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THE COSTS OF MECHANIZED AGRICULTURAL OPERATIONS IN THE MEKEO DISTRICT OF PAPUA

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THE labour resources of the Territory of Papua and New Guinea are limited and considerable interest is being shown in the possibility of introducing mechanization not only to reduce costs but also to enable the labour force to be used to the maximum extent for those operations which cannot be mechanized. Little experimental work has been carried out with regard to the suitability of various types of machinery to Territorial conditions; Australian experience does not necessarily apply fully in the Territory where different soils, vegetation and climatic conditions are encountered. During the past three seasons mechanical operations have been costed at the Department's Experiment Station at Epo and the results are presented in this article.

The Lowlands Experiment Station at Epo comprises about 2,000 acres of flat grassland country with very little timber except on the creek banks. The soil is a clay loam, primarily of alluvial origin. The dominant species is cane grass (*Saccharum* spp.) with a variable mixture of other species, particularly kunai (*Imperata arundinacea*). The average annual rainfall is between 50 and 60 inches with a marked dry season extending from about May to November-December. The Station is the main rice-breeding centre for the Territory and 200-300 acres of rice are grown annually in the course of experimental work. All operations are mechanized as fully as possible, although a little hand labour is used for weeding in certain experimental plots and also during harvesting operations. All rice varieties and strains yet tested in the Territory lodge badly and the selection of non-lodging varieties is the first objective of the rice-breeding programme, in order that harvesting may be fully mechanized. The Department is also experimenting with different types of harvesting machinery in an endeavour to find machines which will handle lodged crops reasonably well.

The figures presented cover operational costs only. They do not include freight and transport of machinery, costs of major overhauls or depreciation. All ordinary running repairs are included as they occurred. Costs of fuels, oils and lubricants are based on Port Moresby retail prices in 44-gallon drum lots and do not include freight. Costs of Native labour include the wages paid, proportion of leave pay where applicable, rations and issues. Costs of recruiting, transport and housing, because they vary so much from place to place, have not been included.

The general service cost includes all routine servicing such as refuelling, oil changes, greasing, minor running repairs, etc.

* Formerly O.I.C., Experimental Station, Epo, since resigned from the Department.

TABLE 1. 40 H.P. WHEELED TRACTOR COSTS FOR VARIOUS OPERATIONS

		Date	Diesaline Consumption 11	Time (Hours)			Labour (Hours)		
				Operation 11	Service 11	Total	Operator 11	Driver 11	Labour
Rice Milling Engleberg Huller		Various	67	80	8.5	88.5	88.5		354
Transport with 3-ton Trailer		Various	26.5	35.5	9.5	45.0	45.0		180
Miscellaneous		June	15	17	2	19	19		38
Ploughing to 6 in. with Shearer 4-disc	General	February	9½	13	2	15		15	15
		March	25	28	7	35		35	35
Ploughing to 9 in. with I.H.C. GL. 70 4-disc	General	Various	63	68	10	78		78	78
	Munabalunga	November	90	114	13	127		127	127
	Paddock 5	December	23	23½	2	25½		25½	25½
	Paddock 14	May	14½	22½	2	24½		24½	24½
	Paddock 14	June	16	36	2½	38½		38½	38½
	Paddock 6A	June	31	67½	5	72½		72½	72½
Ploughing to 4 in with I.H.C. GL. 90	General	Various	60	68	10½	78½		78½	78½
	Paddock 1A	November	5	6	½	6½		6½	6½
	Paddock 13	December	26	30½	3	33½		33½	33½
	Paddock 1C	December	17	19½	1½	21		21	21
	Paddock 13	January	31	35½	3½	39		39	39
	Paddock 1D	January	21	23½	2	25½		25½	25½
Harrowing I.H.C. GL. 9A	General	Various	45	61½	11	72½		72½	72½
	Paddock 3	November	15	19½	1½	21		21	21
	Paddock 1D	December	15	22	2½	24½		24½	24½
	Paddock 5	January	7	8½	1	9½		9½	9½
Rolling with 26-ft. log	Paddock 14	February	13	17½	3	20½		20½	20½
	Paddock 6A	June	27½	46½	2	48½		48½	48½
Planting rice with I.H.C. GL. 130T	General	Various	4	4	½	4½	* 9		27
	Paddock 1C	December	10	14	1	15	15		60
	Paddock 1D	January	11½	14½	2	16½	16½		66
	Paddock 13	January	14	16½	2	18½	18½		74
Harvesting with Sunshine No. 6	General	May	5	10½	2	12½	12½		62½
	Paddock 5	May	13	15	2	17	17		85
	Paddock 1B	May	9	10	2½	12½	15		75
Harvesting rice with Case Harvester	Paddock 1C	May and June	19	51	4	55			55

