CULTIVATION OF LEMON GRASS (*CYMBOPOGON FLEXUOSUS*, 'CKP-25') UNDER POPLAR BASED AGROFORESTRY SYSTEM

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Introduction

Agroforestry is an integrated landuse system approach, different from the sum of its two major components viz. Agriculture and forestry. Specific advantages from this system are early financial returns, increased cash flow and improved ecology. Due to over exploitation, unscientific collection and illegal export, the genetic resources of valuable medicinal plants are getting exhausted very fast. To overcome this situation, the medicinal and aromatic crops are being cultivated along with the trees under agroforestry systems. In earlier studies, Lemon grass has shown promising results when intercropped with *Eucalyptus* and Poplar under Tarai conditions of Pantnagar (Singh *et al.*, 1988; Singh *et al.*, 1989; Yadava, 1995; Yadava and Singh, 1996). Cultivation of light demanding crops in new plantations and shade tolerant crops in existing plantations has provided the farmers with the additional advantages of increased income in recent years (Yadava and Singh, 1996). Growing of certain shade loving cash crops under plantation, agroforestry helps farmers increasing over all production per unit area on profitable and sustainable basis. On an average, a farmer earns Rs. 21,764 ha/year from tree component (Poplar) alone, but after intercropping trees with *Cymbopogon martinii* net return goes upto Rs. 37,026 ha/year. The same is the case of intercropping with *Mentha* species (Singh *et al.*, 1989).

The spacing and fertility levels are the most important factors in controlling the growth and ultimately the final yield of the crop. The ultimate crop yield is dependent on the individual plant productivity and the plant population maintained per unit area. Increasing the plant population only to a certain limit, beyond which it may lead to a reduction in the individual plant productivity, may augment the yield per unit area. Similarly, too wide spacing may result in lower crop yields because of some optimal utilization of resources. Hence selection the optimum spacing of intercrops and doses of fertilizer are considered to be of paramount significance. However, the plant spacing and nitrogen requirement of Lemon grass has not been worked out in agroforestry systems. Keeping these objectives in view the present study was undertaken to work out the optimum plant population and fertilizer requirement in Lemon grass.

Material and Methods

The field investigations were conducted during 1992-1994 at the Central

Institute of Medical and Aromatic Plants (CIMAP), Field Station, Pantnagar (Uttaranchal) situated at 28°N latitude, 79.5°E longitude and 243.8 m above sea level. The climate of the area is humid sub-tropical with dry hot summers and severe winters. The dry season starts from early October to mid-June and a wet season from mid-June to early October. Relative humidity remains highest during July-August and lowest during April-May. The average annual rainfall is about 1400 mm. The average bulk density of soil has been 1.32 mg/m^3 and moisture at field capacity ranged between 30.2 to 34.5 per cent. The CEC (meq./100g) and free lime ($CaCO_3$) content of the soil ranged between 9.9 to 16.2 and 1.2 to 1.5 per cent, respectively, while average organic carbon was 2.2 to 2.4 per cent. The available N, P and K ranged between 372 to 382, 25.70 to 27.30 and 271.3 to 283.1 kg/ha, respectively.

The experiment was laid out under four and five years old Poplar plantations. The treatment consisted of three spacings (30 x 45, 45 x 45 and 60 x 60 cm) and four fertilizer doses ($N_0P_0K_0$, $N_{150}P_{60}K_{40}$, $N_{200}P_{80}K_{60}$ and $N_{250}P_{100}K_{80}$) were arranged in split plot design with three replications, assigned spacing in main plot and fertilizer doses in sub plot.

Nitrogen, phosphorus and potassium were applied in the form of urea, single super phosphate and muriate of potash, respectively. Nitrogen was divided in three equal doses, one third of which was given as basal dressing along with full doses of P and K and the remaining two-third in two equal splits after each harvest of grass.

Disease free and healthy slips of Lemon grass (*Cymbopogon flexuosus*) were transplanted in December, in plots already fertilized as required doses followed by a light irrigation. Agronomical operations like weeding and hoeing were done as and when required. Biometric observations were taken at the harvest time. The grass was harvested three times (April, July and October) in the first year and five times (February, May, July, September and December) in the second year. The essential oil in the samples was extracted by Hydro-distillation with Clevenger's apparatus.

