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Combined effect of land preparation methods and planting geometry on the performance of machine transplanted rice (*Oryza sativa* L.)

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Abstract: Field experiment on effect of land preparation methods and planting geometry on growth and yield of machine transplanted rice (*Oryza sativa* L.) was conducted at Agricultural Research Station, Gangavathi, University of Agricultural Sciences, Raichur, Karnataka during *kharif,* 2012 and 2013 in clay soil under irrigated condition. Pooled mean indicated that, among the different land preparation methods and planting geometry puddling with rotovator fb levelling with spike tooth harrow and planting geometry of 30 x 21 cm recorded significantly higher growth parameters *viz.,* Leaf area index (2.87 and 1.56, respectively) , dry matter accumulation in leaves (13.44 and 14.43 g plant^{-1}, respectively), dry matter accumulation in stem (26.25 and 29.31 g plant^{-1} , respectively), dry matter accumulation in panicles (37.21 and 41.38 g plant^{-1} , respectively), total dry matter accumulation in plant (73.82 and 85.12 g plant^{-1}, respectively), thousand grain weight (18.17 and 18.71,g respectively), grain yield (4906 and 5192 kg ha^{-1} , respectively), straw yield (6247 and 6508 kg ha^{-1}, respectively), gross returns (Rs. 87,733 and 92779 ha^{-1}, respectively), net returns (Rs. 46329 and 50007 ha^{-1}) and benefit cost ratio (2.14 and 2.20). Puddling with rotovator fb levelling with spike tooth harrow and 30 x 21 cm spacing were found better for transplanting of rice by self propelled mechanical transplanter. Land preparation would be helpful as one of the important pre requirement in machine transplanting of rice, which in turn will decide the time (time required for settling of soil particle) and type of machine to be used for transplanting of rice.

Keywords: Dry matter accumulation, Economics, Land preparation methods, Machine transplanting, Manual planting, Planting geometry

INTRODUCTION

Rice (*Oryza sativa* L.) is considered as the “global grain”. It is the major staple food for more than half of the global population. Asian countries consume about 90 per cent of the rice grown and produced in the world and supplies 50 to 80 per cent calories of energy to Asians. Rice is the anchors of food security in the world with challenges of climate change which is grown under wide range of latitudes and altitudes (Anonymous, 2008).

Texturally fine and moderately fine soils such as clayey and clay loam having clay as dominant component are ideal for rice cultivation. These soils have high water holding capacity, less water intake rate and can support power unit and implements while being operated for puddling in standing water. For rice, the basic qualification of the prepared soil is that it should be as compact and impermeable below the rooting depth as possible in order to impede the downward movement of water to the maximum. However, the root zone soil must be well pulverised and cultured for proper nourishment of plants (Razzaq, 1987).

Mechanical cultivation can easily achieve the objectives provided farmers are shown the benefits of using appropriate implements. At the moment farmers owning tractors normally hold and use conventional cultivator for preparing rice fields. The cultivator is the only soil opening tool. It has less pulverizing action and least sealing effect at any level. As a result, many repeats of cultivator followed by planking are required to transform the soil into condition where rice nursery can be transplanted. The only combination of cultivator and plank tend to compact the surface of soil instead of transforming impermeability below the root zone. Such practice entails poor land manipulation at the cost of energy, time and machinery life and low yield of rice. The study of inter-relationship of soil, implement and crop is very much required (Behera *et al*., 2009).

There are various tillage methods used to prepare land for rice cultivation. The effect of these tillage methods on hydraulic conductivity, infiltration rate, bulk density, cone index and rice yield are quite different. The use of suitable tillage practices/implements in each region depends on different factors such as water availability, topography, climate, soil texture, type of rice culture, percolation, depth of water table, soil compaction, aggregation etc. (De Datta *et al.,* 1988).

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Spacing is very important for optimum plant population per unit area and will be reflected on the yield of the crop. A dense population of crops may have limitations in the maximum availability of resource factors. It is, therefore, necessary to determine the optimum density of plant population per unit area for obtaining maximum yield. Optimum plant spacing ensures plants to grow properly both in their aerial and underground parts through different utilization of solar radiation and nutrients (Duraisamy *et al*., 2011).