* European 4½, Asiatic 4½

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Costs (pence)						Acres	Cost per Acre	Acres per Hour	Remarks
Diesaline	General Lubricant	General Service	Costs Drivers	Cost Labour	Total				
2613	2423.2	623.20	3268.31	4842.72	13770.43	....	per hr. 14s. 4d.		
				NOT	COSTED				
				NOT	COSTED				
				NOT	COSTED				
975	848.12	218.12	583.80	478.80	3103.84	13	19s. 11d.	0.46	
				NOT	COSTED				
3510	3453.06	888.06	2188.36	1737.36	11776.84	38	25s. 10d.	0.33	Very rough country. Really tracks required.
897	711.82	183.07	425.34	348.84	2566.07	25	8s. 7d.	1.06	
565.5	681.53	175.28	408.66	335.16	2166.13	13	13s. 11d.	0.57	Land wet.
624	1090.44	280.44	642.18	526.68	3163.74	13	20s. 3d.	0.36	
1209	2044.58	525.83	1209.30	991.80	5980.51				
				NOT	COSTED				
195	181.74	46.74	108.42	88.92	620.82	5½	9s. 5d.	0.92	
1404	923.85	237.60	558.78	458.28	3582.51	40	7s. 6d.	1.31	
760.5	590.66	150.35	350.28	287.28	2139.07	18½	9s. 8d.	0.95	
1209	1075.29	276.54	650.52	533.52	3744.87	40	7s. 10d.	1.13	
819	711.82	183.06	425.34	348.84	2488.06	28	7s. 5d.	1.19	
				NOT	COSTED				
585	590.66	151.91	350.28	287.28	1965.13	30	5s. 6d.	1.54	
585	666.38	171.38	408.66	335.16	2166.58	28	6s. 5d.	1.27	
273	257.46	662.15	158.46	129.96	1481.03	12	10s. 3d.	1.41	
507	530.08	136.33	341.84	280.44	1795.69	13	11s. 6d.	0.74	
1072.5	1408.49	362.24	808.98	663.48	4315.69				
				NOT	COSTED				
390	424.06	109.06	553.95	820.80	2297.87	19	10s. 1d.	1.38	
448.5	439.20	112.96	609.34	902.88	2512.88	28	7s. 6d.	1.93	
546	499.76	128.54	683.21	1012.32	2869.83	40	6s. 0d.	2.42	
195	318.05	81.79	461.33	855.00	1911.17	....	NOT	COSTED	
507	454.35	116.85	627.81	1162.80	2868.81	9	26s. 7d.	0.60	Crop 60 per cent. lodged.
351	302.90	77.90	553.95	1026.00	2311.75	6	32s. 1d.	0.60	
741	1544.79	397.29	3639.9	752.40	7075.38	19	31s.	0.37	Crop 100 per cent. lodged lying absolutely flat on ground.

TABLE 2. 33 H.P. WHEELED TRACTOR (1) COSTS FOR VARIOUS OPERATIONS

Operation and Place		Date	Fuel gallons		Time (Hours)			Labour (Hours)			
			Petrol	Power Kero.	Operations	Service	Total	Europ. & Asiatics	Operator 11	Driver 11	Labour
Stationary Engine Engleberg Huller		Various	21	17	30	4	34		34		170
Transport with 3-ton Trailer		Various	18	273	272½	31	303½		303½		
Ploughing to 9 in. with GL. 90	General	February	¾	4	3½	1	4½			4½	4½
Ploughing to 4 in.-5 in. with GL. 90	General	Various	5	77½	71½	9½	81			81	81
	Paddock 4	November	1½	49	33½	2½	36			36	36
	Paddock 1B	November	1½	46	30½	3	33½			33½	33½
Cultivation with Gaston Scarifyer	General	February and April	4	10½	8	1½	9½			9½	9½
Harrowing with GL. 9A (twice) Tandem disc	General	Various	13	145	109½	13	122½			122½	122½
	Paddock 5	October	48		26	8½	34½			34½	34½
	Paddock 4	October	70		38	6½	44½			44½	44½
	Paddock 3	October	50		27	4	31			31	31
	Paddock 1	October	78		41½	5	46½			46½	46½
	Paddock 5C	November	¾	5	3½	¾	4¼			4¼	4¼
	Paddock 11	November	18		12	1	13			13	13
	Paddock 1C	December	¾	14	10	1	11			11	11
Mowing with GL. 25VO Mower (8 treatments)	General	May	11		10½	2	12½		12½		12½
	Airstrip	Various	96	133	161	21	182		182		182
Planting with GL. 130T.	General	Various	3½	57	41	6	47	94	47		282
	Paddock 5C	November	¾	10	6½	½	7		7		28
	Paddock 11	November	¾	12	8	1	9		9		36
	Paddock 1B	December	½	10½	7½	1	8½		8½		34
	Paddock 3	January	½	4	3	½	3½		3½		14
Harvesting with Case Header	Paddock 11	May	50¼	5	50½	5½	56	56			56
	Paddock 13	May	58		52½	3½	56	56			56
	Paddock 3	May	5		12½	½	13	13			13
	Paddock 1C	June	49		46	3	49	49			49
Harvesting with Sunshine Header	Paddock 13	May	10		9½	2	11½		11½	11½	34½

