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Internal Magnetic Fields of White Dwarf Stars : Circulation Effects

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Abstract : It is shown that in the case of white dwarf stars, circulation effects are unlikely to prevent strong internal magnetic fields from being observed.

1. Introduction

The existence of strong magnetic fields ($\gtrsim 10^{11}$ gauss) in the interiors of white dwarf stars can affect their structure and hence their theoretical mass-radius relationship.[7] Most white dwarfs have no observed magnetic field ; the upper limit for the average surface field being of the order of 10^5 gauss.[8] A fraction ($\sim 10^{-2}$) of white dwarfs do have strong (average) surface fields $\sim 10^6$ to 10^8 gauss.[15] In this work, however, we shall be concerned with white dwarfs with no observable fields and, in particular, determine whether such stars can have strong magnetic fields in their interiors. Chanmugam and Gabriel[3] have discussed this problem for non-poloidal rotating white dwarfs with no internal motions. The time scale of decay for magnetic fields $\tau_n \sim \tau_0/(n+1)^2$ where $\tau_0 \sim 5 \times 10^9$ yr and n is the order of the mode considered. Hence, few modes survive over the typical age of a white dwarf $\gtrsim 10^8$ yr. Since the magnetic field would have to be a linear superposition of the first few modes, such a field would, in general, be unlikely to be both strong in the interior and weak at the surface. However, as pointed out in that paper, the presence of meridional circulation could affect the arguments given. Recently, Kippenhahn and Möllenhoff[6] have discussed the possible existence of circulation in rotating white dwarfs. Similarly, we may envisage the existence of circulation in white dwarfs which contain strong magnetic fields. The purpose of this paper is to consider the effects of circulation on the magnetic field (and vice versa) and to determine whether circulation can prevent a strong internal field from being observed.

2. Circulation Effects

We consider three possible cases for the magnetic field of the white dwarf: (*a*) that it was formed with a strong surface field which is then confined beneath the surface by circulation, (*b*) that it was formed with a weak fossil field which was internally amplified by the dynamo action of circulations, (*c*) that it was formed with a strong fossil field lying entirely beneath the surface.

Consider case (*a*). We first suppose that the circulation is driven by stellar rotation with angular velocity Ω. We denote the ratio of the centrifugal force to the gravitational force by $\lambda_r \sim \Omega^2 R^3/GM$, where M and R are the mass and radius of the white dwarf and G the gravitational constant. Let us denote the ratio of the magnetic force to the gravitational force by $\lambda_m = \bar{B}^2 R^4/GM^2$ where $\bar{B}$ is the mean field. For most white dwarfs $\Omega \lesssim 0.1$ radians s^{-1},[4] so that, taking $R \sim 10^9$ cm, $M \sim M_\odot$, we have $\lambda_r \lesssim 0.1$. We note that even if $\lambda_r \sim 1$ the Eddington-Vogt circulation time τ_{EV} is roughly of the same order or slightly longer than the cooling time τ_{COOL} of white dwarfs.[6] Since $\tau_{COOL} \sim 10^9$ yr, the circulation does not have sufficient time to turn over an adequate number of times during the lifetime of the white dwarf.

Secondly, we consider the possibility that $\lambda_m \geqslant \lambda_r$ so that the circulation is driven by the magnetic field itself. In a rotating magnetic star, the poloidal component of the equation of mechanical equilibrium is :

$$\nabla p = \rho \nabla \phi + \rho \Omega^2 \bar{w} + (\text{curl } \mathbf{B}) \Lambda \mathbf{B}/4\pi \tag{1}$$

where p is the pressure, ϕ the gravitational potential and cylindrical coordinates ($\bar{w}$, θ, z) are used. The general solution of the complete set of equations, magneto-hydrodynamic and hydrostatic, of which equation (1) is one, is of formidable difficulty. However, an estimate of the magnetic effects may be made as follows : we note that the ratio of the centrifugal force term to the magnetic force term in equation (1) is roughly of order $\rho\Omega^2 R/(\bar{B}^2/4\pi R) \gtrsim 3M\Omega^2/\bar{B}^2 R \sim \lambda_r/\lambda_m$. Hence, when $\lambda_r \leqslant \lambda_m$ and $\lambda_m \sim 1$ one should obtain the same order of magnitude for the circulation speed as in the case when $\lambda_m \leqslant \lambda_r$ and $\lambda_r \sim 1$. Thus a strong magnetic field cannot cause adequate circulation to choke off the field. We note here that λ_m cannot be larger than one, as then the star would be unstable because its magnetic energy would be greater in magnitude than its gravitational energy.[2] Clearly, also the case $\lambda_r \approx \lambda_m \sim 1$ would not significantly change the speed of circulation to affect the above discussion.

We now turn to case (*b*). From the preceding discussion, we note that the largest possible values for the speed of the circulation, whether driven by rotation or by magnetic fields, are insufficient to produce large poloidal fields by dynamo action.

We thus discuss the possibility that differential rotation creates a strong magnetic field which necessarily must be toroidal. If we choose the mean rotational velocity $v_{rot} \sim 0.1\ R \sim 10^8$ cm s^{-1} the strength of the toroidal field generated $\sim (4\pi\rho\ \bar{v}^2_{rot})^{\frac{1}{2}} \sim 10^{11}$ gauss. Such a strong toroidal field is unstable in the absence of an equally strong poloidal field.[9,10]

Finally, we consider case (*c*) where the white dwarf is formed with a strong internal field but weak at the surface. Since the effects of circulation, whether driven by rotation or magnetism, are unimportant, this case essentially reduces to the case of a static white dwarf star discussed in the introduction and in the paper by Chanmugam and Gabriel.[3] Such a field would diffuse out of the star on a time scale, at most, of order 10^8 yr, which is less than the typical age of most white dwarfs.

In conclusion, we point out that it is difficult to justify the existence of magnetic fields of sufficient strength which can alter the structure of the star and yet not appear above the surface.

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Skin Temperature in a Group of Students at Peradeniya

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Abstract : Skin temperature was measured with a radiation thermometer at 20 points on the body surface in an atmosphere of 24.4°C (76°F) in 26 young adult Sri Lankan males. The surface temperature was different at different points on the body. The warmest regions were the forehead and hypogastrium. The trunk was warm. The coolest regions were the hand and foot. This pattern of regional variation of the body temperature is essentially the same as has been described elsewhere in the world.

1. Introduction

Cullumbine[4] reported findings on the body temperature of Ceylonese (former name for Sri Lankan) persons. His sample consisted of more than 400 male and more than 50 female university students aged 18 to 25 years. The arithmetical mean and standard error for oral tempereture in males were 98.9 ± 0.03°F, females 99.4 ± 0.04°F; rectal, males 99.9 ± 0.02°F, females, 100.2 ± 0.05°F ; axillary, males 98.6 ± 0.07°F, females, 98.7 ± 0.11°F. Earlier, Castellani[3] had stated that there was no difference in the body temperature of healthy natives and resident Europeans in Ceylon, "with due allowance for individual and seasonal differences and the effects of exercise and clothing". There has been no report on skin temperature in Sri Lanka.

The purpose of the present work was to get some idea of skin surface temperature in persons in Sri Lanka. It was done as a student project during the third term of the physiology course in the Peradeniya medical school in 1978. The sample consisted of 26 male medical students of average age 21 years.

Skin surface temperature (T_{sk}) varies in different parts of the body. Generally speaking, the head is warmest and the feet coolest. There being no such thing as *the* skin temperature, it becomes convenient or necessary to invent the concept of a *mean* skin temperature ($T_{\bar{sk}}$). It is convenient because we can use a single representative figure for skin temperature instead of having to use a number of separate figures. It is necessary when we wish to calculate the heat gain or loss from the body as a whole. In estimating T_{sk} we can measure $T_{\bar{sk}}$ at many different points on the body surface and calculate a weighted mean value. Hardy and DuBois[8] introduced a standard method in which skin temperature was measured at 20 different points on the body surface and a mean value calculated by giving a weight of 7% for the head skin temperature, 35% for the trunk ; arms 14%, hands 5%, thighs 19%, legs 13% and feet 7%. These weightings corresponded to the relative surface areas of the body regions as determined by DuBois and DuBois.[6]

2. Materials and Methods

The thermometer used was an instant-reading radiometric skin thermometer marketed by Messrs Heimann GMBH, Wiesbaden, West Germany.[17] It consists of a bolometer, which the operator holds in his hand and which he places on or close to the skin, and a recording box. The bolometer receives the heat radiated from the skin and converts it into electricity. The electrical change is amplified and converted into a movement of a lever over a temperature scale in the recording box. The instrument was calibrated with a Leslie cube ; the temperature of the water in the cube was taken with a certified mercury-in-glass thermometer ; the bolometer was placed on or near the black surface of the cube and the temperature read on the recording box. It was assumed that the cube surface should have the same temperature as the water within the cube.

The skin temperature measurements in the 26 students were made at 9 to 10 a.m. in an air-conditioned room. It was necessary to fix a time of day because body temperature, including skin temperature, shows a marked diurnal variation.[11,12] The dry bulb temperature of the room was 24.4°C (76°F), the wet bulb temperature 21.1°C (70°F) and the effective temperature 22.2°C (72°F). A dry bulb temperature of 24.4°C was chosen because this is the mean annual temperature of Peradeniya.[18] This is several degrees lower than the air temperature at 9 a.m.

The subject entered the room and sat for 20 minutes. He then changed clothes ; he wore a cotton sarong (a cylindrical tubular garment hanging down from the waist over the legs), leaving his trunk, upper limbs and most of his lower limbs bare. Skin temperature measurements were made immediately thereafter at the 20 sites specified in the Hardy-DuBois method.[5,8]

Mean skin temperature for each person was calculated by the same method using the following steps :— (a) for each of the seven body regions (head, trunk, arms, hands, thighs, legs, feet) the mean of all readings for that region was calculated ; (*b*) this regional mean value was multiplied by the appropriate weighting factor ; (*c*) the weighted mean values were added up, as shown in the formula—

$$\bar{T_{sk}} = 0.07\ T_{head} + 0.35\ T_{trunk} + 0.14\ T_{arm} + 0.05\ T_{hand} + 0.19\ T_{thigh} + 0.13\ T_{leg} + 0.07\ T_{feet}.$$

3. Results and Conclusions

The results are shown in the Table.

TABLE 1. Skin temperature of 26 male medical students in an air-conditioned room with a dry bulb temperature of 24.4°C (76°F), effective temperature 22.2°C (72°F)

Body No.*	Region	Skin temperature		Coefficient of variation	Difference from mean skin temperature
		Mean (°C)	Standard deviation (°C)	(%)	(°C)
—	Skin as a whole (mean skin temperature)	32.9	0.76	2.31	—
1	Forehead	35.8	0.43	1.20	+ 2.9
6	Abdominal, iliac	35.2	0.64	1.82	+ 2.3
5	Chest, over liver	34.6	0.46	1.32	+ 1.7
2	Cheek	34.2	0.61	1.78	+ 1.3
18	Trunk, back of shoulder	34.0	0.71	2.08	+ 1.1
3	Chest, front upper part	33.8	0.59	1.74	+ 0.9
15	Shoulder	33.8	0.50	1.48	+ 0.9
16	Trunk, over scapula	33.8	0.54	1.61	+ 0.9
17	Trunk, loin	33.8	0.48	1.42	+ 0.9
9	Back of knee	33.3	0.59	1.77	+ 0.4
11	Shin	33.3	0.86	2.58	+ 0.4
4	Chest, front middle	33.1	1.16	3.51	+ 0.2
7	Thigh, front	32.3	0.61	1.88	— 0.6
10	Calf	32.3	0.99	3.06	— 0.6
14	Forearm	31.9	0.84	2.63	— 1.0
8	Thigh, back upper end	31.5	0.83	2.64	— 1.4
13	Palm	31.5	1.73	5.66	— 1.4
13*b*	Hand, dorsum	30.8	1.31	4.25	— 2.1
12*b*	Ankle	30.4	3.22	10.59	— 2.5
12	Sole	30.0	1.55	5.16	— 2.9

*The numbers are those in the Hardy-DuBois method of numbering the body regions for skin temperature determination.