Mechanical transplanting not only facilitates better stand establishment of the rice crop at right time but also allows the genotype to exhibit phenotypic characteristics completely. Therefore, it is high time for mechanizing the transplanting operation in rice cultivation. Mechanical transplanting needs a suitable rice seedlings transplanter. Mechanical transplanter using self-propelled transplanter has been considered as the most promising option because it saves labour to the tune of 90 per cent of that required in manual transplanting, minimizes stress and drudgery, ensures timely transplanting and attains optimum plant density contributing to higher productivity (Behera, 2000). The present study was conducted to investigate the combined effect of land preparation methods and planting geometry on the performance of machine transplanted rice (*Oryza sativa* L.).

MATERIALS AND METHODS

A field experiment was conducted at Agricultural Research Station, Gangavathi, University of Agricultural Sciences, Raichur, Karnataka, during *kharif,* 2012 and 2013. The experiment was laid in strip-plot design. The soil of the experimental site was medium deep black clay with soil reaction (8.2), electrical conductivity (2.1) determined following the procedure given by Jackson (1973), available N (247.2 kg ha^{-1}) Subbaiah and Asija (1956), available P_2O_5 (50.2 kg ha^{-1}) Olsen *et al.* (1954) and available K_2O (357.6 kg ha^{-1}) Jackson (1973) at surface 0-20 cm soil depth.

Agricultural Research Station, Gangavathi is situated in the Northen Dry Zone of Karnataka between 15^o 15' 40" North latitude and 76^o 31' 40" East longitude at an altitude of 419 m above mean sea level and represents irrigated transplanted rice belt of Tungabhadra command area. The experiment consisted three different land preparation methods *viz.,* L_1 : passing of cultivator twice fb puddling with disc puddler fb levelling with spike tooth harrow - Farmers practice, L_2 : puddling with rotovator fb levelling with spike tooth harrow and L_3 : puddling with rotomixure fb levelling with spike tooth harrow and three planting geometry planted by transplanter *viz.,* S_1: 30 × 7 cm, S_2: 30 × 14 cm and S_3: 30 × 21 cm along with manual transplanting with 20 × 10 cm spacing (S_4). The land was prepared using tractor drawn cultivator twice, followed by puddling twice with disc puddler and finally levelled using tractor drawn spike tooth harrow in case of farmers practice. Second type of land preparation was puddling with rotovator followed by levelling using tractor drawn spike tooth harrow. The other one was puddling with rotomixure and levelling was done using spike tooth harrow and kept ready for planting and seedlings raised in the trays were planted in the main field. Six days after transplanting, butachlor 50 EC at the rate of 2.5 liter ha^{-1} was sand mixed and broadcasted uniformly over the field containing a thin film of water followed by two hand weedings at 20 and 40 days after transplanting. From the day of transplanting upto 10 days, a thin film of water was maintained and thereafter 5 cm standing water was maintained upto 10 days before harvesting. Water was drained during fertilizer application and spraying of chemicals. Recommended dose of fertilizers (150:75:75 and 20 kg N: P_2O_5 : K_2O and $ZnSO_4$ /ha) were applied as per the recommendation and time. Urea, Di-ammonium phosphate (DAP) and Muriate of potash (MOP) were used to supply N, P and K respectively. Before application, the land was drained and fertilizers were uniformly broadcasted over the field followed by letting in of water 24 hours after application. The recommended package of practices was fallowed. The crop was harvested at physiological maturity, threshed and cleaned manually in both the years. Both grain and straw were sun dried for a week and dry weights were recorded. For computing the cost of cultivation, different variable cost of items was considered. The cost includes expenditure on seeds, fertilizers, irrigation, plant protection chemicals, hiring charges of transplanter, fuel cost and labour charges prevailed in market during 2012 and 2013.