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Cost (pence)									
Petrol	Power Kero.	General Lubri-cant	General Service	Driver	Labour	Total Costs	Acres	Cost per Acre	Acres per Hour
945	1028.5	216.90	144.30	1235.62	2325.60	5895.92	—	16s. 4d. per hr.	....
				NOT	COSTED				
				NOT	COSTED				
				NOT	COSTED				
67.5	2964.5	234.97	156.33	583.80	478.80	4485.90	38	9s. 10s.	1.17
67.5	2783	220.52	146.70	558.78	458.28	4234.78	22	16s.	0.72
				NOT	COSTED				
				NOT	COSTED				
2160	....	187.98	125.06	575.46	471.96	3520.46	50	5s. 10d.	1.92
3150	....	274.74	182.78	742.26	608.76	4958.54	38	10s. 10d.	1.00
2250	....	195.21	129.87	517.08	424.08	3516.24	30	9s. 9d.	1.11
3510	....	300.04	199.61	775.62	636.12	5421.39	75	6s.	1.81
33.75	302.5	25.30	16.84	70.89	61.56	510.84	9	4s. 9d.	2.57
810	....	86.76	57.72	216.54	177.84	1348.96	18½	6s. 1d.	1.54
33.75	847	72.30	48.10	183.48	550.48	1735.11	19	7s. 7d.	1.90
				NOT	COSTED				
4320	8046.5	1164.03	774.41	6721.26	2489.76	23515.96	200	9s. 9d.	1.24
				NOT	COSTED				
33.75	605	96.99	31.26	258.51	383.04	1408.55	9	13s. 0d.	1.38
33.75	726	57.84	38.48	332.37	492.48	1680.92	18½	7s. 7d.	2.31
22.5	635.25	54.22	36.07	313.80	465.12	1526.96	6	21s. 2d.	0.80
22.5	242	21.69	14.43	129.35	191.52	621.69	5	10s. 4d.	1.67
2261.25	302.5	365.12	242.90	3706.08	766.08	7643.93	18½	34s. 5d.	0.37
2610	....	379.57	252.52	3706.08	766.08	7714.25	36	17s. 10d.	0.67
225	....	90.37	60.13	860.34	177.84	1413.68	5	23s. 6d.	0.40
2205	....	332.58	221.26	3242.82	670.32	6671.98	18	30s. 10d.	0.39
450	....	68.68	45.70	616.51	471.96	1652.85	4	34s. 5d.	0.42

TABLE 3. COSTS FOR VARIOUS OPERATIO THE

Operation	Fuel Consumption		Time (Hours)			Labour (Hours)		trol
	Petrol	Distillate	Operational	Service	Total	Asiatic	Native Labour	
Roadwork	1	21	12½	1	13½	26	26	
Transport	24½	435	234½	52	286½	286½	286½	
First ploughing to 10 inches. Virgin country with Shearer Majestic 4-disc	4	96	49	21½	70½	70½	70½	
	8½	182	95	17½	112½	112½	112½	9.75
First ploughing to 10 inches. Old rice land with Shearer Majestic 4-disc	4½	98	43	9	52	52	52	7.9
	1½	44	16½	4	20½	20½	20½	5.3
	4	94	78	3½	81½	81½	81½	4
	1	49	27	12	39	39	39	3.5
Second ploughing to 10 inches. Old rice land with Shearer Majestic 4-disc	2	59	28	2	30	30	30	7
	13	183	127½	26	153½	153½	153½	5.4
	4	149	100½	17	117½	117½	117½	4
	½	23	14½	1	15½	15½	15½	1.8
Second ploughting to 5 inches Shearer Majestic 4-disc	½	20	11½	2	13½	13½	13½	1.8
Ploughing small experimental areas	4½	79	44	5½	49½	49½	49½	
Harrowing GL. 9A Tandem Disc	½	17	6½	1	7½	7½ (1 European)	7½	1.8
Planting rice GL. 130T. Combine	1	20½	13	2	15	28	60	

