonpea (2016-17, 2017-18 and pooled)

Treatments	Seed yield (kg plant^{-1})			Stalk yield (kg ha^{-1})			Harvest index		
Tillage practices	**2016-17**	**2017-18**	**Pooled**	**2016-17**	**2017-18**	**Pooled**	**2016-17**	**2017-18**	**Pooled**
CT_1	2647b	1778a	2212b	5262c	3957b	4609c	33.43a	30.97a	32.20a
CT_2	2725a	1812a	2268a	5516a	4073a	4745b	33.42a	30.74ab	32.08ab
CT_3	2663b	1775a	2219a	5294c	3981b	4637c	33.42a	30.77ab	32.10ab
CT_4	2675b	1790a	2233a	5300b	4137a	4819a	32.69b	30.16b	31.43c
CT_5	2485c	1659b	2072c	5054d	3801c	4427d	32.94ab	30.36ab	31.65bc
CT_6	2232d	1492c	1862d	4550c	3422d	3986e	32.90ab	30.35ab	31.62c
S Em ±	72.73	68.51	70.36	81.33	78.10	83.12	0.16	0.21	0.14
CC management									
CC_1	2394b	1617b	2005b	5027b	3781b	4404b	32.27b	29.94b	31.10b
CC_2	2749a	1818a	2284a	5331a	4010a	4670a	34.00a	31.18a	32.59a
S Em ±	75.31	68.87	85.41	90.33	93.32	93.18	0.40	0.34	0.03
Interactions (CT X CC)									
CT_1CC_1	2432e	1662c	2047e	5115f	3847d	4481f	32.24c	30.19b	31.21c
CT_1CC_2	2863b	1893a	2378b	5409c	4068b	4738c	34.61a	31.75a	33.18a
CT_2CC_1	2503d	1676c	2089d	5256de	3953cd	4605de	32.26c	29.77b	31.02c
CT_2CC_2	2947a	1948a	2448a	5576b	4194a	4885b	34.58a	31.72a	33.15a
CT_3CC_1	2453de	1643c	2048e	5156ef	3878cd	4517ef	32.24c	29.71b	30.98c
CT_3CC_2	2874b	1907a	2390b	5431c	4084b	4758c	34.61a	31.83a	33.22a
CT_4CC_1	2484de	1686bc	2085d	5286d	3976bc	4631d	31.97c	29.73b	30.85c
CT_4CC_2	2866b	1895a	2380b	5715a	4298a	5006a	33.40b	30.60b	32.00b
CT_5CC_1	2336f	1577d	1957f	4857g	3653e	4255g	32.48c	30.13b	31.31c
CT_5CC_2	2633c	1741b	2187c	5250de	3949cd	4599de	33.40b	30.60b	32.00b
CT_6CC_1	2154g	1457e	1805h	4494i	3380f	3937i	32.41c	30.10b	31.25c
CT_6CC_2	2310f	1527d	1919g	4606h	3464f	4035h	33.40b	30.60b	32.00b
S Em ±	17.83	17.79	10.82	33.34	33.37	28.89	0.22	0.32	0.21

CT_1: Conservation tillage with BBF and crop residues retained on the surface

CT_2: Conservation tillage with BBF and incorporation of crop residues

CT_3: Conservation tillage with flat bed with crop residues retained on the surface

CT_4: Conservation tillage with flat bed with incorporation of crop residues

CT_5: Conventional tillage with crop residues incorporation

CT_6: Conventional tillage (flat bed and no crop residues)

CC_1: With cover crop

CC_2: Without cover crop

CT_3CC_2 (40.83 g plant^{-1}) and CT_4CC_2 (39.68 g plant^{-1}). Whereas significantly lower TDMP was noticed in CT_6CC_1 (31.65 g plant^{-1}).

At 90 DAS, conservation tillage with BBF with incorporation of crop residues CT_2 (96.65 g plant^{-1}) recorded significantly higher TDMP compared to other tillage treatments and was on par with CT_3 (95.61 g plant^{-1}). Significantly lower TDMP was recorded in conventional tillage with flat bed with no crop residues CT_6 (77.96 g plant^{-1}). Among cover crop management pigeonpea without cover crop CC_2 (91.73 g plant^{-1}) recorded higher TDMP compared to cover crop CC_1 (87.40 g plant^{-1}). Interaction of tillage practices and cover crop management practices differed significantly and CT_2CC_2 (100.31 g plant^{-1}) recorded significantly higher TDMP as compared to all other combinations and was at par with CT_3CC_2 (96.70 g plant^{-1}). Significantly lower TDMP was noticed in conventional tillage with flat bed with no crop residues with cover crop CT_6CC_1 (74.29 g plant^{-1}). At 120 DAS, conservation tillage with BBF with incorporation of crop residues CT_2 (150.03 g plant^{-1}) recorded significantly higher TDMP production as compared to other tillage treatments and was on par with CT_1 (144.55 g plant^{-1}), and CT_3 (147.54 g plant^{-1}). Significantly lower TDMP was observed in conventional tillage with flat bed with no crop residues CT_6 (122.19 g plant^{-1}). Among cover crop management pigeonpea without cover crop CC_2 (144.63 g plant^{-1}) recorded significantly higher TDMP compared to with cover crop CC_1 (135.85 g plant^{-1}). The cover crop cowpea being indeterminate in growth habit and early sowing with pigeonpea has produced more vegetative growth and affected the pigeonpea growth and yield. Even though it add more biomass as leaf litter to soil and cover the soil, the advantage on yield grains during first two years was not observed. Interaction of tillage practices and cover crop management differed significantly and CT_2CC_2 (157.91 g plant^{-1}) recorded significantly higher TDMP as compared to all other combinations and was on par with CT_3CC_2 (150.91 g plant^{-1}). Significantly lower TDMP was noticed in CT_6CC_1 (116.98 g plant^{-1}). At harvest all the conservation tillage systems : CT_1 (197.95 g plant^{-1}), CT_2 (208.92 g plant^{-1}), CT_3 (201.02 g plant^{-1}) and CT_4 (197.95 g plant^{-1}) recorded significantly higher TDMP as compared to other tillage practices and were followed by CT_5 (183.78 g plant^{-1}). Significantly lower TDMP was noticed in CT_6 (163.70 g plant^{-1}). Among cover crop management systems pigeonpea without cover crop CC_2 (198.16 g plant^{-1}), recorded higher TDMP compared to with cover crop CC_1 (186.28 g plant^{-1}). Interaction of tillage practices and cover crop management differed significantly and CT_2CC_2 recorded significantly higher TDMP 216.94 g plant^{-1}. Significantly lower TDMP was noticed in CT_6CC_1 (155.53 g plant^{-1}). The conservation tillage systems with crop residues retention on the surface favors the reduction in evaporation loss and led to higher soil moisture content due to increased infiltration and water holding capacity of the soil. Further build up of organic carbon, decomposition of added crop residues, mineralization of nutrients contributed for increased supply of nutrients resulted in higher TDMP (Venkanna, 2008).

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