RESULTS AND DISCUSSION

Growth parameters

Land preparation methods: Significant response to both methods of land preparation and planting geometry was exhibited by rice. Pooled data of two years indicated that significantly higher Leaf area index (2.87), dry matter accumulation in leaves (13.44 g $plant^{-1}$), dry matter accumulation in stem (0.44 g $plant^{-1}$), dry matter accumulation in panicles (37.21 g $plant^{-1}$), total dry matter accumulation in plant (73.82 g $plant^{-1}$) (Tables 1 and 2) were recorded with puddling with rotovator fb levelling with spike tooth harrow method of land preparation over passing of cultivator twice fb puddling with disc puddler fb levelling with spike tooth harrow, but was found to be on par with puddling by rotomixure fb levelling with spike tooth harrow. The higher dry matter production in case of puddling with rotovator fb levelling with spike tooth harrow method of land preparation perhaps may be attributed to enhanced growth parameters like plant height at harvest, number of leaves at 60 DAT and higher leaf area at all the growth stages of crop as a

Table 1. Leaf area index, DMA in leaves and DMA in stem of machine transplanted rice at different growth stages as influenced by land preparation methods and planting geometry (Pooled data of two years).

Treatments	Leaf area index			DMA in leaves (g plant^{-1})			DMA in stem		
	30 DAT	60 DAT	At harvest	30 DAT	60 DAT	At harvest	30 DAT	60 DAT	At harvest
Main treatments (L)									
L_1	1.82	3.44	2.55	3.13	13.42	12.26	4.06	20.28	23.44
L_2	1.98	3.76	2.87	3.51	14.60	13.44	4.36	22.46	26.25
L_3	1.94	3.66	2.82	3.34	14.30	13.15	4.22	21.12	25.25
S.Em.±	0.03	0.05	0.06	0.07	0.23	0.19	0.23	0.36	0.41
C.D. (P=0.05)	0.10	0.18	0.20	NS	0.90	0.73	NS	1.40	1.61
Sub treatments (S)									
S_1	2.67	5.12	3.88	3.19	13.90	12.67	4.01	19.62	23.37
S_2	1.42	2.72	2.15	3.59	14.53	14.05	4.42	22.25	26.44
S_3	1.01	1.95	1.56	3.97	15.89	14.43	4.62	25.45	29.31
S_4	2.53	4.70	3.39	2.57	12.10	10.64	3.78	17.84	20.79
S.Em.±	0.10	0.11	0.11	0.14	0.36	0.36	0.18	0.94	0.81
C.D. (P=0.05)	0.34	0.37	0.37	0.48	1.25	1.24	NS	3.25	2.79
Interaction (L x S)									
L_1S_1	2.62	4.96	3.67	3.02	13.37	12.42	3.92	18.65	21.15
L_1S_2	2.73	5.23	3.89	3.30	14.25	12.89	4.12	20.83	24.91
L_1S_3	2.67	5.17	4.06	3.23	14.09	12.72	4.00	19.38	24.04
L_1S_4	1.40	2.66	2.10	3.44	14.27	13.87	4.13	21.11	25.34
L_2S_1	1.45	2.77	2.20	3.72	14.67	14.18	4.67	23.31	27.78
L_2S_2	1.42	2.72	2.14	3.60	14.64	14.09	4.47	22.31	26.21
L_2S_3	0.98	1.88	1.51	3.73	15.34	14.02	4.52	24.36	27.91
L_2S_4	1.03	2.03	1.61	4.24	16.37	14.80	4.68	26.65	30.64
L_3S_1	1.01	1.95	1.56	3.93	15.97	14.47	4.67	25.35	29.38
L_3S_2	2.28	4.27	2.89	2.34	10.69	8.74	3.65	17.00	19.34
L_3S_3	2.68	5.01	3.76	2.78	13.12	11.87	3.95	19.06	21.64
L_3S_4	2.64	4.82	3.52	2.59	12.50	11.33	3.74	17.46	21.38
S.Em.±	0.10	0.11	0.07	0.17	0.60	0.18	0.31	1.04	0.23
C.D. (P=0.05)	NS	NS	0.21	NS	NS	0.57	NS	NS	0.70