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Costs (pence)						Total Cost	Acreage	Cost per Acre	Remarks
Petrol	Distillate	General Lubricant	General Service	Asiatic	Native Labour				
	NOT	COSTED							Mainly hauling other vehicles out of bogs.
	NOT	COSTED							
369.75	7098	667.85	613.7	7056	1173.38	16978	75	18s. 10½d.	Standing cane grass 8 ft. tall. Much radiator chokage.
197.9	3822	302.4	2777.7	3261	542.3	8403	38	18s. 11d.	Soft grasses only.
65.3	1716	116	106.6	1286	213.8	3524	16	18s. 3d.	Clean ground.
174	3666	548.4	503.9	5112	850	10854	30	30s. 2d.	Dense covering of Solanum
43.5	1911	189.9	174.4	2446	406.7	5172	15	28s. 8d.	Very wet conditions.
87	2301	196.9	130.9	1881	312.8	4959	30	13s. 9d.	Soft grasses only.
565.4	7139	896.4	823.5	9629	1601	20654	70	24s. 7d.	Wet conditions.
174	5812	706.5	649.1	7370	1226	15948	75	17s. 8½d.	Heavy regen. cane grass.
21.8	897.1	102	93.7	972.1	161.6	2248	16	11s. 8½d.	Light ditto.
21.8	779.8	80.8	74.3	846.7	140.8	1948	15	10s. 9½d.	Soft grasses only.
	NOT	COSTED							
21.8	663	45.7	42	900.1	782	1751	27	5s. 5d.	Tractor overpowered for this machine.
	NOT	COSTED							

TABLE 4. 40 H.P. TRACKED TRACTOR COSTS FOR VARIOUS OPERATIONS

Operation and Place		Date	Fuel Consumption		Time (Hours)			Labour (Hours)	
			Petrol (Gals.)	Distillate (Gals.)	Oper.	Service	Total	Asiatic	Native Labour
Logging-haulage		August October	0.20	18	11	2	13		
Clearing 26-ft. log	A. Dragging Paddock 6A.	August	0.50	13	12	1.5	13.5	13.5	13.5
	B. Munabalunga	October	0.71	53	33	3	36	36	72
Ploughing to 9 inches with 4-disc Shearer	C. Paddock 1 D. Munabalunga	July	2.81	171	105	51.5	156.5	156.5	156.5
		October	2	148	93	14	107	107	107
	E. Paddock 11	August	1.50	45	25	5.5	30.5	30.5	30.5
	F. Paddock 3	August/ September	3	89	56	19	75	75	75
	G.Paddock 13	November	1.00	58	51	7	58	58	58
	Boundaries	August	0.50	11	8	3	11	11	
2nd ploughing 9 in. 4-disc Shearer	Paddock 1	September	2.50	176	92	31	123	123	123
	Paddock 3	October	0.50	42	26	11.5	37.5	37.5	37.5
2nd ploughing to 4 in. GL. 90	Paddock 4	October	0.50	42	27	8.5	35.5	35.5	0.20

A. Cane and kunai grasses, with only widely scattered saplings.
B. Cane and kunai grasses but many saplings, stumps and Solanum. Work abnormally slow.
C. Land heavily infested with trash, sticks and large roots.
D. Land infested with regenerating Solanum.

There are a few minor errors and inaccuracies in the costing for the following reasons :—

(*a*) The Station over the costing period frequently found it necessary to run its tractors as transport vehicles. A machine engaged in a costed operation such as ploughing might be needed urgently to travel to another Station in the area. The amount of fuel used on such transport work has only been estimated and is subject to minor inaccuracy. The error would, however, be small and does not affect the validity of the figures offered.

(*b*) Oils and greases have not been assessed separately for individual operations. Total oil consumption has been measured for each tractor over a period and the oil consumption for each operation assessed on a proportionate basis per hour. The variation in oil consumption for different operations would be small and the minor inaccuracy thus introduced can be ignored. Similarly, the same grease gun was used for greasing the prime mover and the machine it was operating and the quantities of grease used cannot be separated. Different machines use different quantities of grease but the cost of lubricants is only a minor item in any case and the small error thus introduced could not affect the results. It would not have been worthwhile to purchase a separate grease gun for each machinery unit merely to achieve pedantic accuracy on this point.