The mean skin temperature for the 26 subjects was 32.9°C. The scatter of mean skin temperature values was : range, 30.0°C to 35.8°C, standard deviation 0.76°C, coefficient of variation 2.3%.

A regional variation in skin temperature in different parts of the body was apparent. The warmest region was the forehead (35.8°C) while the coolest was the sole of the foot (30.0°C). In the limbs, a pattern of falling of temperature in a proximodistal direction was observed. The extensor surface was cooler than the flexor surface.

Sites of the body where skin temperature was closest to the mean skin temperature were *a)* the chest near the nipple *b)* the front of leg, and *c)* the back of the knee. Individual variation was greatest in the ankle, sole of foot, dorsum of hand and palm of hand.

4. Discussion

It is well known that the temperature of the skin surface shows marked differences in different parts of the body in a cool or cold atmosphere. The warmest part is the head, the coolest is the foot, and the trunk is warm. A graph that is frequently reproduced in textbooks shows the results for J. D. Hardy in a range of room temperatures from 23°C to 34°C.[9] In a warm environment, the regional variation in skin temperature practically disappears ; the temperature in all parts becomes about 35°C. The present work shows that the skin temperature in a cool room shows the usual pattern of regional variation : the forehead was warmest (mean value 35.8°C), the foot coolest (sole 30.0°C); the difference between the two was 5.8°C. The trunk was warm ; the warmest point on it was the abdominal iliac region (35.2°C).

The body can be divided into three main regions on the basis of surface temperature :—[11]

A, a region of greatest warmth with a small range of temperature : forehead, chest, abdomen.

B, a region of moderate warmth and a larger range of temperature : arm, thigh.

C, a region of least warmth and greatest range of temperature : hands, lower part of the leg, foot.

This three-region concept is supported by the present work, except in certain points of minor detail. *Region A* consisted of the forehead and parts of the abdomen and chest. The mean temperature was 35.8°C to 34.0°C. The inter-individual variation of skin temperature was lower for the forehead than for any other site (coefficient of variation 1.2%). The variation in the other sites of Region A were of the order of 1 or 2 per cent. *Region B* consisted of the rest of the trunk and the limbs down to the forearms and legs (with the exception of the upper end of the back of the thigh, near the buttock, which falls into the next category). The mean temperature was 33.8°C to 31.9°C. Inter-individual variation was of the order of 2 per cent, ranging from 1.4% for the loin to 3.5% for the chest (breast). *Region C* consisted of the hands and feet and the upper end of the back of the thigh near the buttock. The mean temperature was 31.5°C to 30.0°C. Inter-individual variation was of the order of 7%, going up to 10.6% in the ankle region.

Mean skin temperature ($T_{\bar{sk}}$) is an artificial and elastic quantity. With so much difference of skin temperature in different parts of the body, the calculated $T_{\bar{sk}}$ will depend on (*a*) the points on the body surface at which the temperature was measured, (*b*) the weightage given to the temperature at the different points. The number of regions and points at which skin surface temperature (T_{sk}) has been measured in

order to estimate $T_{\bar{sk}}$ has ranged from about 3 to 25. Burton[2] used three points (chest, calf, lower arm), Newburgh and Spealman[14] 4 points (chest, thigh, leg, lower arm) ; Miller and Blyth[13] 5 (forehead, arm, chest, back and thigh) ; Palmes and Park[15] 9 ; US Quartermaster Corps[19] 10 ; Iampietro *et al*[11] 10 ; Hale *et al*[17] 15 points in 7 regions ; Adams and Covino[1] 16 ; Hardy and DuBois[9] 20 ; Mali[11] 24. The weighting of the temperature from the various body regions has usually been on the basis of the contribution which the surface area of the region makes to the total body surface area, as in the Hardy-DuBois method. Ramanathan[16] proposed a simpler weighting system where :

$$T_{\bar{sk}} = 0.3\ T_{chest} + 0.3\ T_{arm} + 0.2\ T_{thigh} + 0.2\ T_{leg}.$$

For each of the four regions represented in the formula, he took the mean of 10 readings from thermocouples placed in various places in the front, back and sides of the body region, which makes 40 readings in all.

It has been noticed by Teichner[19] and Ramanathan[16] that the temperature of the medial aspect of the thigh corresponds to the mean skin temperature of the body. The present work used entirely the Hardy-DuBois method with regard to the sites at which the skin temperature was measured and the weightings used to calculate the mean skin temperature. This was found to be 32.9°C with a standard deviation of 0.76°C, at a room temperature of 24.4°C (76°F). This seems to be much the same for an environmental temperature of 24.4°C as in other studies in other parts of the world. Accordingly, it seems that the skin vasoconstrictor mechanism which reduces skin temperature in a cool environment at 24.4°C is not more sensitive in these tropical subjects than in others.

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Studies on Cereal-Legume Intercrop Systems

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Abstract : Studies were conducted at Kundasale and Peradeniya to assess the agronomic and economic potential of some locally important cereal-legume intercrop systems. Total yield of the maize-soyabean intercrop increased although the yield of the component crops tended to be depressed. Maize-cowpea and maize-mung bean crop combinations appeared to be compatible. Land Equivalent Ratio (LER) and gross economic returns were increased by intercropping. The net protein utilization value of the intercrop systems were higher, highlighting the importance of such systems for the subsistence level farmers in developing countries.

1. Introduction

Results of preliminary studies on intercropping indicated that cereal-legume intercropped systems are superior to monocropped systems.[1] Intercropping with compatible crop combinations increased both total economic yields as well as gross economic returns, thus providing for more efficient utilization of N, land and other inputs. Cereal-legume intercrop systems also appeared to enhance net protein utilization value of the system, highlighting the importance of such management practices for increasing the nutritional intake of subsistence level farming families in developing countries. In view of the preliminary findings, studies on intercropping were further developed to evaluate the yields and economics of intercropping cereal crops with legumes against their respective monocrop systems.

2. Materials and Methods

Six experiments were conducted in 1976/77 with three trials each at the University Farm, Kundasale and Peradeniya. The elevation of the locations were approximately 450 m. The rainfall during the experimental period varied widely between locations, ranging from 256 mm at Kundasale to 2516 mm at Peradeniya. The rainfall received during experimentation also showed considerable variation and the crops were supplementally irrigated as needed.

Augmented design[4,6,7] was used to include several cereal-legume intercrop systems having a local potential in the study. Six treatments replicated three times formed the main experiment, while others were augmented or unreplicated. Replicated treatments consisting of maize (*Zea mays* L.)—soyabean (*Glycine max* (L) Merr.) intercrop system was included to systematically vary the row-intercrop species between locations for comparing the trends of treatments. The selection of maize (Var. Thai composite)

as the row crop and soyabean(Var. S. J. 2) as the legume in the main experiment was based on their performance in previous intercropping studies.[8] In the augmented intercrop combinations, four locally grown legumes were intercropped with maize to identify compatible intercrop systems and to observe general trends. Maize (Var. Thai Composite) was used as the row crop as it has been found to be compatible with most legumes.[3] Maize-cowpea (*Vigna unguiculata* L.) (Var. MI 35) and maize-mung-bean (*Vigna radiata* L.) (Var. MI 1) intercrop systems were also selected based on previous experimentation[8] while maize-groundnut (*Arachis hypogaea* L.) (Var. A 92) and maize-dwarf bean (*Phaseolus vulgaris* L.) (Var. Wade) intercrops were assumed to have potential for the mid-country wet zone.

Maize-soyabean intercrop system and the monocrop system was tested at three levels of N. N levels selected were 0.25 and 50 kg/ha, the highest level being the locally recommended rate for the row crop. Mono and intercrop systems were compared at 0 and 25 kg/ha only. The recommended N (50 kg/ha) applied to the row crop was used as a control treatment. N was band applied adjacent to the row crop. N was not applied to any of the other legumes grown in the augmented treatments. All plots received blanket applications of 56 kg P_2O_5 and K_2O/ha respectively and other cultural practices uniformly as per local recommendations. Maize was spaced 100 × 50 cm, while intercrop spacings were soyabean and mungbean 50 × 5 cm, and cowpea and groundnut 50 × 10 cm. Soybean seeds were inoculated with the commercial inoculant "Nitragin S" at 5 g per 60 kg of seed. It was assumed that indigenous rhizobia would be adequate to inoculate other legumes, as a commercial inoculant was not available. Both row and legume crops were planted at the same time.

3. Results and Discussion

The mean grain yields of maize and soyabean for both locations are given in Table 1.

3.1 Yield of Maize—i. *Effect of N*—Whether intercropped or not, maize showed a positive response to N. In both locations, under the monocrop system, yield increased in the zero and 25 kg N levels, the differences being significant in Kundasale (2) and (3) ; Peradeniya (4) and (5). The yields however varied widely, from 0.35 t/ha in Peradeniya (4) to 3.11 t/ha in Kundasale (1) with zero N, and from 1.72 t/ha in Peradeniya (5) to 3.69 t/ha in Kundasale (3) with 25 kg N. The yield differences between 25 and 50 kg N were significant in 3 locations : Kundasale (3), Peradeniya (4) and (5). The highest yield at the 50 kg N/ha recommended level of N was reported in Kundasale (3) (4.87 t/ha) and lowest for Peradeniya (6) (2.4 t/ha). Under intercropping yield differences between zero and 25 kg N were significant in 5 cases, Kundasale (1), (2) and (3), Peradeniya (4) and (5). The highest and lowest

yields for zero and 25 kg N levels were : 0.32 t/ha in Peradeniya (4) and 2.56 t/ha in Kundasale (2), respectively. As evident, wide yield variations have been reported for various experiments in both locations. Gunasena *et al*[8] reported similar yield variations in the previous intercropping studies. Such variations could be expected to result from agroclimatic variations among locations,[5] as the differences in the total N contents among locations varied only slightly.

TABLE 1. Mean grain yield of maize and soyabean under various levels of nitrogen. t/ha.