NS – Non significant; L_1: Cultivator (twice) fb pudling with disc puddler fb spike tooth harrow (PF); L_2: Puddling with rotovator fb spike tooth harrow; L_3: Puddling with rotomixture fb spike tooth harrow; S_1: 30 × 7 cm; S_2: 30 × 14 cm; S_3: 30 × 21 cm; S_4: 20 × 10 cm

result of better utilization of nutrients as compared to other methods of land preparation. These findings are in conformity with the studies of Razzaq (1987) who reported that the highest yield was due to better tillering which was observed under this combina-tion of implements and Rahamati and Solakhe (2001) highlighted the production of higher number of panicles, tillers and yield (4.27 t ha^{-1}).

Planting geometry: Rice growth parameters were significantly influenced by different planting geometry. Planting geometry of 30 x 21 cm recorded significantly higher dry matter accumulation in leaves (14.43 g plant^{-1}), dry matter accumulation in stem (29.31 **g** plant^{-}), dry matter accumulation in panicles (41.38 g plant^{-1}), total dry matter accumulation in plant (85.12 g plant^{-1}) and thousand grain weight (18.71) over manual planting at spacing of 20 x10 cm, however, it was followed by intra plant spacing of 30 x 14 cm (Tables 1 and 2). The increased dry matter production in case of 30 x 21 cm spacing might be due to obvious reasons of optimum plant population, better leaf area and availability of nutrients, water and energy so also wider feeding area offered by planting in wider row spacing resulting in opportunity for greater root growth, increased availability and accessibility of nutrients to rice plants as reported by Duraisamy *et al.* (2011) observed significantly higher dry matter production by a wider spacing of 30 × 22 cm over 30 × 32 cm and 30 × 16 cm due to obvious reasons of optimum plant population. Sannagoudra *et al*. (2012) attributed increased dry matter accumulation to plants grown with wider spacing having more area of land to draw the nutrients from and compensate for the low nutrient level of the soil. The plants also were exposed more to solar radiation which encouraged superior photosynthetic process.

Yield

Land preparation methods: Methods of land preparation had significant influence on yield parameters of rice. Significantly higher grain yield (4906 kg ha^{-1}) and straw yield (6247 kg ha^{-1}) were recorded with puddling by rotovator fb levelling with spike tooth harrow method of land preparation over passing of cultivator twice fb puddling with disc puddler fb levelling with spike tooth harrow (Table 3). However it was found to be on par with puddling by rotomixure fb levelling with spike tooth

Table 2. DMA in panicles, Total dry matter accumulation and Thousand grain weight ofrice at different growth stages as influenced by land preparation methods and planting geometry.