(*c*) Costs of minor running repairs such as the correction of fuel blocks and faulty ignition are presented in the tables as a general service cost and are also allotted proportionately on an hourly basis. Such minor faults are random and not specific to the particular operation which was in

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Costs (pence)						Total Cost	Average	Cost per Acre	Acre per hour
Petrol	Distillate	Lubricant General	General Service	Asiatic	Native Labour				
	NOT COSTED								
21.75	507	115.63	70.62	893.43	225.18	1833.61	30	5s. 1d.	2.5
30.88	2067	317.99	194.21	2382.48	1200.96	6193.52	38	13s. 7d.	1.06
122.24	6669	1011.78	606.16	10387.17	2610.42	21406.77	75	23s. 9d.	0.48
87	5772	896.15	547.31	7081.26	1784.76	16168.48	38	35s. 5d.	0.36
65.25	1755	240.90	147.13	2018.49	508.74	4735.51	18.5	21s. 4d.	0.41
130.50	3471	539.62	329.56	4963.50	1251	10685.18	35	25s. 5d.	0.47
43.50	2262	491.44	300.16	3838.44	967.44	7902.98	42	16s. 8d.	0.72
	NOT	COSTED							
103.75	6864	886.51	541.42	8140.41	2051.64	18587.73	75	20s. 8d.	0.60
21.75	1638	250.54	153.01	2481.75	625.64	5170.69	35	12s. 4d.	0.93
0.71	1638	260.87	158.90	2349.39	592.14	5021.05	38	11s.	1.07

E. Rice trash and dense regeneration of crab grass.
F. Very clean paddock. Light regeneration of creek grasses.
G. Very clean paddock.

progress when they occurred. Other minor repairs which are specific to the particular operation, for example, the cleaning of the radiator when in trashy country, are presented as additional servicing costs for that particular operation.

The following tractors were used in costed operations :—

1. 40 h.p. Tracked Diesel.
2. 40 h.p. Wheeled Diesel.
3. 33 h.p. Wheeled (1) Kerosene.
4. 33 h.p. Wheeled (2) Kerosene.
5. 17 h.p. Wheeled Kerosene.
6. 18 h.p. Wheeled Petrol.

All Wheeled Tractors were equipped with rubber tyres.

Table 1 shows the full costing for the 40 h.p. Wheeled Tractor for all operations carried out in the 1953-1954 season. For comparison costs for various operations with the 33 h.p. Wheeled Tractor (1) are shown in Table 2.

The costs for any one season as given in Tables 1 and 2 are not necessarily fully indicative of costs over a longer period. A particular machine may in any one season be almost trouble free but then suffer a series of minor breakdowns in the following season, with a consequent increase in costs. This is well illustrated in Tables 3 and 4 which represent costs for the 40 h.p. Tracked Tractor in the years 1952-1953 and 1953-1954. This tractor was in excellent condition in 1952-1953 but was in need of overhaul in 1953-1954. The sluggishness of this unit in 1953-1954 is shown in higher costs per acre when compared with the same operations in the previous year; the very large number of hours spent in servicing in the latter year also contributes heavily to higher costs.

Tables 5-14 represent the average cost per acre of operation of all machinery combinations tried for the period from January, 1951, to June, 1954. Some combinations which were obviously uneconomic were not tried more than once, but where suitable machinery combinations were found the results have usually been taken over several seasons and should be reasonably reliable. Nevertheless, it has not always been possible to cost over a long enough period to eliminate seasonal differences and differences due to variation in soil texture, etc., and these factors account largely for apparent discrepancies.

TABLE 5. Deep ploughing, 10 inches to 12 inches virgin grass country.

Tractor	Implement			
	Shearer 4-disc Majestic	Acres Costed	I.H.C. 4-dics G.L. 70	Acres Costed
40 h.p. Tracked (A)	19s. 5d.	113	....	....
40 h.p. Wheeled (B)	19s. 11d.	14	16s. 7d.	30

(A)—Asiatic operated. (B)—Native operated.

TABLE 6. Deep ploughing. Initial opening old rice land 9 inches to 10 inches.

Tractor	Implement			
	Shearer 4-disc Majestic	Acres Costed	I.H.C. 4-dics G.L. 70	Acres Costed
40 h.p. Tracked (A)	21s.	224	....	....
40 h.p. Wheeled (B)	....	....	8s. 7d.	25
33 h.p. Wheeled (1) (B)	45s. 5d.	37	25s. 6d.	18½

(A)—Asiatic operated. (B)—Native operated.

TABLE 7. Deep second ploughing 7 inches to 9 inches.

Tractor	Implement			
	Shearer 4-disc Majestic	Acres Costed	I.H.C. 4-dics G.L. 70	Acres Costed
40 h.p. Tracked (A)	17s. 11d.	196	....	....
40 h.p. Wheeled (B)	....	....	8s. 8d. (17s. 1d.)	12s. (26s.)
33 h.p. Wheeled (1) (B)	....	....	22s. 8d.	72
33 h.p. Wheeled (2) (B)	....	....	21s. 4d.	17

(A)—Asiatic operated. (B)—Native operated.

The figures in brackets were taken for wet season ploughing.

TABLE 8. Shallow ploughing 4 inches to 5 inches.