Results and Discussion

Poplar growth : From the results presented in the Table 1, it could be seen that the height and diameter at breast height of Poplar increased significantly with increase in spacing of Lemon grass as intercrops and increasing doses of N, P and K fertilizers over control. These conditions have created less competition between grass and tree and increased availability of nutrient because of low plant density, which have resulted in higher growth rate of trees. Frequent intercultural operations and moisture conservation have also contributed towards increased height and diameter at breast height of Poplar tree. Several workers have also found similar beneficial effect of fertilizer on medicinal and aromatic plants with increased spacing under Poplar and *Eucalyptus* plantation (Singh *et al* 1988; Singhal and Yadava, 1994).

Lemon grass : The herbage yield of Lemon grass got significantly affected due to change to spacing and application of fertilizer does compared to control. The yield of oil per hectare has been significantly higher in respective treatment combinations of spacing and fertilizer doses (Table 2). The difference can be attributed largely to the net biomass production per

Table 1

Effect of spacing and fertility levels of Lemon grass on the growth of Poplar

Treatments	Height (m)		Diameter (cm)	
	1992	1994	1992	1994
S_1F_0	14.80	18.23	15.80	17.35
S_1F_1	15.40	18.68	15.75	17.53
S_1F_2	15.20	18.78	15.90	18.08
S_1F_3	15.40	19.13	16.40	18.37
S_2F_0	14.90	18.23	15.35	17.53
S_2F_1	15.50	18.33	15.90	18.10
S_2F_2	15.60	18.80	16.95	18.22
S_2F_3	15.30	19.13	16.90	18.67
S_3F_0	15.00	18.32	15.80	19.27
S_3F_1	15.25	18.50	15.60	18.07
S_3F_2	15.30	18.92	16.25	18.38
S_3F_3	15.50	19.18	16.50	18.83
CD at 5%	0.15	0.11	0.87	0.55

Table 2

Effect of spacing and fertility levels on the yield of Lemon grass intercropped with Poplar

Treatments	Herbage yield (MT/ha)		Oil yield (kg/ha)	
	1993	1994	1993	1994
S_1F_0	44.52	49.48	203.2	225.1
S_1F_1	48.50	57.01	220.0	258.8
S_1F_2	52.53	60.22	238.0	273.3
S_1F_3	52.48	61.82	237.2	279.7
S_2F_0	44.53	50.94	201.7	231.3
S_2F_1	49.12	58.14	222.5	263.4
S_2F_2	52.15	61.29	237.4	277.6
S_2F_3	57.60	68.01	260.9	309.4
S_3F_0	45.06	50.73	204.1	230.8
S_3F_1	50.88	60.35	230.0	274.0
S_3F_2	54.41	65.57	246.5	297.7
S_3F_3	54.08	64.30	244.4	297.9
CD at 5%	1.27	1.37	6.43	7.76

unit area due to higher fertility status of the soil in respect to N, P and K (Afridi *et al.*, 1992; Chandra, 1986; Maheshwari *et al.*, 1984; Pal *et al.*, 1992). The increase, in fresh herb has been in the range of 0.02-29.38 per cent and 2.53-37.45 per cent in first and second year, respectively (Patra *et al.*, 1989).

The height of plants has been significantly varying during different harvests (Table 3). In the first year when three cuttings were taken in the months of April, July and October, the height followed a linearly increasing trend during July-August and upto October. However, in the second year when cuttings were taken in the months of February, May, July, September and December, the plants height showed maximum growth during July to 15th September, because of warm, humid and higher rainfall conditions (Rana, 1994). The variation can be attributed mainly to changing climatic conditions in different months and also observed that the Lemon grass grows well under warm and humid (higher rainfall) conditions (Patra *et al.*, 1989; Yadava, 1995). The number of effective tillers first decreased from April to July but thereafter increased upto October. Many frequent cuttings and dry and hot climatic conditions have affected the tiller number adversely. Short time interval perhaps has checked the vegetative regeneration of the new shoots of the Lemon grass (Rana, 1994).

The oil content and citral content in Lemon grass remained unaffected with the change in spacing and application of N, P and K fertilizers. However, the yield of citral per hectare varied significantly due to higher yields of herbage and oil per hectare in the respective combinations.