Treatments	DMA in panicles (g plant^{-1})			Total DMA (g plant^{-1})			Thousand grain weight (g)		
	2012	2013	Pooled	30 DAT	60 DAT	At harvest	2012	2013	Pooled
Main treatments (L)									
L_1	32.56	35.26	33.91	7.18	33.75	69.39	17.31	16.96	17.14
L_2	35.98	38.43	37.21	7.87	37.21	76.75	18.12	18.21	18.17
L_3	34.64	36.89	35.77	7.56	35.49	73.82	17.58	17.52	17.55
S.Em.±	0.59	0.47	0.56	0.38	0.44	0.89	0.26	0.35	0.29
C.D. (P=0.05)	2.3	1.84	2.22	NS	1.72	3.50	NS	NS	NS
Sub treatments (S)									
S_1	32.38	34.77	33.57	7.19	33.52	69.50	17.17	17.07	17.12
S_2	35.86	38.52	37.19	8.01	37.15	76.86	18.03	18.03	18.03
S_3	40.1	42.66	41.38	8.59	41.34	85.12	18.67	18.74	18.71
S_4	29.23	31.50	30.37	6.34	29.94	61.80	16.80	16.41	16.61
S.Em.±	0.96	1.06	0.93	0.48	1.17	2.17	0.29	0.33	0.30
C.D. (P=0.05)	3.34	3.67	3.21	NS	4.06	7.50	0.99	1.13	1.04
Interaction (L x S)									
L_1S_1	30.93	33.20	32.07	6.93	32.01	65.63	16.75	16.27	16.51
L_1S_2	33.60	35.67	34.63	7.42	35.08	72.43	16.40	15.72	16.06
L_1S_3	32.60	35.43	34.02	7.23	33.46	70.44	17.50	17.33	17.42
L_1S_4	34.07	37.67	35.87	7.57	35.61	74.23	17.20	16.97	17.08
L_2S_1	37.45	39.40	38.43	8.38	38.58	79.85	17.80	17.80	17.80
L_2S_2	36.07	38.50	37.28	8.07	37.25	76.43	18.05	18.10	18.08
L_2S_3	37.53	40.50	39.02	8.25	39.69	80.94	16.61	15.94	16.28
L_2S_4	42.37	45.03	43.70	8.92	43.01	89.14	18.50	18.35	18.43
L_3S_1	40.40	42.43	41.42	8.60	41.31	85.26	15.40	15.03	15.22
L_3S_2	27.70	29.66	28.68	5.98	27.68	56.76	17.03	16.67	16.85
L_3S_3	30.50	33.63	32.07	6.73	32.18	65.58	18.61	18.85	18.73
L_3S_4	29.50	31.20	30.35	6.32	29.96	63.06	18.83	18.90	18.87
S.Em.±	0.97	0.88	0.74	0.94	1.19	0.54	0.50	0.93	0.47
C.D. (P=0.05)	NS	NS	NS	NS	NS	1.66	NS	NS	NS

NS – Non significant; L_1: Cultivator (twice) fb pudling with disc puddler fb spike tooth harrow (PF); L_2: Puddling with rotovator fb spike tooth harrow; L_3: Puddling with rotomixture fb spike tooth harrow; S_1: 30 × 7 cm; S_2: 30 × 14 cm; S_3: 30 × 21 cm; S_4: 20 × 10 cm

harrow method of land preparation. The higher yield of rice in case of puddling with rotovator fb levelling with spike tooth harrow was mainly due to the fact that puddling with rotovator reduced bulk density and cone index in the plough layer compared to other land preparation methods. Similar findings were reported by Rahamati and Solakhe (2001) reported increased rice yield due to reduction in cone index and bulk density in plough layer (0-15) and also decreased hydraulic conductivity and infiltration rate over this depth and Tripathi *et al*. (2004) observed that the yield of crop grown by transplanter was more even though the plant population was less than the manually transplanted one. This is to due to the higher number of effective tillers in the former crop than in the later. The crop planted through transplanter produced higher plant height, more number of effective tillers m^{-2} and more number of grains per panicle which contributed to higher yield when compared with manual planting

Planting geometry: Significantly higher grain yield (5192 kg ha^{-1}) and straw (6508 kg ha^{-1}) were noticed with planting at a spacing of 30 x 21 cm as compared to manual planting at a distance of 20 x 10 cm. However, it was found on par with planting geometry of 30 x 14 cm with respect to number of panicles m^{-2}, panicle length and straw yield, while it was followed by with respect to number of filled grains per panicle, filling percent and grain yield. These results are in agreement with the findings of (Duraisamy *et al* (2011) who reported higher grain yield in wider spacing and the same was attributed to the enhanced stature of yield attributes, forming larger sink size coupled with efficient translocation of photosynthates to the sink, when the crop was raised under optimum planting pattern. Naidu *et al.* (2013) reported wider spacing leads to enhanced root growth, more productive tillers and ultimately leads to higher grain yield. Rasool *et al.* (2013) reported increased rice grain yield due to wider spacing, as the wider spacing adopted appears to be an advantageous factor for better development of panicles resulting in higher panicle length, panicle weight, spikelets number and filled grains panicle^{-1}.