Tractor	Implement					
	Shearer 4-disc Majestic	Acres Costed	I.H.C. 4-disc G.L. 70	Acres Costed	Ferguson double mould-board	Acres costed
40 h.p. Tracked (A)	10s. 9d.	15	....	....	....	....
33 h.p. Wheeled (1) (B)	....	....	8s. 11d.	39	....	....
33 h.p. Wheeled (2) (B)	....	....	17s. 3d.	14	....	....
18 h.p. Wheeled (B)	....	....	....	....	30s. 1d.	6
	IHC 6-Furrow GL. 90		IHC 5-Furrow GL. 90		IHC 4-Furrow GL. 90	
40 h.p. Tracked (A)	11s. 8d.	73	....	....	....	....
40 h.p. Wheeled (B) ...	7s. 11d.	126½	9s. 5d.	5½	8s. 4d.	96
33 h.p. Wheeled (1) (B)	....	....	12s. 1d.	60	9s. 11d.	22
33 h.p. Wheeled (2) (B	....	....	....	....	12s.	104

(A)—Asiatic operated. (B)—Native operated.

Notes on Ploughing Operations.—

On virgin land the first and second ploughings must be deep and thorough. The dominant species, Cane grass (*Saccharum* spp.) and kunai (*Imperata cylindrica, I. arundinacea*) have deep crowns which must be torn up and the first ploughing operation must be followed by at least two months of very dry weather to kill the crowns and persistent rhizomes. Even under the best conditions enough regrowth will occur to necessitate a second deep ploughing.

On old rice land a dense and persistent mat of soft grasses follows when the crop is removed. One deep ploughing will eradicate these weeds and also serve to bury the rice trash thoroughly. A second shallow ploughing is necessary, especially if rain occurs.

Commercial rice growers working in conditions similar to those in the Mekeo would require a heavy plough for deep cultivation and a light plough for operations just prior to planting. The 4-disc Shearer Majestic has proved very efficient for the heaviest work and is of rugged construction; the I.H.C. 4-disc GL 70 has also been very useful and is lighter than the Shearer Majestic but for that reason does not penetrate trashy ground so well in the initial ploughing.

A machine with a bigger cut is desirable for the second ploughing in order to minimize cost and the I.H.C. 4-furrow GL. 90 has proved satisfactory. However a 6-furrow implement is more economical when the draught is not too heavy for the tractors used.

A disc seeding implement would cut costs further by combining the seeding operation with the last cultivation and thus eliminate the shallow ploughing.

For all ploughing operations a heavy tractor such as the 40 h.p. Wheeled Tractor has proved to be most efficient. For initial ploughing of virgin land a tracked tractor is more suitable but if the grass is first burned the wheeled tractor is then able to handle

it. A tracked machine could probably handle a 6-disc plough, thus further increasing its efficiency.

The final operation before planting is harrowing. Costs of harrowing are shown in Table 9.

TABLE 9. Harrowing.

Tractor	Implements					
	I.H.C. GL. 9A Tandem disc	Acres Costed	Ferguson tandem disc	Acres Costed	Diamond 4-leaf	Acres Costed
40 h.p. Tractor (A)	5s. 5d.	27	....	....	....	....
40 h.p. Wheeled (B)	4s. 9d.	170	....	....	....	....
33 h.p. Wheeled (1) (B)	7s. 5d.	256	....	....	....	....
33 h.p. Wheeled (2) (B)	9s.	66	....	....	....	....
17 h.p. Wheeled (B)	9s. 11d.	15	....	....	....	....
18 h.p. Wheeled (B)	....	....	6s. 7d.	37	32s. 8d.	1½

(A)—Asiatic operated. (B)—Native operated.

Notes on Harrowing.—

Harrowing before planting would be less necessary and could be omitted if a disc drill were used. With a tyne drill harrowing is essential as the drill will not eradicate young germinating weeds and grasses.

Again the heavier tractors, both on tracks and wheels, proved most economical for harrowing operations. The diamond tyne drag harrows proved too heavy for the light tractor and considerable wheel slip occurred. Wheel weights would possibly have overcome this difficulty. The same tractor could handle the Ferguson disc-harrows quite well on this country and operated them fairly economically.

The next operation is planting and costs as shown in Table 10.

TABLE 10. Planting.

Tractor	Implement			
	GL. 130 T. I.H.C. Drill	Acres Costed	GL. 130 T. Drill plus GL. 9A Harrow	Acres Costed
40 h.p. Wheeled (B)	6s. 4d.	187	....	
33 h.p. Wheeled (1) (B)	10s. 7d.	107½	10s. 11d.	13½
33 h.p. Wheeled (2) (B)	7s. 10d.	74	14s. 5d.	70

(B)—Native operated.