			Monocrop System			Intercrop System		LSD P=0.05	CV%
		Rate of N, kg/ha							
		50	25	0		25	0		
Kundasale (1)	Maize	3.64	3.38	3.11		3.41	2.45	0.29	16.4
	Soyabean	—	—	—	0.36	0.46	0.40	0.16	7.7
	Total	3.64	3.38	3.11	0.36	3.87	2.85	0.46	14.9
Kundasale (2)	Maize	3.33	3.27	2.75		3.29	2.46	0.30	20.4
	Soyabean	—	—	—	0.21	0.27	0.26	0.11	6.3
	Total	3.33	3.27	2.75	0.21	3.56	2.72	1.08	20.3
Kundasale (3)	Maize	4.87	3.59	2.51		3.89	1.99	0.71	16.8
	Soyabean	—	—	—	0.86	0.49	0.60	0.92	10.4
	Total	4.87	3.59	2.51	0.86	4.38	2.59	0.63	16.0
Peradeniya (4)	Maize	3.97	1.98	0.34		2.01	0.31	0.31	10.9
	Soyabean	—	—	—	3.03	1.94	1.92	0.82	32.6
	Total	3.97	1.98	0.34	3.03	3.95	2.23	0.56	12.0
Peradeniya (5)	Maize	4.51	3.41	1.19		3.72	2.12	0.63	13.6
	Soyabean	—	—	—	2.21	0.69	0.85	0.25	18.0
	Total	4.51	3.41	1.19	2.21	4.41	2.97	0.53	7.5
Peradeniya (6)	Maize	2.40	1.72	0.82		1.73	1.18	0.61	24.9
	Soyabean	—	—	—	0.84	0.28	0.19	0.29	26.8
	Total	2.40	1.72	0.82	0.84	2.01	1.37	0.71	19.5

ii. *Effect of Cropping System*— At zero N, maize yields were somewhat depressed by intercropping except in two cases; Peradeniya (5) and (6). However the reduction was not significant. The yield gap between mono and intercropped maize tended to decrease at 25 kg N. Although the differences were non-significant, yield tended to increase in most of the trials. This may probably be due to the inability of maize to compete with the soyabean for available nutrients and other resources. Similar conclusions have also been reported by Harwood and Banta.[10] However, the treatment trends suggest that maize could withstand intercropping with soyabean. Beets[3] and Gunasena *et al*[8] reported similarly. This would indicate that there is competition between maize and interplanted legume for nutrients or other resources and that the competitive effects decrease as N level increases. The results also suggest that future experimentation should include higher rates of N under intercropping.

3.2 Yield of Soyabean—Except in a few cases, intercropping depressed the yield of soyabean. Monocropped soyabean at zero N out-yielded intercropped soyabean at the same level of N in four out of six locations. Exceptions were : Kundasale (1) and (2). The yield increase was significant in two locations, Peradeniya (4) and (5). However, intercropping at 25 kg N decreased the magnitude of yield reduction and in four locations yield increased over intercropped soyabean at zero N. This would suggest that at low N levels, the shading effect due to the row crops is less severe. At high N levels, however, reductions in legume yields have been reported.[15]

3.3 Yield of Total System—In general, total yield of the intercropped system increased and depended considerably on N level used. Thus, at 25 kg N total yield increased under intercropping in all six locations, the differences being significant in Kundasale (3) and Peradeniya (4) and (5). Intercropping at 0 N level increased total yield over monocropped soyabean in all except Peradeniya (4). In the case of maize, however, total yield of the system exceeded only in two locations. This could be expected as monocropped maize at zero N will have better competitive ability over the intercropped system. The magnitude of the differences varied widely depending on locations. In general, this would indicate that intercropping makes better overall resource use than when the same crops are grown separately. The results of these and previous studies[8] show a potential for a total production system if plant types of a complementary nature could be selected to exploit those specific environments. Similar results have been reported for maize-soyabean combination,[11-12] for maize-groundnut and maize-mungbean combinations[14] and for rice-soyabean and maize-soyabean combinations.[2]

3.4 Augmented Intercrop Systems—Four different augmented intercrop systems with the corresponding monocrops were tested. There were three augmented intercrop systems in Kundasale and two at Peradeniya with the locally potential legumes used in the combination. The mean yield of monocrop maize at zero N level from the main experiment have been used for comparison with intercropped maize, in the respective experiments. The mean yield data of the cropping systems is indicated in Table 2.

3.5.1 Maize-Cowpea Intercrop system

Maize-cowpea intercrop system was augmented in 5 experiments with three trials at Kundasale (1, 2 and 3) and two trials (4) and (5) at Peradeniya. Intercropped maize out-yielded monocropped maize in three trials, with yield increases as high as 78% and 103% in Kundasale (1) and (2), respectively. In Peradeniya (5), intercropping decreased maize yield by 54% while equal yields were reported under both cropping systems in Kundasale (3). Similar results have been reported by Haizel[9] when

maize was intercropped with cowpea in two cropping seasons. This indicates the compatibility of the maize-cowpea intercrop system suggesting the insignificant competitiveness for available soil nutrients and other resources, perhaps due to differences in the rooting habit of the crops. On the other hand, Agboola and Fayemi[1] studied the effect of intercropping maize with cowpea at varying levels of N and found that maize yield decreased only at lower levels of N, suggesting competition between maize and interplanted cowpea for N and that the competitive effect decreased as N level increases.

As a general trend, cowpea yields were depressed by intercropping. The highest reductions were in Kundasale trials 1 and 2 (56% to 74%) while in others, the magnitude ranged from 14% to 26%. The poor yields reported for cowpea could have been due to shading effect of the row crop, although this argument may have been more appropriate, if N was applied to the row crop and not grown at zero level of N.

As indicated in Table 2, except in Peradeniya (5), yield of the total system was higher than the monocrop of either maize or cowpea. The magnitude of the difference, however, varied with location.

TABLE 2. Mean grain yield of augmented (unreplicated) intercrop systems, t/ha

Crop used	Kundasale 1		Kundasale 2		Kundasale 3		Peradeniya 4		Peradeniya 5	
	Inter	Mono	Inter	Mono	Inter	Mono	Inter	Mono	Inter	Mono
Maize	0.70	0.35	2.12	1.19	0.82	0.82	6.15	5.80	2.06	4.50
Cowpea	0.75	1.30	0.46	1.05	0.17	0.20	1.05	1.08	0.71	0.85
Total	1.45		2.58		0.99		7.20		2.77	
Maize	0.40		2.17	1.19	1.34	0.82			2.32	4.50
Mungbean	0.44	1.00	0.45	1.09	0.54	5.6			1.16	1.60
Total	0.84		2.62		1.88				3.48	
Maize	0.49		1.39	1.19						
Bush bean	0.11		0.21	0.97						
Total	0.60	0.20	1.60							
Maize					1.37	0.82				
Groundnut					0.82	1.39				
Total					2.19					

3.5.2 Maize-mungbean Intercrop System

Maize-mungbean intercrop system was tested in Kundasale (1), (2) and (3) and Peradeniya (5) only. Intercropped maize increased yield over its monocropped counterpart in three out of four trials, with increases ranging from 16% to 82%. Intercropping decreased maize yield by 48% in Peradeniya (5) only.

As reported in maize-cowpea intercrop system, mungbean yield was depressed under intercropping in all trials. The magnitude of yield reduction varied from 27% to 58%, the highest being for Kundasale trials (1) and (2) (56% to 58%).

The total yield of the system was higher in Kundasale (2) and (3) compared to maize or mungbean monocrop systems. The exceptions were in Kundasale (1) and Peradeniya (5) where mungbean and maize monocrops exceeded the total yield of the system.

3.5.3 Maize-dwarf bean Intercrop System

This intercrop system was tested in Kundasale (1) and (2) trials only. Similar to that reported above, intercropped maize yields were higher than monocropped maize, being 42% and 16% in Kundasale (1) and (2) respectively. Legume yield decreased in both experiments due to intercropping, the reduction being 78%. The total system yield was higher than under the monocrop system.

3.5.4 Maize-Groundnut Intercrop System

Intercropped maize increased yield by 68% over monocropped maize in Kundasale(3), while monocropped groundnut outyielded intercropped groundnut by 71%. The total yield of the system was higher than those of the monocropped system.

Human Nutrition Value

The effect of the cropping systems and N level on crude protein content of maize and soyabean in three trials at Kundasale are indicated in Table 3.

TABLE 3. Effect of cropping system and N level on crude protein content of maize and soyabean

crude protein %

			Monocrop System				Intercrop System		LSD	CV
		N, kg/ha	50.00	25.00	0		25.00	0	P=0.05	(%)
		Maize	10.56	10.00	9.75		9.94	9.00	0.22	10.6
Kundasale	(1)	Soyabean	—	—	—	33.63	33.11	32.95	0.08	1.8
		Total kg/ha	38.42	33.79	30.24	11.90	49.44	35.31	0.30	4.6
		Maize	9.94	9.63	8.69	—	10.06	8.75	0.18	9.7
Kundasale	(2)	Soyabean	—	—	—	35.5	35.06	34.40	0.25	5.2
		Total kg/ha	33.11	31.52	23.94	7.50	42.54	30.41	0.26	4.1
		Maize	8.38	7.75	7.68	—	7.56	6.63	0.17	5.7
Kundasale	(3)	Soyabean	—	—	—	31.74	32.43	33.00	0.50	5.1
		Total kg/ha	40.94	27.82	19.24	27.42	44.64	33.13	0.26	4.5

N increased the crude protein content of maize under both systems of cropping. In monocropped maize, the differences were significant in Kundasale (1) and (2) at both 25 kg N and 50 kg N and in Kundasale (3) at 50 kg N only.

Similarly, under intercropping, the crude protein content of maize increased in the 25 kg N level in all trials, the differences being significant in Kundasale (1) and (3). At 25 kg N, intercropping depressed crude protein content of maize in two out of three trials, the difference being significant in Kundasale (1) and (3). A similar effect was noted at the zero N level. The crude protein content of intercropped soyabean increased in the 25 kg N level in two trials, the effect being significant in Kundasale (1) and (2). Monocropped soyabean significantly increased crude protein content in Kundasale (1) and (2). The results indicate the possibility of enhancing the crude protein content of intercropped soyabean with N application.

In general, applied N tended to increase the crude protein content of both maize and soyabean. Although intercropping tended to depress the crude protein content in some cases, the crude protein harvest of combined maize-soyabean was significantly higher than that of the monocropped system. Since soyabean contains a higher content of amino acids, including those deficient in maize, intercropping could substantially contribute to the protein intake, which is below the required minimum in most Asian regions. From a human nutrition point of view, therefore, intercropping will be of great importance.

Economics

A method commonly used to assess intercropping advantages is the Land Equivalent Ratio (LER), defined as the relative land area required for monocrops to produce yields obtained in intercropping.[13] The yield increase shown by the LER could then be used to calculate the monetary advantage.

LER computed at various levels of N are given in Table 4. For convenience of comparison, data collected in the same season in different locations were grouped together, e.g.—Kundasale (1) and (2) and Peradeniya (4) and (5).

TABLE 4. Land Equivalent Ratio (LER) for intercropped maize-soyabean

	25 kg N/ha	0 kg N/ha
Kundasale (1) and (2)	1.40	0.95
Kundasale (3)	1.21	1.03
Peradeniya (4) and (5)	1.55	1.41
Peradeniya (6)	1.16	1.68

At 25 kg N, LER increased in all experiments. The highest LER was recorded for Peradeniya (4) and (5) 1.55 followed by Kundasale (1) and (2) 1.40. At zero N, the highest LER was for Peradeniya (6) and the lowest values of LER could be attributed to the lower yields obtained from intercrops compared to the monocrops. Comparison of the values of LER indicates better land utilization due to intercropping.

The total economic value of the produce obtained (Rs/ha) from both systems of cropping is shown in Table 5. The data was computed on the basis of market prices prevailing during the period of experimentation. In all experiments, regardless of N level, the intercrop system provided higher economic returns than the corresponding monocrop system.