Grain and straw yield of machine transplanted rice was influenced significantly due to interaction of land preparation methods and spacing between the plants. Puddling with rotovator fb levelling with spike tooth

Table 3. Grain yield, straw yield and harvest index of machine transplanted rice as influenced by land preparation methods and planting geometry.

Treatments	Grain yield (kg ha^{-1})			Straw yield (kg ha^{-1})			Harvest index		
	2012	2013	Pooled	2012	2013	Pooled	2012	2013	Pooled
Main treatments (L)									
L_1	4474	4576	4525	5609	5688	5648	0.45	0.45	0.45
L_2	4859	4953	4906	6199	6295	6247	0.44	0.44	0.44
L_3	4749	4851	4800	5830	5909	5870	0.45	0.45	0.45
S.Em.±	49	47	50	109	83	104	0.00	0.00	0.00
C.D. (P=0.05)	192	183	196	430	326	409	NS	NS	NS
Sub treatments (S)									
S_1	4538	4640	4589	5704	5789	5747	0.44	0.45	0.45
S_2	4810	4911	4861	6109	6194	6152	0.44	0.44	0.44
S_3	5147	5237	5192	6465	6550	6508	0.44	0.45	0.45
S_4	4283	4385	4334	5238	5323	5280	0.45	0.45	0.45
S.Em.±	71	60	78	128	124	132	0.01	0.01	0.01
C.D. (P=0.05)	245	207	269	444	430	457	NS	NS	NS
Interaction (L x S)									
L_1S_1	4278	4379	4329	5698	5778	5738	0.43	0.43	0.43
L_1S_2	4715	4817	4766	5823	5919	5871	0.45	0.45	0.45
L_1S_3	4621	4723	4672	5592	5671	5632	0.45	0.46	0.46
L_1S_4	4741	4843	4792	6000	6079	6040	0.44	0.45	0.45
L_2S_1	4872	4974	4923	6278	6374	6326	0.44	0.44	0.44
L_2S_2	4816	4917	4867	6049	6129	6089	0.44	0.45	0.45
L_2S_3	5354	5422	5388	6741	6837	6789	0.45	0.45	0.45
L_2S_4	5067	5168	5118	6401	6481	6441	0.44	0.44	0.44
L_3S_1	5020	5122	5071	6253	6333	6293	0.45	0.45	0.45
L_3S_2	3811	3913	3862	4335	4414	4375	0.47	0.47	0.47
L_3S_3	4497	4598	4548	5953	6049	6001	0.43	0.43	0.43
L_3S_4	4541	4643	4592	5425	5504	5465	0.46	0.46	0.46
S.Em.±	102	99	103	216	207	217	0.01	0.01	0.01
C.D. (P=0.05)	314	305	318	667	637	668	NS	NS	NS

NS – Non significant; L_1: Cultivator (twice) fb pudling with disc puddler fb spike tooth harrow (PF); L_2: Puddling with rotovator fb spike tooth harrow; L_3: Puddling with rotomixture fb spike tooth harrow; S_1: 30 × 7 cm; S_2: 30 × 14 cm; S_3: 30 × 21 cm; S_4: 20 × 10 cm

harrow and intra plant spacing of 30 x 21 cm treatment combination recorded significantly higher grain and straw yield (5388 and 6789 kg ha^{-1}, respectively) and it was found to be on par with puddling with rotovator fb levelling with spike tooth harrow with 20 x 10 cm manual planting (5118 and 6441 kg ha^{-1}, respectively) and puddling with rotomixure fb levelling with spike tooth harrow with 30 x 7 cm plant spacing (5071 and 6293 kg ha^{-1}, respectively).