Nutrient status under this system

Availability of nitrogen has been higher under pure Poplar plantation than under agroforestry combination throughout the soil depth, with maximum in surface 0-15 cm layer. The lower content of nitrogen under Poplar based agroforestry combinations, has been due to excessive uptake of nitrogen by these Lemon grass, as could be seen by their luxuriant vegetative growth and deep green colour besides volatilization and leaching losses during soil working. The P_2O_5 and K_2O, however, did not find the same trend and variable contents variation. The uptake of phosphorus and potassium has been mainly for cell division, flowering, fruiting, increasing crop resistant to disease and counteracting the effect of excess nitrogen. The insignificant variations in the N, P, K contents of pure Poplar plantation can be accounted for biomass decomposition in the soil. The available N, P_2O_5 and K_2O content were increased in all the treatment combinations. The higher availability of nitrogen (420.7 kg/ha), phosphorus (33.53 kg/ha) and potassium (334.1 kg/ha) in 60 x 60 cm spacing and $N_{250}P_{100}K_{80}$ fertility level indicates lower uptake to these nutrients by Lemon grass from the nutrient pool (Table 4). Similar findings have also been reported in respect to available nutrients under low density cropping in agroforestry (Pal *et al.*, 1992; Singh *et al.*, 1989; Yadava and Singh, 1996).

Economic viability of the system

The total operational costs have been found different for different treatments, which includes total cost of agronomical practices and extraction of commercially active components. The experiment involving Lemon grass as intercrop clearly

Table 3

Effect of spacing and fertility levels on yield attributes of Lemon grass intercropped with Poplar

Treatments	No. of tillers/plant		Plant height (cm)	
	1993	1994	1993	1994
S_1F_0	62.00	84.37	120.8	121.8
S_1F_1	62.57	86.90	136.6	137.3
S_1F_2	67.20	89.10	140.2	140.3
S_1F_3	69.70	96.40	146.0	146.2
S_2F_0	63.27	86.67	123.1	124.3
S_2F_1	66.80	91.17	137.5	138.8
S_2F_2	72.37	94.17	141.9	142.3
S_2F_3	77.83	113.70	153.8	156.0
S_3F_0	66.80	95.97	125.0	125.9
S_3F_1	70.97	103.80	138.2	139.1
S_3F_2	76.00	108.90	142.7	144.2
S_3F_3	76.30	108.50	151.0	152.6
CD at 5%	1.86	1.43	2.15	2.32

Table 4

Effect of soil properties under Poplar based agroforestry system

Treatments	Available N (kg/ha)		Available P_2O_5 (kg/ha)		Available K_2O (kg/ha)	
	N	Gain (+) or loss (-)	P_2O_5	Gain (+) or loss (-)	K_2O	Gain (+) or loss (-)
S_1F_0	376.0	- 6.1	24.53	-1.17	275.7	+4.4
S_1F_1	383.7	+1.6	26.33	+0.63	288.9	+17.6
S_1F_2	391.2	+9.1	29.30	+3.60	307.4	+36.1
S_1F_3	392.0	+9.9	30.87	+5.17	325.8	+54.5
S_2F_0	379.4	- 2.7	25.23	-0.47	273.2	+1.9
S_2F_1	386.5	+4.4	27.10	+1.40	292.0	+20.7
S_2F_2	389.2	+7.1	29.87	+4.17	314.3	+43.0
S_2F_3	394.9	+12.8	33.10	+7.40	329.4	+58.1
S_3F_0	381.0	- 1.1	25.80	+0.10	276.1	+4.8
S_3F_1	390.5	+8.4	28.37	+2.67	304.3	+33.0
S_3F_2	398.0	+15.9	32.07	+6.37	326.6	+55.3
S_3F_3	420.7	+20.7	33.53	+7.83	334.1	+62.0
CD at 5%	4.27		0.37		3.54	
CD at 5%	8.98		0.61		7.45	

Table 5a

Operational costs (Rs./ha) incurred in various treatments of Lemon grass under Poplar in first year