TABLE 5. Economic returns (Rs/ha) of mono and intercropping at varying N levels

Expt. No.	Crop	Monocrop system				Intercrop system	
		(Rs/ha)				(Rs/ha)	
	N kg/ha	50	25	0		25	0
Kundasale (1 and 2)	Maize	5894.40	5618.10	4942.78		5664.15	4144.50
	Soyabean	—	—	—	1396.85	1427.55	1320.10
	Total	5894.40	5618.10	4942.78	1396.85	7091.70	5464.60
Kundasale (3)	Maize	8273.65	6078.60	4236.60	—	6585.15	3361.65
	Soyabean	—	—	—	3407.70	1857.35	2379.25
	Total	8273.65	6078.60	4236.60	3407.70	8442.50	5740.90
Peradeniya (4 and 5)	Maize	7183.80	4543.60	1274.05	—	4835.25	2041.55
	Soyabean	—	—	—	10345.90	5188.30	5449.25
	Total	7183.80	4543.60	1274.05	10345.90	10023.55	7490.80
Peradeniya (6)	Maize	4067.75	2901.15	1381.50	—	2916.50	1995.50
	Soyabean	—	—	—	3284.90	1089.85	752.15
	Total	4067.75	2901.15	1381.50	3284.90	4006.35	2747.65

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Induction of Parturition in Sows with Prostaglandin $F_{2\alpha}$

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Abstract : Forty two cross bred sows were used to study the efficacy of prostaglandin $F_{2\alpha}$ on induction of parturition and its effects on sow and litter performance subsequent to farrowing. Twenty mg of prostaglandin $F_{2\alpha}$ was administered as a single intramuscular injection between day 109 and 111 of pregnancy. The response to treatment was 89% and the mean interval to farrowing was 33.3 ± 5.5 hrs. The gestation period of the treated sows were significantly shorter ($p > 0.001$) compared to controls (110 ± 0.8 vs 114.3 ± 1.6 days). The mean birth weight of the piglings in the treated group was found to be significantly lower ($p < 0.05$) than the control (2.62 + 0.33 vs 2.84 + 0.81 lbs). The mean litter size at birth, weaning weight and the number of pigs weaned per litter were not affected by prostaglandin treatment. Day 109 of pregnancy was found to be little early, for induction of successful parturition as treatment at this time resulted in more still-births. Post weaning reproductive performance of the treated sows was also not affected by prostaglandin treatment.

1. Introduction

The development of artificial methods for regulating the onset of parturition in farm animals has long been a goal of animal physiologists. Effective methods for controlling the time of onset of parturition would have several practical applications. Parturition can be induced by the administration of corticosteroid and prostaglandins in cattle, sheep, horses and swine.[2] Daily injections for three days of 75 mg of dexamethasone induced parturition in sows[9] but did not provide an accurate prediction of farrowing time. A single intramuscular injection of prostaglandin $F_{2\alpha}$ ($PGF_{2\alpha}$) given after 110 days of pregnancy will induce the onset of parturition within 40 hrs or less in a high percentage of sows.[4] Subsequent studies using $PGF_{2\alpha}$[3,8] and analogues of $PGF_{2\alpha}$[1,6] have supported these findings. However, considerable variability in response was also reported.[5,7,10] Variability in response was attributed to the effects of genetic and environmental factors.[5] The present study was conducted to assess the efficacy of $PFG_{2\alpha}$ in inducing farrowing in cross bred sows, in Sri Lanka. The effect on litter performance and post weaning sow performance were of particular interest.

2. Experimental

A total of 42 cross bred sows were used in this experiment. The sows were managed intensively at Mahaberiatenne farm, National Livestock Development Board, Teldeniya, Sri Lanka. The elevation in this area is about 1000 ft above sea level, the temperature ranges from 68F° to 84°F, relative humidity 72% and the annual

rainfall is between 55 to 75 inches. The sows in the farm were given locally mixed concentrate feed containing 16% crude protein at the rate of 2 lbs per sow per day before service. Thereafter, the amount of concentrate was gradually increased upto 6 lbs per day per sow before farrowing. Ad-lib feeding was given during the period of lactation. A creep feed of crude protein content of 20% to 21% was gradually introduced to the piglings one week after farrowing and given ad-lib upto 2 months of age when they were weaned from the sow and transferred to the fattening unit.

The experiment was carried out in two stages. Initially, a preliminary trial was done to determine the effective dose of $PGF_{2\alpha}$ to induce farrowing successfully. In this trial, four sows were given $PGF_{2\alpha}$ intramuscularly at the rate of 5 mg per sow, 4 sows with 10 mg and another 4 sows with 20 mg of $PGF_{2\alpha}$.[10] The results of this trial suggested that 20 mg of $PGF_{2\alpha}$ is the optimum dose for induction of parturition in sows. In the experiment proper, 30 sows were used. Nineteen sows were treated with a single intramuscular injection of 20 mg of $PGF_{2\alpha}$ and the balance 11 were kep as controls. All animals were not treated on the same day but on several visits withint one and a half months. The pregnancy period of treated sows varied from day 109 to 111 (day 1 = day of service). The $PGF_{2\alpha}$ treated and the control sows were kept in different sets of farrowing pens. These pens were in pairs, each pair having a common opening so that only the piglings can go through. The sows were housed in such a way that there was no mixing of piglings of the treated and control groups.

Constant observation was made following treatment to determine side effects, to record the interval from injection to the birth of first pigling, the interval between births of successive piglings, signs of dystocia and retained placenta. Baby piglings were wiped dry immediately after birth, numbered and weighed. The number of piglings born alive and the still-births were recorded. Piglings were weaned at the age of 2 months, their weight recorded and transferred to the fattening unit. The sows were served at post weaning oestrus and the time from weaning to fertile oestrus was determined. The litter size and birth weights were also recorded at subsequent farrowing. Student 't' distribution was used to test the significance of treatment effects.

3. Results

The results of the response of sows and litter performance following treatment are summarised in Table 1. Of the 19 animals treated with $PGF_{2\alpha}$, 17 responded to treatment and farrowed within 22 to 44 hrs with a mean interval of 33.3 ± 5.5 hrs. The distribution of sows according to the time interval from the administration of $PGF_{2\alpha}$ until birth is shown in Figure 1, and it can be seen that 7 out of 19 sows farrowed 32 to 37 hours after treatment. The two sows which failed to respond to treatment farrowed 75 hours later. The pregnancy period of the treated sows was significantly reduced ($p < 0.001$) compared to the control group (110.8 ± 0.8 vs 114.3 ± 1.6 days).

There were no signs of dystocia or any significant differences in the time taken from the birth of first pigling to expulsion of placenta, in either group. In both treated and control sows, milk was present in the mammary glands prior to the onset of parturition and normal milk secretion was initiated following parturition except for one sow in the treated group.

TABLE 1. Effects of intramuscular injection of prostaglandin $F_{2\alpha}$ on production characteristics of sows and piglings.

Characteristics		Treated	Control
Total number of animals		19	11
Gestation length (days)	(*a*)	110.8 ± 0.8**	114.3 ± 1.6
Time from injection to farrowing (hours)		33.3 ± 5.5	—
Litter size at birth (numbers/litter)		8.7 ± 2.0	8.8 ± 3.6
Number still-born per litter		1.3 ± 3.3	0.5 ± 1.0
Live pigs at birth (number/litter)		7.4 ± 2.9	8.4 ± 3.9
Mean birth weight/pig (lbs)		2.62 ± 0.33(*)	2.84 ± 0.28
Time from first pigling to expulsion of placenta (hours)		4.8 ± 2.0	4.3 ± 1.7
Live pigs weaned per litter		6.7 ± 1.9	6.8 ± 2.1
Mean weight at weaning (lbs)		27.1 ± 2.5	27.5 ± 3.6
Time from weaning to fertile oestrus (days)		9.3 ± 13.7	9.2 ± 1.1
Mean litter size at subsequent farrowing		8.9 ± 2.7	—
Mean birth weight at subsequent farrowing (lbs)		2.88 ± 0.21	—

(*a*) Mean + standard deviation
(**) Significant at 0.1% level
(*) Significant at 5% level

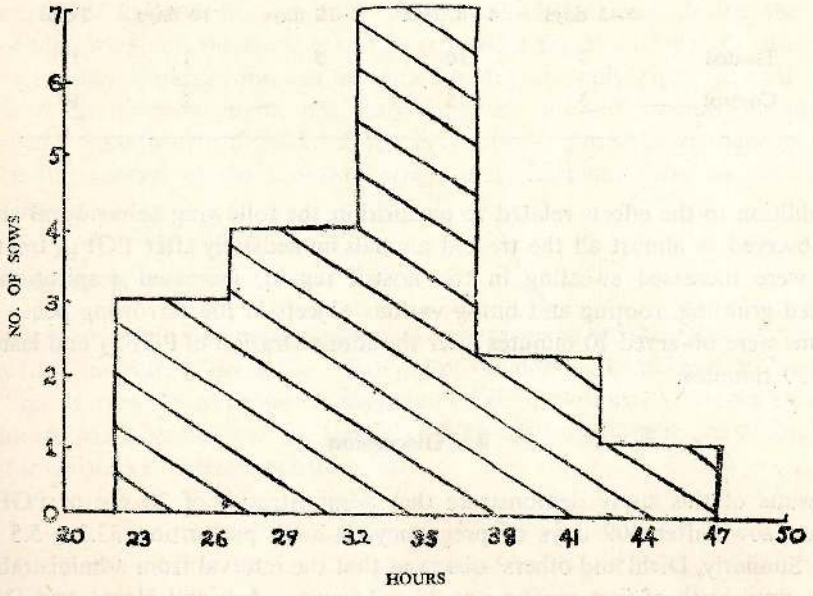

Figure 1.

The number of live and still-born piglings per litter between the two groups did not differ significantly ($p > 0.05$). The mean litter size at birth was 8.7 ± 2.0 and 8.8 ± 3.6 for the treated and control groups, respectively. Number of still-births in the treated group was 22 and the control group 5. In the treated group all the still-births were from the sows treated with $PGF_{2\alpha}$ on day 109 of pregnancy. The mean birth weight of the piglings was significantly reduced ($p < 0.05$) in the treated group compared to controls ($2.62 + 0.33$ vs $2.84 + 0.8$). The weaning weight at 8 weeks and number of piglings weaned did not differ between the treated and control groups.

Soon after weaning, the sows returned to oestrus normally except for one sow in the treated group which returned to oestrus 56 days after weaning and two sows in the control group which took 25 and 34 days, respectively, to return to oestrus. The distribution of the sows according to the period taken from weaning to fertile oestrus is shown in Table 2. It can be seen that the majority of them returned to oestrus within one week after weaning. The mean litter size and birth weight of piglings at subsequent farrowing for the $PGF_{2\alpha}$ treated group were 8.9 ± 2.7 and 2.88 ± 0.21 lbs respectively.

TABLE 2. Frequency distribution of sows according to the time taken from weaning to the first oestrus

	0—3 days	4—6 days	7—10 days	10 days	Total
Treated	3	10	5	1	19
Control	3	5	—	2	10

In addition to the effects related to parturition, the following behavioural changes were observed in almost all the treated animals immediately after $PGF_{2\alpha}$ treatment. There were increased sweating in the nostril region, increased respiration rate, increased grunting, rooting and biting various objects in the farrowing pen. These reactions were observed 10 minutes after the administration of $PGF_{2\alpha}$ and lasted for about 30 minutes.