Economics: Puddling with rotovator fb levelling with spike tooth harrow method of land preparation and planting at spacing of 30 x 21 cm recorded higher gross returns (Rs. 87,773 and 92,779 ha^{-1}, respectively). Net returns (Rs. 46,329 and 50,007 ha^{-1}, respectively) and benefit cost ratio (2.14 and 2.20) over passing of cultivator twice fb puddling with disc puddler fb levelling with spike tooth harrow and manual planting , but were found to be on par with puddling by rotomixure fb levelling with spike tooth harrow and planting at a spacing of 30 x 21 cm The interaction effect of land preparation and spacing between on gross and net returns was significant. Puddling with rotovator fb levelling with spike tooth harrow with planting at spacing of 30 x 21 cm treatment combination recorded significantly higher gross and net returns (96,316 and 54,649 ha^{-1}, respectively) over rest of the treatment combinations.

Conclusion

Puddling with rotovator fb levelling with spike tooth harrow was found to be the best for transplanting of rice by self propelled mechanical transplanter. As this treatment recorded higher net returns (Rs. 46329) and B:C of 2.14. Among the different planting geometry, 30 × 21 cm was found to be better over other planting geometry tested by visualizing higher net returns (Rs. 50007) and B:C of 2.20 .

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Table 4. Gross returns, net returns and B:C of machine transplanted rice as influenced by land preparation methods and planting geometry.

Treatments	Gross returns (` ha^{-1})			Net returns (` ha^{-1})			Benefit cost ratio		
	2012	2013	Pooled	2012	2013	Pooled	2012	2013	Pooled
Main treatments (L)									
L_1	83900	77764	80832	42271	30153	36212	2.02	1.64	1.83
L_2	91187	84279	87733	52590	40068	46329	2.36	1.91	2.14
L_3	88987	82345	85666	50206	38002	44104	2.30	1.87	2.09
S.Em.±	905	905	905	1229	1229	1229	0.04	0.03	0.03
C.D. (P=0.05)	3552	3552	3552	4826	4826	4826	0.18	0.10	0.10
Sub treatments (S)									
S_1	85105	78865	81984	45523	33556	39539	2.16	1.75	1.95
S_2	90237	83535	86886	50502	38086	44294	2.28	1.85	2.07
S_3	96521	89037	92779	56596	43418	50007	2.43	1.96	2.20
S_4	80237	74413	77325	40801	29238	35019	2.05	1.66	1.86
S.Em.±	1304	1304	1304	1456	1456	1456	0.04	0.06	0.06
C.D. (P=0.05)	4503	4503	4503	5040	5040	5040	0.15	0.20	0.20
Interaction (L x S)									
L_1S_1	80417	74692	77555	38893	27173	33033	1.94	1.57	1.76
L_1S_2	88364	81802	85083	49851	37670	43761	2.29	1.86	2.08
L_1S_3	86533	80100	83317	47825	35825	41825	2.24	1.81	2.03
L_1S_4	88938	82346	85642	47158	34597	40878	2.13	1.72	1.93
L_2S_1	91463	84678	88071	52857	40460	46659	2.37	1.92	2.15
L_2S_2	90312	83580	86946	51490	39201	45346	2.33	1.90	2.12
L_2S_3	100410	92221	96316	61536	47761	54649	2.58	2.08	2.33
L_2S_4	95041	87878	91460	53077	39964	46521	2.27	1.84	2.06
L_3S_1	94112	87013	90563	55176	42531	48854	2.43	1.96	2.20
L_3S_2	71205	66140	68673	29957	18877	24417	1.73	1.40	1.57
L_3S_3	84512	78413	81463	46115	34382	40249	2.21	1.79	2.00
L_3S_4	84993	78686	81840	46331	34454	40393	2.20	1.79	2.00
S.Em.±	1620	1620	1620	1795	1795	1795	0.06	0.06	0.06
C.D. (P=0.05)	4992	4992	4992	NS	NS	5530	NS	NS	NS

NS – Non significant; L_1: Cultivator (twice) fb pudling with disc puddler fb spike tooth harrow (PF); L_2: Puddling with rotovator fb spike tooth harrow; L_3: Puddling with rotomixture fb spike tooth harrow; S_1: 30 × 7 cm; S_2: 30 × 14 cm; S_3: 30 × 21 cm; S_4: 20 × 10 cm

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