Operations	Treatments											
	S_1F_0	S_1F_1	S_1F_2	S_1F_3	S_2F_0	S_2F_1	S_2F_2	S_2F_3	S_3F_0	S_3F_1	S_3F_2	S_3F_3
Preparation of land	400	400	400	400	400	400	400	400	400	400	400	400
Lay out	100	100	100	100	100	100	100	100	100	100	100	100
Planting material	7400	7400	7400	7400	4930	4930	4930	4930	2770	2770	2770	2770
Planting	300	300	300	300	300	300	300	300	300	300	300	300
Irrigation	800	800	800	800	800	800	800	800	800	800	800	800
Fertilizer	0	2450	3325	4185	0	2450	3325	4185	0	2450	3325	4185
Weeding	1400	1400	1400	1400	1400	1400	1400	1400	1400	1400	1400	1400
Hoeing	250	250	250	250	250	250	250	250	250	250	250	250
Harvesting	900	900	900	900	900	900	900	900	900	900	900	900
Miscellaneous	200	200	200	200	200	200	200	200	200	200	200	200
Total cost in agronomical practices	11750	14200	15075	15935	9280	11730	12605	13465	7120	9570	10445	11305
Extraction of oil	6096	6600	7140	7110	6051	6675	7122	7827	6123	6900	7395	7332
Total Cost	17846	20800	22215	23051	15331	18405	19727	21292	13243	16470	17840	18637

Table 5b

Output (Rs./ha) received from one hectare of Poplar intercropped with Lemon grass in first year

Operations	Treatments											
	S_1F_0	S_1F_1	S_1F_2	S_1F_3	S_2F_0	S_2F_1	S_2F_2	S_2F_3	S_3F_0	S_3F_1	S_3F_2	S_3F_3
Oil yield (intercropped)	62992	68200	73780	73532	62527	68975	73594	80879	63271	71300	76415	75764
Firewood (Poplar)	650	650	650	650	650	650	650	650	650	650	650	650
Total Cost	63642	68850	74430	74182	63177	69625	74244	81529	63921	71950	77065	76414

Table 6a

Operational costs (Rs./ha) incurred in various treatments of Lemon grass under Poplar in second year

Operations	Treatments											
	S_1F_0	S_1F_1	S_1F_2	S_1F_3	S_2F_0	S_2F_1	S_2F_2	S_2F_3	S_3F_0	S_3F_1	S_3F_2	S_3F_3
Preparation of land	-	-	-	-	-	-	-	-	-	-	-	-
Lay out	-	-	-	-	-	-	-	-	-	-	-	-
Planting material	-	-	-	-	-	-	-	-	-	-	-	-
Planting	-	-	-	-	-	-	-	-	-	-	-	-
Irrigation	800	800	800	800	800	800	800	800	800	800	800	800
Fertilizer	0	2450	3325	4185	0	2450	3325	4185	0	2450	3325	4185
Weeding	1400	1400	1400	1400	1400	1400	1400	1400	1400	1400	1400	1400
Hoeing	250	250	250	250	250	250	250	250	250	250	250	250
Harvesting	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500
Miscellaneous	600	600	600	600	600	600	600	600	600	600	600	600
Total cost in agronomical practices	4550	7000	7875	8735	4550	7000	7875	8735	4550	7000	7875	8735
Extraction of oil	7878.5	9058	9565.5	9789.5	8095.5	9219	9716	10829	8078	9590	10419.5	10216.5
Total Cost	12428.5	16058	17440.5	18524.5	12645.5	16219	17591	19564	12628	16590	18294.5	18951.5

Table 6b

Output (Rs./ha) received from one hectare of Poplar intercropped with Lemon grass in second year

Operations	Treatments											
	S_1F_0	S_1F_1	S_1F_2	S_1F_3	S_2F_0	S_2F_1	S_2F_2	S_2F_3	S_3F_0	S_3F_1	S_3F_2	S_3F_3
Oil yield (intercropped)	86663.5	99638	105220.5	107684.5	89050.5	101409	106876	119119	88856	105490	114614.5	112381.5
Fire wood (Poplar)	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
Total Cost	87663.5	100638	106220.5	108684.5	90050.5	102409	107876	102119	89858	106490	115614.5	113381.5

indicates higher net returns when spaced and applied with higher doses of fertilizers in the first year of growth. The minimum net returns have been obtained with closed spacing of 30 x 45 cm with no fertilizer application (Table 7). Although there was no difference in the growth trend during the second year, the net returns increased by over one and half times, than first year. Similar results in turmeric and *Cymbopogon* species were reported in association with Poplar (Chandra, 1986; Pal *et al.*, 1992; Singh and Bordoloi, 1987).