4. Discussion

The results of this study demonstrate that administration of 20 mg of $PGF_{2\alpha}$ to pregnant sows after 109 days of pregnancy, induces parturition 33.3 ± 5.5 hours later. Similarly, Diehl and others[3] observed that the interval from administration of $PGF_{2\alpha}$ until birth of first pigling was 33 ± 2 hours. Ash and Heap[1] and Downey

et al[6] found that parturition began about 26 and 27 hours, respectively, after the injection of analogues of $PGF_{2\alpha}$. In the results reported here 89% of the sows farrowed within 22 to 44 hours. This is in agreement with previous studies, reporting 80% to 90% of animals responding to treatment with $PGF_{2\alpha}$.[4,12]

The number of live piglings at birth was not affected by $PGF_{2\alpha}$ treatment. However, the mean birth weight of the piglings in the treated group was significantly lower than the controls. Similar observations were made by others.[5,11,12] This low weight is expected, because parturition was induced and piglings are born 3 days early. Inspite of the low birth weight, the mean weaning weight and the number of piglings weaned at 8 weeks in the treated group did not differ from the controls and this observation again is in agreement with previous studies. Even though there were 22 and 5 still births in the treated and control groups, respectively, the difference was not significant. In the treated group, all the still-births were from sows treated with $PGF_{2\alpha}$ on day 109 of pregnancy. Hence, it is not advisable to induce parturition before day 110 of pregnancy.

Very little data is available on the post weaning performance of $PGF_{2\alpha}$ treated sows. The results of this study clearly demonstrate that post weaning fertile oestrus, subsequent litter size and mean birth weight were not affected by $PGF_{2\alpha}$ treatment.

In conclusion, the results of the present study demonstrates that $PGF_{2\alpha}$ can be used as a management tool to control time of parturition of sows in Sri Lanka. Earlier relevant studies indicate that majority of the still-births occur during the latter stages of farrowing and these losses can be reduced if the exact time of farrowing is known. Further, if parturition can be limited to daytime only, piglet survival would improve in farms where night time farrowings are allowed presently to proceed unattended. Successful utilisation of the induction of farrowing is dependent on having a full control of the breeding programme, adequate facilities and a well trained labour force.

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Rubber Seed Meal as a Protein Supplement in Growing Swine Rations

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Abstract : A study was conducted to investigate the effects of different levels of rubber seed meal on the performance of growing swine. The results indicate that rubber seed meal could be included in swine rations only upto 10% level. Poor performance of swine fed on rations containing 20% and 30% rubber seed meal was attributed to deficiencies of lysine and sulphur amino acids, rather than to the presence of cyanogenic glucoside.

1. Introduction

The usefulness of rubber seed meal as a protein supplement in poultry rations is well documented.[2,3,6,7] However there is no record of the use of rubber seed meal in swine rations. Hence it was intended in this study to investigate the possibility of utilizing rubber seed meal as a replacement for coconut poonac which is the traditional protein supplement in rations for growing swine. This trial was conducted at the Swine Production Unit of the Department of Animal Husbandry of the University of Peradeniya, Sri Lanka.

TABLE 1. Chemical composition of rubber seed meal (%)

Dry matter	—	91.14
Crude protein	—	24.70
Ether extract	—	7.18
Crude fibre	—	10.16
Ash	—	5.59
Nitrogen free extract	—	37.61
Hydrocyanic acid	—	0.0019

2. Experimental

The rubber seed meal used was supplied by Lever Brothers (Ceylon) Ltd., and the proximate analysis of this material is shown in Table 1.

TABLE 2. Percentage composition of rations used in the trial.

	Control	10% Rubber seed meal	20% Rubber seed meal	30% Rubber seed meal
Coconut poonac	30	20	10	—
Rubber seed meal	—	10	20	30
Wheat flour	40	40	40	40
Rice polish	23	23	23	23
Meat meal	5	5	5	5
Bone meal	2	2	2	2
Zoodry*	0.25	0.25	0.25	0.25
Proximate composition**				
Crude protein %	15.90	16.24	16.58	16.92
Crude fibre %	4.84	4.69	4.54	4.39
Ether extract %	5.31	5.81	6.31	6.81
Ash %	7.20	7.14	7.08	7.02

*Vitamin and mineral supplement **Calculated values.

Thirty two crossbred swine, of approximately three months of age and weighing an average of 18.12 kg, were allocated at random to four treatments. A coconut poonac based ration, which was balanced to carry the nutrient requirements of growing swine as recommended by the National Research Council[5], served as the control. The coconut poonac was replaced by 10, 20 and 30% levels of rubber seed meal in the experimental rations. Composition of ration is presented in Table 2.

The housing and feeding procedures used in this trial were identical to those described by Rajaguru *et al.*[8] Intake capacity of feed in each group was estimated at the beginning of each week, on the basis of feed consumption per half an hour. The feed provided per meal, in all groups, was then restricted to the lowest estimate recorded per group, so that the feed intake between groups was maintained at the same level. The feed intake determined this way was used as the basis of feeding during the week. Weekly weight gains were recorded throughout the trial period, which lasted eight weeks.

3. Results

The effect of different levels of rubber seed meal on the performance of growing swine is shown in Table 3.

TABLE 3. Mean effects of different levels of rubber seed meal on rate and efficiency of gain of growing swine.

	Initial weight (kg)	Final weight (kg)	Weight gain (kg)	Feed consumption (kg)	Feed Conversion efficiency
Control	17.50	35.64	18.14[a]	70.0	3.85[a]
10% Rubber seed meal	17.67	34.12	16.45[a]	70.0	4.25[a]
20% Rubber seed meal	19.09	33.57	14.48[b]	70.0	4.80[a]
30% Rubber seed meal	17.61	25.97	8.36[c]	70.0	8.37[c]

Statistical significance at 5% level is denoted by different letters.

There is no significant differences in the weight gains or feed conversion efficiency of growing swine fed on control ration and those fed on rations containing 10% rubber seed meal. However, the growth response and feed conversion efficiency were depressed progressively and significantly as the levels of rubber seed meal in the rations were increased.

4. Discussion

The results indicate that the rubber seed meal could be used only upto 10% level in growing swine rations. Increasing the levels of rubber seed meal over 10% depressed performance of growing swine. This effect may be attributed to amino acid imbalance rather than any other nutrient deficiency, since the composition (Table 1) and metabolizable energy values[9] of rubber seed meal are somewhat similar to those of coconut poonac. When the essential amino acid requirements of growing swine[5] was compared with the amino acid profile of rubber seed meal,[4] it was revealed that rubber seed meal is deficient in lysine and sulphur amino acids for growing swine. Various workers have suggested similar amino acid imbalances in rubber seed meal based poultry rations.[2,7] Thus by supplementing these essential amino acids, it may be possible to improve the nutritive value of rubber seed meal for growing swine. Further research in these lines is suggested.

The presence of cyanogenic glucoside in rubber seed meal was reported first by Bredemenn.[1] This deleterious factor is mainly found in the kernel of the seed and would be destroyed at temperatures above 25°C.[9] The decorticated rubber seed meal used in this trial contained less than 0.002% (20 PPM) HCN hence, this could not have been the reason for the poor performence of swine fed 20% and 30% rubber seed meal. Rajaguru *et al*[8] reported that growing swine could tolerate cyanide levels higher than this.

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Manioc Leaf Meal (*Manihot esculanta* Crantz) as a Source of Protein for Fattening Swine

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Abstract : Studies were conducted to evaluate manioc leaf meal MLM as a source of protein in rations for growing and finishing swine. The results suggest that MLM could be included upto 30% level in fattening swine rations, without any adverse effects on the performance of animals. Significant improvements in growth rate and feed conversion efficiency were observed in growing swine fed on 20% and 30% levels of MLM when compared to the coconut meal based control ration. This effect was attributed to the high lysine content of manioc leaf meal.

1. Introduction

The rapid increases in cost and shortages of coconut meal, which is the major protein supplement for swine in Sri Lanka, has hampered the expansion of the swine industry during the recent past. Thus, it has become necessary to find alternate cheap sources of protein to replace coconut meal in rations.

Manioc Leaf Meal (MLM) is potentially a good source of protein (Table 1) and it may be possible to use it as a substitute for coconut meal. The essential amino acid profile of manioc leaves has been reported to be comparable to that of soyabean meal.[8] Further, manioc leaves apparently contain adequate amounts of vitamins and minerals for inclusion in livestock rations.[3,8] Despite of a certain amount of risk of toxicity due to its cyanogenetic glucoside content, MLM has been subjected to much research work and there is sufficient evidence on the usefulness of manioc leaf in poultry ration.[2,6,9,10] However, very little work has been done on the use of MLM in swine rations.

Hence the trials reported here were designed to evaluate MLM as a protein supplement for swine and to determine the possible levels of replacing coconut meal with MLM in rations for both growing and finishing swine. The trials were conducted at the swine production unit of the Department of Animal Husbandry of the University of Peradeniya, Sri Lanka.

2. Experimental

MLM was prepared from fresh manioc leaves and petioles, obtained from mature plants at the time of harvest by wilting in the shade for three days and drying overnight in an Unitherm Oven at 100°C. The dried material was then ground into a semi-powdery form. Siriwardene and Ranaweera[10] resorted to bruising of leaves,

while wilting them in shade, to lower the cyanide levels. They recorded a cyanide level of 0.0049% (4.9mg/100g) in their test material. However the procedure used in our trials was sufficient to lower the cyanide levels to 0.00329% (3.29 mg/100g). The proximate analysis of the MLM used is given in Table 1.

TABLE 1. Chemical composition in manioc leaf meal (%)

Dry matter	90.85
Crude protein	22.60
Ether extract	6.20
Crude fibre	19.71
Ash	6.32
Nitrogen free extract	36.02
Hydrocyanic acid (HCN)	0.00329

Two trials were conducted using twenty Large White male piglings in each trial, utilizing the same facilities and experimental procedure. The housing and feeding methods were similar to those described by Rajaguru *et al.*[7] Intake capacity of feed in each group was estimated at the beginning of each week, on the basis of the feed consumption per half an hour.

The feed provided per meal, in all groups, was then restricted to the lowest estimate recorded, so that the feed intake between treatments was maintained at the same level. The feed intake determined this way was used as the basis of feeding during the week.

2.1. Trial I.

20 Large White males selected from three littermate groups, were assigned at random into four treatments on the basis of weight. They were around 75 days of age and weighed an average of 13.14 kg at the commencement of the trial.

A coconut meal based ration, formulated to contain the recommended nutrient requirements of growing swine,[5] was used as the control. The three experimental rations were formulated by substituting the coconut meal with 10%, 20% and 30% MLM (Table 2).

The weekly weight gains were recorded until the termination of the trial, which lasted five weeks.

TABLE 2. Percentage composition of rations used for growing swine—Trial I.

	Control Ration	Experimental Rations		
		10% Manioc leaf meal	20% Manioc leaf meal	30% Manioc leaf meal
Coconut meal	40	30	20	10
Manioc Leaf meal	—	10	20	30
Rice polish	25	25	25	25
Maize	16	16	17	16
Manioc chips	10	11	10	11
Milk powder	2	2	2	2
Fish meal	6	5	5	5
Bone meal	1	1	1	1
Zoodry*	0.25	0.25	0.25	0.25
Methionine	0.06	0.06	0.06	0.06
Chemical analysis (%)				
Crude protein	16.0	15.90	15.91	15.69
Crude fibre	9.89	12.01	12.46	13.36
Ether extract	5.20	5.08	4.20	5.30
Ash	7.06	7.12	7.03	11.20
Nitrogen free extract	51.45	50.29	50.97	44.95

*Vitamin and mineral supplement.