Notes on Planting.—

The only seeding implement used was the I.H.C. GL. 130T. Combine. It has proved unsatisfactory on this type of country, as would any tyned machine, owing to its tendency to choke on trashy country. Only a disc-seeder will handle these conditions satisfactorily and the use of such a machine would no doubt prove to be much more economical, especially as it would probably eliminate the need for one working prior to seeding.

However, with the machinery available the 40 h.p. Wheeled Tractor again proved its superiority over the other prime movers used.

Tables 11 and 12 present the results for various tractor and harvester combinations.

TABLE 11. Rice Harvesting—Case Header.

Condition of Crop	Tractor			
	40 h.p. Wheeled	Acres Costed	33 h.p. Wheeled (1)	Acres Costed
Erect, clean	....	....	27s. 4d.	36
100 per cent. lodged, clean	46s. 6d.	19	39s. 8d.	5
60 per cent. lodged, weedy	....	....	49s. 2d.	18½
100 per cent lodged, weedy	....	....	57s. 2d.	28

TABLE 12. Rice Harvesting—Sunshine Header.

Condition of Crop	Tractor					
	33 h.p. Wheeled (1)	Acres Costed	40 h.p. Wheeled	Acres Costed	33 h.p. Wheeled (2)	Acres Costed
Erect, clean	53s. 1d.	4	....	....	....	....
60 per cent lodged, clear	....	....	39s. 6d.	6	....	....
Erect, weedy	58s. 7d.	9½	37s. 9d.	9	....	....
60 per cent. lodged, weedy	60s. 8½d.	20	....	....	51s. 7d.	18

Notes on Harvesting.—

Great difficulty has always been experienced in harvesting rice mechanically as all varieties so far tried lodge to a greater or lesser extent. Almost 100 per cent. lodging of the whole crop is common. Much of the area grown at the Station, consisting as it does of small experimental plots, must in any case be harvested by hand but bulk seed is also grown. The Sunshine Header has never been able to handle really badly lodged crops and until 1953-1954 these have been harvested by hand and later threshed with the Sunshine; it is quite efficient for this purpose and will doubtless also be efficient in the field when non-lodging varieties have been produced.

The Case Harvester was in use for the first time in 1953-1954 and immediately proved to be most valuable. It will handle completely lodged crops even when dirty and it will be noted that it operated more

economically than the Sunshine in every instance where a direct comparison is possible. The Case still leaves behind too much of a badly lodged crop but it is thought that the fitting of a pick-up reel with spring steel crop lifting mechanism will give the machine added efficiency in this respect.

The only operation remaining is rice milling. The figures are given in Table 13.

TABLE 13. Rice Milling, Engleberg Rice Huller.

	40 h.p. Wheeled	33 h.p. Wheeled (1)	33 h.p. Wheeled (2)
Cost per hour	9s. 5d.	16s. 5d.	13s. 11d.
Hours costed	520	30	19

Cost per ton 1952-1953.—

40 h.p. Wheeled—£3 4s. 4d.
33 h.p. Wheeled (1)—£3 19s. 11d.
33 h.p. Wheeled (2)—£16 1s. 10d.

(Note : 33 h.p. Tractor (2) was in very poor condition at this time.)

Notes on Milling.—

Rubber-roller type mills of Japanese and British manufacture which produce brown rice are being tried at Epo but the only machine for which extensive cost figures are available is the Engleberg which produces an undermilled white rice—that is, a grain from which the germ and part of the outer layers have been removed, but not a fully polished rice. The figures again show a marked advantage in economy with the 40 h.p. Tractor as a source of power.

One other miscellaneous operation not directly connected with rice growing has been costed, namely the mowing of the airstrip. Cost figures are presented in Table 14.

TABLE 14. Mowing Airstrip.

Tractor	Implement					
	GL25VO P.T.O. Mower	Acres Costed	Ferguson P.T.O. Mower	Acres Costed	Sunshine Drawn Mower	Acres Costed
40 h.p. Wheeled (B)	....	....	....	....	8s. 5½d.	25
33 h.p. Wheeled (2) (B)	9s. 11d.	100	....	....	....	....
33 h.p. Wheeled (1) (B)	9s. 11d.	350	....	....	....	....
17 h.p. Wheeled (B)	5s. 2½d.	25	....	....	....	....
18 h.p. Wheeled (B)	....	....	4s. 7½d.	25	....	....

It is seen from Table 14 that the lighter tractors and mowers are more efficient for this operation but the lighter mowers are more susceptible to breakage in this type of country.

NOTES ON TRACTORS.

1. 40 H.P. TRACKED TRACTOR.

This machine has been on the Station since 1951. It has operated efficiently but it is considered that its power has not been fully utilized in many operations and it would be more efficient with, for instance, 6-disc ploughs rather than with the 4-disc ploughs used for the deep ploughing in this area.