To have an insight into the value of the investor's rupee, the net return per rupee invested (NRRI) was determined which provided the actual economics with justification for modification in respect of package of practices and of the various inputs in the system. The net return per rupee invested in Lemon grass has been found in the order of $S_3>S_2>S_1$ in case of spacing and $F_0>F_1>F_2>F_3$ in case of fertilizer application. Nevertheless, the value of NRRI in second year has been one and half times in the first year of plant growth (Fig. 1).

The higher net returns with the increase of spacing and fertility dose have indicated the higher productivity due to efficient nutrient utilization and higher biomass production. The same has enhanced due to increase in the number of tillers as a function of optimum land and moisture utilization. Further, the higher net return in second year as compared to first year is on account of less operational cost incurred on various package of practices namely, preparation of land, planting

Table 7

Cost-benefit analysis of Poplar-Lemon grass based agroforestry

Intercrops	1993				1994			
	Gross income (Rs.)	Gross expenditure (Rs.)	Net return (Rs.)	Net return per rupee invested	Gross income (Rs.)	Gross expenditure (Rs.)	Net return (Rs.)	Net return per rupee invested
S_1F_0	63642	17846	45796	2.57	87663.5	12428.5	75235	6.05
S_1F_1	68850	20800	48050	2.31	100638.0	16050.0	84588	5.27
S_1F_2	74430	22215	52215	2.35	106220.5	17440.5	88780	5.09
S_1F_3	74182	23015	51131	2.22	108684.5	18524.5	90160	4.87
S_2F_0	63177	15331	47846	3.12	90050.5	12645.5	77405	6.12
S_2F_1	69625	18405	51220	2.78	102409.0	16219.0	86190	5.31
S_2F_2	74244	19727	54517	2.76	107876.0	17591.0	90285	5.13
S_2F_3	81529	21292	60237	2.83	120119.0	19564.0	100555	5.14
S_3F_0	63921	13243	50678	3.83	89858.0	12628.0	77230	6.12
S_3F_1	71950	16470	55480	3.37	106490.0	16590.0	89900	5.42
S_3F_2	77065	17840	59225	3.32	105614.5	18294.5	97320	5.32
S_3F_3	76414	18637	57777	3.10	113381.5	18951.5	94430	4.98