2.2. Trial II

20 Large White males, initially averaging 130 days of age and weighing 23.82 kg, were randomly allocated to four treatments with five animals in each group. A coconut poonac based ration, which was formulated to provide the nutrient requirements of finishing swine as recommended in the N.R.C. standards,[5] served as the control. In the three experimental rations, coconut meal was replaced by 10, 20 and 30% levels of MLM. The energy was kept at a higher level in this trial by using a maize as the main energy source. Composition of these rations is presented in Table 3. Weekly weight gains were recorded throughout the trial period, which lasted seven weeks.

TABLE 3. Percentage composition of rations for finishing swine—Trial II

	Control Ration	Experimental Rations		
		10% Manioc leaf meal	20% Manioc leaf meal	30% Manioc leaf meal
Coconut poonac	40	30	20	10
Manioc leaf meal	—	10	20	30
Maize	41	42	41	42
Manioc chips	10	10	10	11
Fish meal	6	5	5	5
Milk powder	2	2	2	2
Bone meal	1	1	1	1
Zoodry*	0.25	0.25	0.25	0.25
Methionine	0.06	0.06	0.06	0.06
Chemical analysis (%)				
Crude protein	14.36	14.28	14.88	15.39
Ether extract	6.75	6.00	6.20	5.30
Crude fibre	9.89	12.01	12.46	13.36
Ash	10.00	10.20	10.20	10.60
Nitrogen free extract	49.00	48.33	47.18	45.85

*Vitamin and mineral supplement.

3. Results

3.1. Trial I

The effects of different levels of MLM or the performance of growing swine are given in Table 4.

TABLE 4. Mean effects of manioc leaf meal on weight gain, feed consumption and feed conversion efficiency of growing swine.

	Initial weight (kg)	Final weight (kg)	Weight gain (kg)	Feed Consumption (kg)	Feed Conversion efficiency
Control	12.72	21.22	8.50[a]	52.80	6.09[a]
10% MLM	13.32	24.25	10.93[ab]	53.20	4.87[b]
20% MLM	13.18	25.32	12.14[b]	53.20	4.37[b]
30% MLM	13.32	25.82	12.50[b]	53.20	4.25[b]

Statistical significance at 5% level is denoted by different letters.

No significant differences were observed in the average weight gains, between the animals fed on coconut meal based control ration and those fed on ration containing 10% MLM. Inclusion of both 20% and 30% MLM into the growing swine rations resulted in significantly higher weight gains over the control ration. Feed conversion efficiency of animals fed on rations containing all three levels of MLM was significantly superior to those fed on control ration.

3.2. Trial II

The performance of finishing swine fed on different levels of MLM is presented in Table 5.

TABLE 5. Mean effects of manioc leaf meal on weight gains and feed conversion efficiency of finishing swine.

	Initial weight (kg)	Final weight (kg)	Weight gain (kg)	Feed Consumption (kg)	Feed Conversion Efficiency
Control	24.09	45.45	21.26	84.85	3.94
10% MLM	23.48	43.33	19.85	84.85	4.27
20% MLM	23.18	43.64	20.45	84.85	4.14
30% MLM	23.72	45.68	21.96	84.85	3.86

Data statistically not significant.

There were no significant differences between the average weight gains or the feed conversion efficiency of finisher swine fed on control ration and those fed on rations containing 10%, 20% and 30% levels of MLM.

4. Discussion

The results of these two trials suggest the usefulness of MLM as a substitute for coconut meal in rations for both growing and finishing swine. MLM could be safely incorporated into swine rations upto 30% level without any adverse effect on the performance of animals. This is to be expected, since the nutrient composition (Table 1) and the metabolizable energy value[10] of MLM are comparable to those of coconut meal. However, these results are in complete disagreement with the only work recorded on the utilization of MLM in swine rations by Kok Choo and Hutagalung.[4] They reported that inclusion 10% and 20% MLM reduced palatability and depressed weight gains and feed conversion efficiency in growing and finishing swine. The explanation for the above disagreement probably lies in the differences in HCN in the MLM used. Apparently the MLM used in their trials was not processed to eliminate the HCN. It is well known that HCN depresses performance of swine, by interfering with the efficiency of energy utilization.[7]

The reason for the improvements observed in the performance of growing swine fed on rations containing 20% and 30% levels of MLM could be attributed to the high lysine content of MLM. Rajaguru[6] reported similar results in the performance of broilers fed on rations containing 20% MLM. It was reported that MLM contains almost twice as much lysine as coconut poonac.[10] However, inclusion of MLM in finisher rations did not result in any significant responses as observed with growing swine (Tables 4 and 5). This difference may be due to the high lysine requirements of growing swine, when compared with finisher swine.[1,5] The high vitamin and mineral content of MLM[3,8] also may have influenced the superior performance in the growing swine.

Based on the results of this study, it may be concluded that MLM could be used to replace coconut meal upto 30% level in swine fattener rations. It is also apparent that MLM does not carry any factors that affect the palatability of the ration. Further, because of its high lysine content, inclusion of MLM will be of advantage in balancing rations deficient in lysine. It may be advisable however to supplement the MLM rations with methionine, since the HCN present in the MLM increases the requirement for methionine to provide sulphur for the detoxification of cyanide.[9]

Inclusion of MLM will also be an economic proposition as it could be prepared cheaper as a by-product of manioc grown for tubers. From the foregoing explanations, it could be recommended that detoxified MLM will be a substitute superior in quality to coconut meal to be used in the swine feed industry. More work is essential to study the effects of MLM in the carcass quality of swine.

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SHORT COMMUNICATION

Preservation of Murrah Buffalo Semen at 4°C

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The present consumption levels of milk in Sri Lanka is estimated at 1.4 ounces per caput per day which is 70% of the consumption levels estimated in 1963.[4] This would mean that our present milk production levels need to be increased by nearly 800%, if we are to achieve nutritional standards of 5.49 ounces per caput per day, recommended by the Medical Research Institute of Sri Lanka. This large gap between production levels and consumption needs, calls for an immediate strategy for the genetic improvement of our indigenous cattle resources from a national viewpoint. Owing to this present need, the hitherto neglected Sri Lankan indigenous buffalo is now being recognized as a potential milk producer on account of its ruggedness to thrive under adverse environmental conditions and poor nutrition. In 1967, largescale importation of Murrah and Surti Buffalo breeds for cross breeding purposes with local buffaloes to increase milk, meat and draught power were made from India. One of the quickest ways of achieving this objective is by artificial insemination. Artificial insemination service for buffaloes was available in Sri Lanka during 1950/55 period, but did not gain popularity because breeding of buffaloes for milk production was not appreciated then. At present, artificial insemination with buffaloes is not practised in Sri Lanka. Further, no work has been done on the preservation of buffalo semen in Sri Lanka. Hence the present study was undertaken to compare the effectiveness of three diluents in preserving Murrah Buffalo semen at 4°C.

Six ejaculates, one per week, obtained from a six year old Murrah Buffalo bull, were used for preservation. The ejaculates were obtained by the artificial vagina method. The diluents used were, modified tri-hydroxymethyl-methylamine (TRIS), TRIS with egg yolk and Illini-variable-temperature (IVT) medium. The components of each of the above diluents is shown in Table 1. Immediately after collection, the semen samples were assessed for volume, density, motility and dead sperm percentage. The percentage motile spermatozoa was assessed as follows: the semen sample was diluted with 2.9% sodium citrate solution and a drop of diluted semen was placed on a clean, warm slide. Individual progressive motility of spermatozoa was observed under the microscope and an estimate was made of the percentage of motile spermatozoa. The semen samples after assessment were diluted with experimental

diluents to give a dilution rate of 1 : 10 in 15 × 125 mm glass tubes. The tubes were then capped and stored in a refrigerator. The temperature inside the refrigerator during the experimental period varied between 4°C and 6°C. The stored semen was examined daily on a warm stage (38°C) microscope for the assessment of the percentage of motile spermatozoa. Dead spermatozoa percentage was counted after staining the semen for 2 minutes with Eosin Nigrosin stain.

TABLE 1. The components of three diluents

TRIS diluent		
TRIS (tri-hydroxymethyl-methylamine)	2.6497	g
Citric acid monohydrate	1.4652	,,
Cysteine	0.10	,,
Potassium chloride	0.04	,,
Glucose	0.625	,,
Distilled water	100	ml
TRIS with egg yolk diluent		
TRIS	2.5192	g
Citric acid monohydrate	1.3928	,,
Glucose	0.40	,,
Egg yolk	20	ml
Distilled water	80	,,
Modified IVT (Illini-variable-temperature) diluent		
Sodium citrate	20	g
Sodium bicarbonate	2.1	g
Potassium chloride	0.4	,,
Sulfanilamide	3.0	,,
Distilled water	100	ml

1000 iu/ml of Penicillin G and 1000 μg/ml of streptomycin were added to all the diluents.

Semen volume ranged from 4 to 7.5 ml per ejaculate and the average sperm density was 0.66 × 10^9 per ml of semen. The percent motile spermatozoa during storage in the three diluents is shown in Table 2. There was a gradual decrease in the percentage of motile sperm during storage in both TRIS and TRIS with egg yolk diluent and 50% motility was reached at 168 hours. Analysis of variance indicate that there is no significant (p 70.01) difference in the percent motile spermatozoa during storage of semen in TRIS and TRIS with egg yolk diluent. The results observed with TRIS diluent in the present study is in agreement with the observation made by Chaube and Sengupta.[1] However, Sengupta and Chaube,[5] reported that TRIS with egg yolk diluent could maintain 50% motility of buffalo semen for 216 hours. There was a sharp decline in the percentage motile sperm in IVT diluent and 50% motility was reached within 48 hours. Dagweker and Mittal,[3] reported that buffalo semen can be preserved for 4 days with 50% motility in IVT diluent at room temperature. The

reason for the poor response with IVT diluent observed in this study is not clear but could be attributed to the difference in storage temperature, as the semen samples after dilution was stored at 4°C in the present study. The percent dead spermatozoa during storage of buffalo semen in three diluents at 4°C to 6°C is shown in Table 3. Results indicate that percent dead spermatozoa gradully increased during storage in TRIS and TRIS with egg yolk diluent and reached 32% and 12% respectively, at 168 hours. This observation is in agreement with Chaube and Sengupta,[2] who reported that egg yolk percentage in the diluents helps to reduce dead spermatozoa.

TABLE 2. Percent motile spermatozoa during storage of buffalo bull semen in different diluents at 4°C. (mean ± S.D)

Time (hours)	TRIS	TRIS with egg york	IVT
0	80.3 ± 3.0	80.8 ± 3.0	80.0 ± 2.9
24	78.8 ± 1.8	78.0 ± 2.4	71.0 ± 11.1
48	77.0 ± 2.4	75.0 ± 2.9	50.0 ± 2.5
72	73.0 ± 4.0	74.2 ± 1.2	
96	71.3 ± 1.6	72.0 ± 2.4	
120	62.5 ± 2.5	66.0 ± 4.9	
144	65.0 ± 2.9	52.5 ± 5.8	
168	50.0 ± 2.9	50.0 ± 4.3	

TABLE 3. Percent dead spermatozoa during storage of buffalo bull semen in different diluents at 4°C. (mean ± S.D.)