For a period in June and July, 1952, the tractor was operated by Native drivers but this was not considered satisfactory and it has since been driven only by European or Asiatic staff. As all the wheeled tractors are driven by Native operators, this fact militates against economical operation of a tracked tractor.

After almost 1,000 hours' service in 1952-1953, it required minor repairs. However, this was not possible, as parts were not available and in the 1953-1954 season only 539 hours of work were done with this tractor and it was relatively sluggish and inefficient when compared with its performance in the previous season. During its period of efficient operation in 1953-1954 the general lubricant cost was 7.03 pence per hour and general service cost was 6.46 pence per hour. Operation during this period was particularly trouble free.

2. 40 H.P. WHEELED TRACTOR.

This tractor has been in use since February, 1951, and has to date completed almost 4,000 hours of service. It gave 2,800 hours of service, including 646½ hours in eleven weeks at one period, without a major overhaul or breakdown. This is the best performance so far recorded in this area. In April, 1953, a failure in the oil reticulation system caused one of the big end bearings to seize but after the replacement of the bearing and repair of the oil pump it again gave excellent service in the 1953-1954 season.

This type of tractor has proved the most economical in use at Epo for practically every operation and is rugged and simple in construction. Lubricant cost was 9.59 pence per hour from February, 1951, to July, 1953, and the general service cost was 3.73 pence per hour. This tractor is a dry sump type which accounts for the relatively high oil consumption. The simplicity of operation is reflected in the low service cost and this machine is particularly suitable for use by Native operators.

3. 33 H.P. WHEELED TRACTOR (1).

This tractor was on the Station for a number of years prior to the commencement of the costing period. Its total operational time to date is not known but it was under repair during the 1952-1953 season and did 1,099 hours' work in 1953-1954. It is not quite heavy enough for the heavier operations in this type of country and costs for most operations do not compare favourably with those obtained for the 40 h.p. Wheeled Tractor.

4. 17 H.P. WHEELED TRACTOR.

This machine was available on loan for a short time only and was in poor condition. It consumed lubricants valued at 8.95 pence per hour and service costs amounted to 12.84 pence per hour. However, these very high figures should not be taken as indicative of the true performance of the tractor owing to its need for attention at the time and the limited period of costing.

5. 33 H.P. WHEELED TRACTOR (2).

This tractor was operated only in the 1951-1952 season when it had to do the bulk of the Station work. It was in need of a top overhaul when the season began and for that reason the costs for its 1,102 hours of operation that year are higher than should normally be the case. Owing to shortage of parts at the time several minor repairs which would have improved efficiency could not be effected. When these facts are considered the performance of the tractor is seen in a better light. However, the tricycle undercarriage makes it difficult to operate under the conditions encountered at Epo and renders turning difficult whether the ground be wet or dry and powdery.

Over the costing period lubricants cost 12.51 pence per hour and overall servicing costs were 7.84 pence per hour. As already stated both these costs are abnormally high owing to the condition of the tractor.

6. 18 H.P. WHEELED TRACTOR.

This tractor is too light for large scale ploughing and cultivation activities but is an excellent machine for transport, row crop

work and similar light jobs. It was costed for only a short period before it was destroyed by a fire. During the costing period the lubricant cost was 2.90 pence per hour and the general service cost 3.32 per hour. These figures are low but the tractor was still almost a new unit when it was destroyed.

Summary and Conclusions.—

In this article costs have been calculated for all the operations in mechanized rice production at the Lowlands Agricultural Experiment Station, Epo. For the cultivation of about 300 acres of rice per year the following machinery would appear to be most suitable.

(*a*) A medium-heavy tractor. If only one unit is to be purchased it should be wheeled. The 40 h.p. Wheeled Diesel has been outstanding for performance and economy at Epo.

(*b*) A heavy plough. The 4-disc Shearer Majestic and the I.H.C. GL 70 have been tried at Epo and both performed well.

(*c*) A combined disc-cultivator and seed-drill. No such machine has been available at Epo but it should prove superior to the tyned machines used as the latter choke readily with grass and rice trash.

(*d*) A harvester. The " header " type is unsatisfactory as crops are usually badly lodged. The Case Harvester has been successful and should be further improved by the addition of a pick-up reel with spring steel crop lifting mechanism. Any machine of the " harvester " type should be suitable.

(*e*) A rice mill, if the rice is to be milled on the property. Small and cheap Japanese mills would appear to be suitable. The tractor would provide the necessary power.

(*f*) A transport vehicle.

On this basis, with rice as the only crop, the tractor would be used for about 1,250 hours per annum to perform all the normal operations necessary for the production of a 300 acre rice crop. Milling would require some hundreds of hours during the off season in addition if the rice were milled on the property.