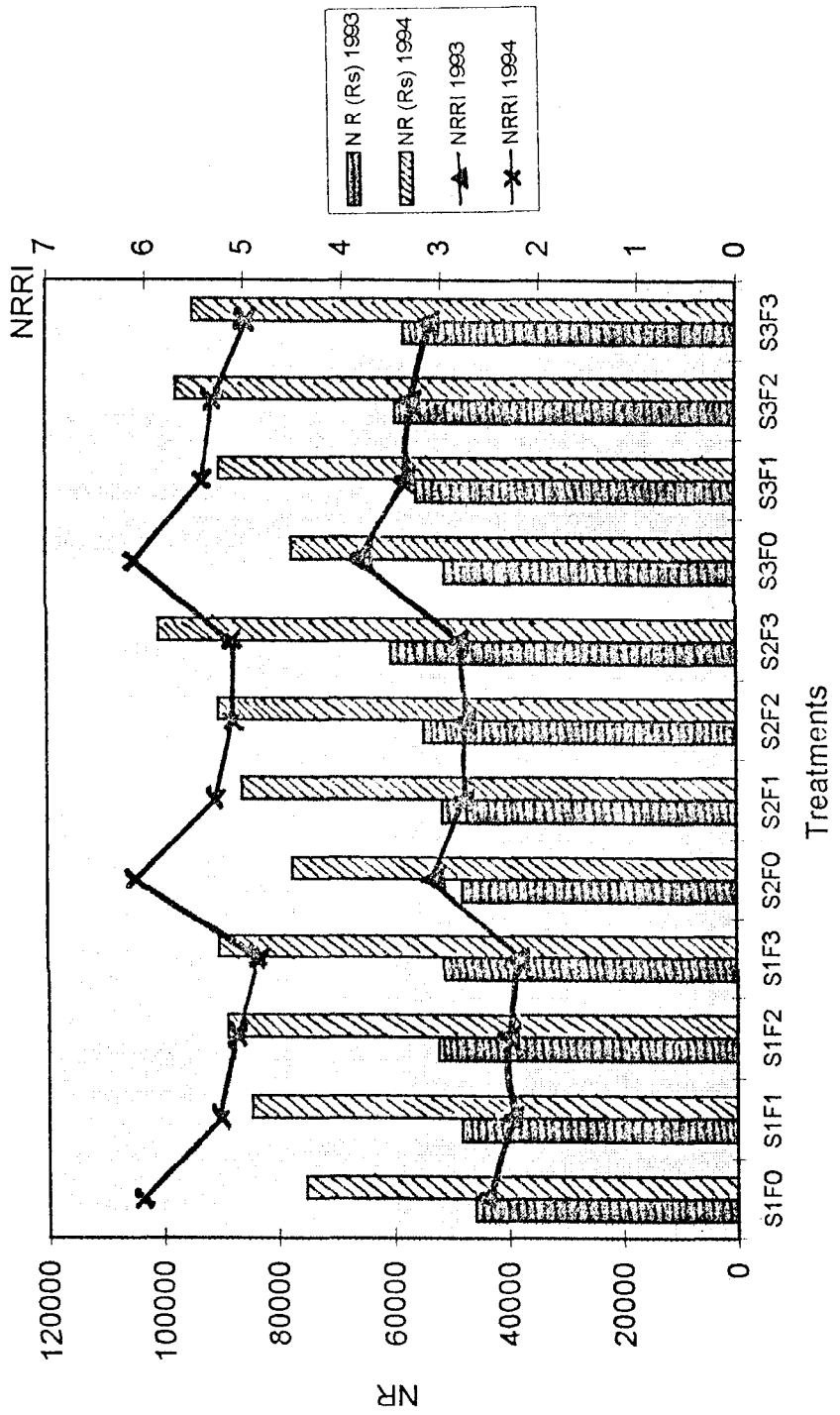

Fig. 1 Effect of spacing and fertility levels on net return per rupee invested of Lemon grass under Poplar

material and planting. The better herbage and oil yield in the second year has been due to greater availability of residual nutrient along with fresh ones (Table 5a and 5b, 6a and 6b).

NRRI value were higher with no fertilizer, the probability of it being decreased in subsequent years of crop growth rationally explained that the optimum productivity in first year could be due to the higher initial soil fertility. Therefore, in the condition of medium to low fertility, the effectiveness of the external addition of nutrient could be more prominently observed in terms of NRRI (Chandra *et al.*, 1991; Pal *et al.*, 1992; Yadava and Singh, 1996).

SUMMARY

Lemon grass was tested with three spacing and four fertility levels under Poplar (*Populus deltoides* 'G-3') for its performance in Kumaun foothills for two years (1993-1994). The treatment combination S_2F_3 (spacing 45 x 45 cm and fertility level $N_{250}P_{100}K_{80}$) proved to be superior in respect of number of tillers (78 and 114), plant height (153 and 150 cm), herbage yeild (57.6 and 68 t/ha) and oil yield (260.9 and 309.4 kg/ha) when compared to other treatments in the first and second year, respectively. The soil content and quality of oil was similar in all the treatments.

पोपलर आधारित कृषिवानिकी प्रणालियों में निम्बुघास (*सिम्बोपोगोन फ्लेक्सुअस* – सीकेपी–25) की खेती करना

ए०के० यादव

साराशं

कुमांऊ की पादपहाड़ियों में पोपलर (*पोपुलस डेल्टायडिस*, जी3) रोपवन में तीन फसलों और चार उर्वरता स्तरों पर निम्बुघास उगाने का परीक्षण, उसकी क्रियाशीलता ज्ञात करने के लिए दो वर्षों तक (1993–94) किया गया। उपचार संयोग एस$_2$एफ$_3$ (फासला 45 x 45 सेमी और उर्वरता स्तर ना$_{250}$ फा$_{100}$ पो$_{80}$) अन्य उपचारों की तुलना में, जहां तक प्ररोहों की संख्या (57.6 और 68 टन/हेक्टे०) और तेल प्राप्ति (260.9 और 309.4 किग्रा/हेक्टे०) की बात है, श्रेष्ठतर पाया गया जब उसकी तुलना क्रमशः पहले और दूसरे वर्ष उनसे की गई। तेल की मात्रा और गुणवत्ता सभी उपचारो में मिलती–जुलती ही रही।

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