Time (hours)	TRIS	TRIS with egg yolk	IVT
0	10.6 ± 2.9	7.2 ± 1.2	10.4 ± 4.8
24	12.8 ± 0.6	9.2 ± 1.2	15.2 ± 6.5
48	18.0 ± 7.4	10.0 ± 2.7	26.3 ± 8.2
72	18.6 ± 8.8	11.8 ± 9.6	
96	22.3 ± 7.8	11.0 ± 2.7	
120	24.7 ± 5.7	11.8 ± 3.9	
144	28.5 ± 2.5	12.5 ± 2.5	
166	32.0 ± 2.9	12.9 ± 3.1	

In conclusion, the results of the present trial indicate that both TRIS and TRIS with egg yolk diluent could maintain motility of 50% or above of Murrah Buffalo semen upto 7 days. However, IVT diluent maintained similar motilities upto 48 hours, only. The fertility rate following insemination with preserved semen was not tested in this study. However, studies in cattle indicate that there is a good correlation between percent motile spermatozoa and fertility rate. Further research is in progress to evaluate suitable diluents to preserve Murrah, Surti and Local Buffalo semen at room temperature, 4°C and – 196°C.

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SHORT COMMUNICATION

A study of various alkali treatments to improve the nutritive value of rice straw

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Rice straw, the largest annually harvested agricultural by-product in Sri Lanka, is little used as an animal feed because of its low nutritive value. Spray treatment with sodium hydroxide solution improves its feeding value[4,5] but the high cost of treatment prohibits its use as an economical feed at present. The amount of sodium hydroxide required for treatment is one of the major cost components of this system.

A number of chemicals other than sodium hydroxide have been tested for their ability to increase digestibility of roughages[1,2,11,12,13] but none have been proved to be as effective as sodium hydroxide.[3]

The present paper reports an experiment designed to study the effectiveness of a number of alkalis including ammonium hydroxide on *in vitro* digestibility of rice straw, with a view to finding a low cost treatment system.

Rice straw variety H4, milled (Christy Norris Laboratory mill) to pass through a 1.0 mm screen was treated with sodium hydroxide, sodium carbonate, equal parts of sodium hydroxide and sodium carbonate, calcium hydroxide or ammonium hydroxide. Milled straw (100 g) was mixed with the alkali solution (0, 2.0, 4.0, 6.0, 8.0, 10.0, 12.0, or 14.0 g alkali in 120 or 200 ml water) in a domestic food mixer; the alkali being added as a fine jet from a 20 ml syringe over a five minute period and mixing continued for a further five minutes.

Four to six hours after treatment, the treated material was dried in an oven at 98°C for six hours and from these quadruplicate samples containing 0.5 g straw dry matter were weighed into 100 ml polypropylene centrifuge tubes for subsequent *in vitro* digestion by the method of Tilley and Terry.[10] Rumen liquor for *in vitro* digestion was obtained from four fistulated wether sheep of 25 kg average live weight receiving a standard diet of 400 g hay and 100 g concentrate mixture. Fistulated sheep also had access to *ad libitum* mineral mixture and drinking water.

In view of the low crude protein content of rice straw (4% to 5% in dry matter) 1.0 ml of 1.0N ammonium sulphate was added to each centrifuge tube at the time of innoculation with rumen liquor.

The effect of alkalis at different dilutions on the *in vitro* organic matter digestibility (IVOMD) of rice straw is shown in Figure 1. Sodium hydroxide was clearly the most effective alkali for rice straw. This confirms the work reported elsewhere for many low quality roughages.[3,7]

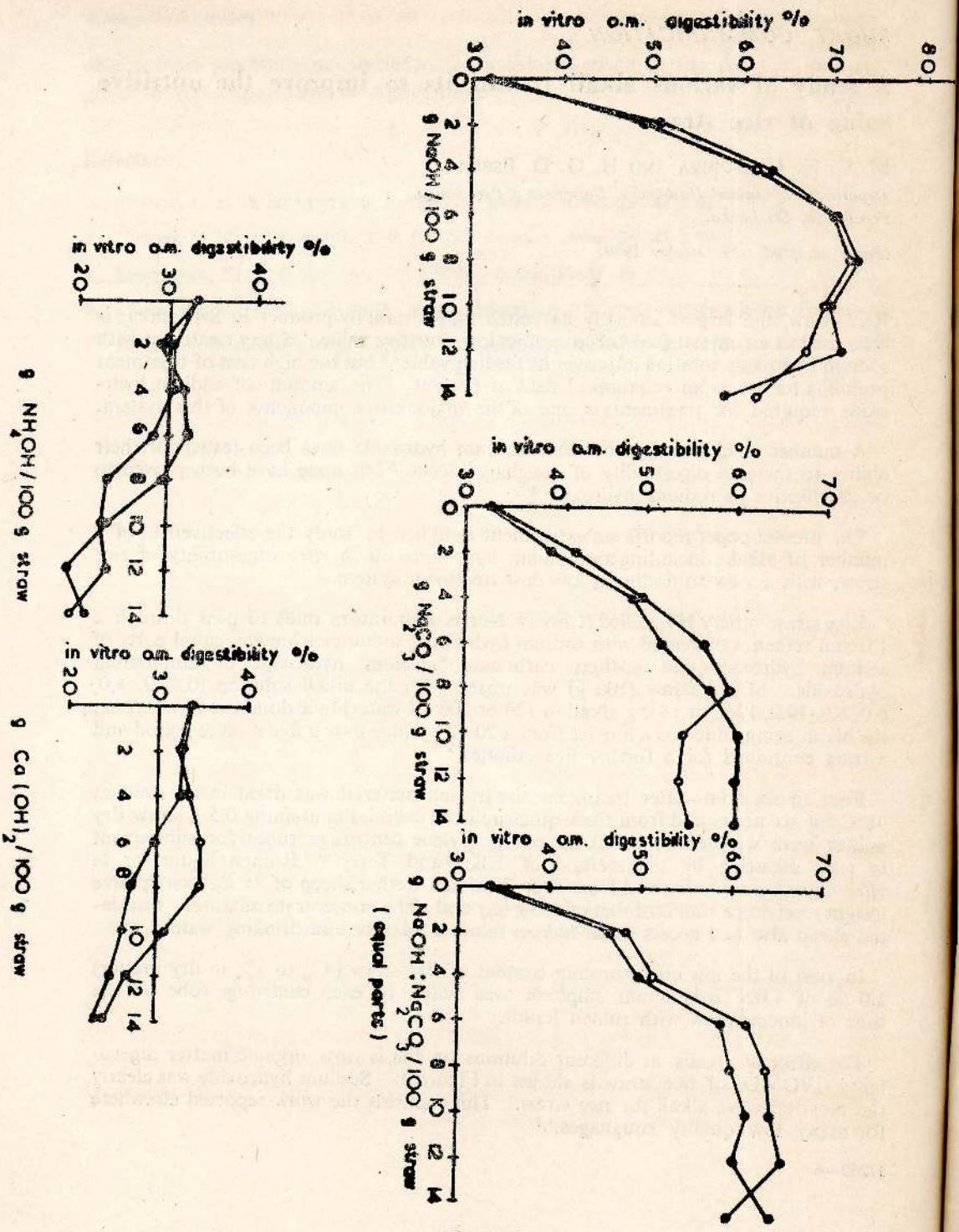

Figure 1.

Sodium carbonate alone was less effective than pure sodium hydroxide. But unlike the findings of Chandra and Jackson[1] for ground maize cobs, the mixture of equal parts of sodium hydroxide and sodium carbonate did not improve the organic matter digestibility of rice straw any further than pure sodium carbonate. This could have been due to the nature of the substrate as different substrates may require specific treatments.[9]

Similar to the work reported elsewhere[2,11] calcium hydroxide appeared to have no effect on the organic matter digestibility of rice straw. This was probably because of its low solubility since Gharib *et al*,[2] found that when calcium hydroxide treated material was allowed to stand for 150 days, its digestibility increased as much as the material treated with sodium hydroxide. This could be of significance when developing techniques for ensiling alkali treated straws.

In recent years, ammonium hydroxide has attracted much attention for the treatment of roughages because of the added advantage of increased nitrogen content of the treated material. However as recorded by Waiss *et al*[13] ammonium hydroxide was much less effective than sodium hydroxide in increasing the digestibility of straw. The poor response to ammonium hydroxide could have been due to the 'open treatment' practiced as a closed reaction vessel may probably be essential to obtain maximum effectiveness.[3]

With all alkalis, the dilution rate examined showed no significant influence of digestibility. As reported earlier[4,6] there appears to be no benefit in increasing the volume of solution beyond 120 ml per 100 g straw.

Sodium hydroxide was the most effective alkali for improving the nutritive value of rice straw. The diminishing digestibility response with increasing level of sodium hydroxide from 4 to 8 g/100 g straw is in general agreement with work that has been reported earlier.[6,8] As suggested by Jayasuriya,[4] 4 to 6 g sodium hydroxide per 100 g straw appears to be the most effective dosage for treating rice straw. However in view of the high cost of sodium hydroxide, more effective methods of treatment will have to be developed if alkali treated straw is to be of benefit to the ordinary farmer. This aspect should receive high priority in future research.

Acknowledgements

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SHORT COMMUNICATION

Chemical Characterization of Winged Bean, *Psophocarpus tetragonolobus* (L.) DC and related *P. Palustris* Desv.

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Systematic and evolutionary studies on a wide variety of plants have been made on the basis of chemical constituents.[2,7] In one line of investigations, paper chromatographic maps of leaf phenolic compounds have been used for biochemical documentation of plant species and for the identification of hybrids.[1,3,4,7,8,9]

The winged bean *Psophocarpus tetragonolobus* has evinced much interest during the last few years as a potentially important legume for the developing tropics because of its high protein content and amino acid composition which are comparable to the better known soybean *Glycine max* (L). Merr.[6] The natural range of distribution of winged bean is the tropical belt of south and south-east Asia. Papua-New Guinea is suspected to be its native habitat. Of the few species in the genus *Psophocarpus*, only winged bean and *P. palustris* are cultivated. The latter however compared to winged bean is a less vigorous creeper, bears smaller fruits and seeds and is native to West Africa.[10] Due to the wide separation of native habitats of the two species, an investigation was begun to study their relationship through interspecific hybridization and distribution of phenolic constituents on paper chromatograms. This report identifies differences that were observed in the chromatograms of the two species.

Leaves of the two species harvested from plants grown in the field were used for the study. 2*g* of fresh leaves were heated in methanol for 10 mts, then homogenized in a Waring blendor and extracted in a Soxhlet for 8—10 hrs. in methanol.

The extractant was concentrated in a vacuum at room temperature and the final volume was prepared in the proportion of 1 ml for every 0.07*g* fresh weight of leaves. The extracts were spotted on Whatman No. 1 paper at 400λ and 450λ after preliminary tests ranging from 50λ to 450λ revealed these to be the best concentrations. Descending chromatography was used by running the papers in the first direction in butanol-acetic acid-water (4 : 1 : 2.2 v/v/v) and in the second direction in 2% acetic acid.

The dried papers were examined in visible light and under ultra violet light (254mμ and 360 mμ) before and after spraying with 10% sodium carbonate. They were next examined after spraying with sulphanilic acid (9 *g* sulphanilic acid + 90 *ml* cone. HCl in 1l of water) and 4% sodium nitrate in the ratio of 1 : 5).

The combined chromatogram of the two species is shown in Figure 1 and the detection methods and the appearance of the compounds are given in Table 1. In this study the spots were not identified. The chromatogram shows that there are spots common to both species (1, 2, 5, 9, and 10) even though the two species are widely separated geographically suggesting a common origin in their evolution. Spots specific to the two species were also found. For example while spots 11, 12 and 18 were found only in *P. tetragonolobus*, spots 3, 6, 8 13, 14, 16, 17, 19, 20, 21, 22 and 24 were specific to *P. palustris*. The larger number of species specific spots in *P. palustris* and the prominent colours of some of them (3, 6, 8, 13, 14, 17) after spraying with Na_2CO_3 (Table 1) would be helpful in identifying this species and hybrids derived from it. 75% of the spots were not common to the two species. Such a wide difference is suggestive of a long period of isolation of the two species which could contribute to reproductive barriers. Preliminary studies on interspecific hybridization between the two species (Senanayake, unpublished) suggests that such barriers exist.

TABLE 1. Colour reaction of spots on dry paper chromatograms of *P. tetragonolobus* and *P. palustris*

Detection procedure	Appearance	Spot Number
Visible light	None	None
UV light-(254 mμ)	White	1
	Light purple	9, 10, 11, 14
	Purple	2
	Light blue	22
	Light green	17
	Bluish green	5
UV light (360 mμ)	White	1
	Pink	2
	Light blue	17, 22
	Blue	14
	Light green	20
	Light purple	8
	Dark purple	9, 10, 13
After Na_2CO_3 Spray		
Visible light	Yellow	9, 10, 13
UV light- (254 mμ)	Light blue	12
	Blue	14, 19, 20, 21
	Purple	16, 26
	Light brown	2
	Brownish yellow	4
	Light yellow	5, 8, 11
	Greenish yellow	1, 6, 13
	Dark yellow	9, 10
UV light- (360 mμ)	Brownish yellow	1
	Pink	2
	Blue	12, 14, 17, 18, 19
	Purple	24
	Light yellow	3, 5, 8
	Dark yellow	9, 10, 13
	Light green	6
After sulphanilic acid Spray		
Visible light	Light brown	2, 13.

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සුදු වාමන තාරකා පිළිබඳව කරන ලද මෙම පරීක්ෂණයෙන්, එම තාරකාවන්ගේ ප්‍රබල අභ්‍යන්තර චුම්බක ක්ෂේත්‍ර නිරීක්ෂණය කරනු ලැබීමට බාධාවක් වශයෙන් සංසරණ ප්‍රසාධ පැවතිය නොහැකි බව පැහැදිලි කොට ඇත්තේය.

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වැඩුණු තරුණ ලාංකික පිරිමින් (වෛද්‍ය ශිෂ්‍යයන්) 26 දෙනෙකුගේ ශරීරයෙහි ස්ථාන (ලක්ෂ්‍ය) 20 ක් යෙන්ට්‍රේඩ් අංශක 24.4 (පැරන්හයිට් අංශක 76) ක වායුගෝලීය පරිසරයකදී විකිරණ තාපමානයෙන් මැන බලා චර්ම උෂ්ණත්වය ගැන සොයා බලන ලදී. ශරීරයේ විවිධ ස්ථානවල මතුපිට උෂ්ණත්වය ඉතා අධික කලාප වශයෙන් නලළ හා අධරාමාශයද පැවතිණි. කඳ උණුසුම්ව පැවතිණි. අත් හා පාද ශීතල ඉතා අධික කලාප විය. ශරීර උෂ්ණත්වය පිළිබඳ මෙම කලාපීය විවලන රටාව ලෝකයේ වෙනත් තැන්වල විස්තර කොට ඇති උෂ්ණත්ව විවලන රටාවට බෙහෙවින් සමානය.

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එච්. ඊ. එම්. ගුණසේන, ආර්. සංගක්කාර සහ ප්‍රීති වික්‍රමසිංහ

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දේශීය වශයෙන් වැදගත් ධාන්‍ය — රනිල අතුරු බෝග පද්ධති කීපයක ශස්‍ය විද්‍යාත්මක හා ආර්ථික ඵලවයන් පැහැයීම සඳහා කුණ්ඩසාලේ සහ පේරාදෙනියෙහි හැදෑරීම් රැසක් කරගෙන යන ලදී. ඇතැම්විට සංරචක බෝගවල අස්වැන්න හීනවීමේ ගතියක් ඇති වුණ නමුදු බඩ ඉරිහු-සෝයා බෝංචි අතුරු බෝගයෙන් ලද මුලු අස්වැන්න ප්‍රමාණය වැඩිවිය. බඩ ඉරිහු - කව්පි යහ බඩ ඉරිහු-මුං වගා සම්බන්ධ කිරීමෙන් අහුකුල ප්‍රතිඵල ලබාගත හැකිවිය. බීම් තුල්‍යතා අනුපාතය (බී.තු.අ.) සහ දළ ආර්ථික ආදයමද අතුරු බෝග පද්ධතියෙන් වැඩි විය. අතුරු බෝග පද්ධතින්ගේ ශුද්ධ ප්‍රෝටීන උපයෝජන අගය ඉහල මට්ටමක පවතින බැවින් සංවර්ධනය වන රටවල ස්වකීය පරිභෝජනයට පමණක් ගොවිතැන් කරන ගොවිජනතාව සඳහා එකී අතුරු බෝග පද්ධති ප්‍රයෝජනයට ගැනීමේ යෝග්‍යතාවය තවදුරටත් කහඹුරු විය.

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ප්‍රොස්ටග්ලැන්ඩින් $F_{2\alpha}$ යෙදීමෙන් ඌරු දෙනුන්ගේ ප්‍රසූති ප්‍රේරණය

ආර්. රාජමහේන්ද්‍රන්, ඩබ්ලිව්. ඒ. වී. වික්‍රමසිංහ සහ ජේ. ධර්මවර්ධන

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ප්‍රසූති ප්‍රේරණය සඳහා ප්‍රොස්ටාග්ලැන්ඩින් $F_{2\alpha}$ භාවිතා කිරීමේ සාර්ථකත්වය ගැනද පැටවි ගැහීමෙන් පසුව ඌරු දෙන කෙරෙහි හා පැටවි රැල කෙරෙහි එම බෙහෙත බලපාන ආකාරය ගැනද හැදෑරීම් පිනිස දෙමුහුන් ඌරු දෙනුන් හතළිස් දෙදෙනෙක් යොදා ගනු ලැබුහ. ගැබ් දැරීමෙන් 109 දින හා 111 දින දෙක අතර කාලය තුලදී ප්‍රොස්ටාග්ලැන්ඩින් $F_{2\alpha}$ මිලිග්‍රෑම් විස්සක් අන්තඃපේශීය එන්නතක් වශයෙන් එක් වරක් විදින ලදී. මේ ප්‍රතිකාරයට දක්වන ලද ප්‍රතිචාරය 89% ක් වූ අතර පැටවි ගැහීමේ මධ්‍යන්‍ය පරතරය පැය 33.3 ± 5.5 ක් විය. ප්‍රතිකාරයට බඳුන් කළ ඌරු දෙනුන්ගේ ගැල් කාලය සෝදිසි දෙනුන්ගේ (110 ± 0.8 VS 114.3 ± 1.6 දින) කාලයට වඩා බෙහෙවින් කෙටි ($P < 0.001$) විය. ප්‍රතිකාරයට බඳුන් කළ කාණ්ඩයට අයත් ඌරු පැටවුන්ගේ ජන්ම මධ්‍යහනය බර සෝදිසි කාණ්ඩයට අයත් (2.62 ± 0.33 VS 2.84 ± 0.81 රාත්තල්) ප්‍රමාණයට වඩා බෙහෙවින් පහළ මට්ටමක ($P < 0.05$) පැවතුණි. පැටවුන්ගේ ජන්ම මධ්‍යන්‍ය තරම, කිරිවැරුම් බර, පැටවි රැලකින් කිරි වරන ඌරන්ගේ ගණනද ප්‍රොස්ටාග්ලැන්ඩින් ප්‍රතිකාරය නිසා වෙනස් නොවිය. ගැබ්දැරීමෙන් 109 වන දින බෙහෙත් එන්නත් කිරීම නිසා ප්‍රසූත කළ පැටවුන් රාශියක් මැරී සිටියහ. ප්‍රතිකාරයට බඳුන් කරනු ලැබූ ඌරු දෙනුන්ගේ පශ්චාත් කිරිවැරුම් ප්‍රජනක ක්‍රියාවලියට ද ප්‍රොස්ටාග්ලැන්ඩින් ප්‍රතිකාරය නිසා බලපෑමක් ඇති නොවිය.

වැඩෙන ඌරන්ගේ ආහාර සලාකයේ ප්‍රෝටීන ප්‍රතිපූරකයක් වශයෙන් රබර් ඇට මද යොදා ගැනීම

ඒ. එස්. බී. රාජගුරු සහ වී. රවීන්ද්‍රන්

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වැඩෙන ඌරන්ට දෙනු ලබන ආහාර වේලට විවිධ ප්‍රමාණවලින් කලවම් කරන ලද රබර් ඇට මද මිශ්‍රණයන්ගේ ක්‍රියාකාරිත්වය හා බලපෑම් ගැන සොයා බැලීමට අධ්‍යයනයක් කරන ලදී. ඒ ප්‍රතිඵල වලින් පෙනී ගියේ රබර් ඇට මද මිශ්‍රණය 10% ක අනුපාතයක් දක්වා ඌරු ආහාර සලාකයට කලවම් කළ හැකි බවයි. සියේට 20 ක සහ 30 ක අනුපාත වලින් රබර් ඇට මද මිශ්‍ර කළ ආහාර සලාක දීම නිසා ඌරන්ගේ වැඩීම දුර්වල වූයේ රබර් ඇට වල ඇති සයනෝජනික ග්ලුකෝසයිඩ් නිසා නොව, ලයිසින් හා සල්පර් ඇමිනෝ අම්ලය නිසාය.

මංකෙදක්කා (මැනිහොට් එස්කියුලාන්ටා ක්‍රාන්ට්ස්) කොළ ආහාරය මසට ඇති කරන ඌරන්ගේ ප්‍රෝටීන මූලයක් වශයෙන් යොදා ගැනීම.

ඒ. එස්. බී. රාජගුරු, වී. රවීන්ද්‍රන් සහ ආර්. එම්. රණවීර බණ්ඩා.

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වැඩෙන හා වැඩි හමාරවන ඌරන්ගේ ආහාර සලාකයට ප්‍රෝටීන ලබාදීමේ මූලයක් වශයෙන් මංකෙදක්කා කොළ ආහාර මිශ්‍රණය ඇගැයීම් සඳහා හැදෑරීම් කිපයක් කරන ලදී. සතුන්ගේ වැඩීමේ වේගයට හානිකර බලපෑමක් ඇති නොවන පරිදි, මසට ඇති කරන ඌරන්ගේ ආහාර සලාක වලට සියයට 30 ක අනුපාතයක් දක්වා මංකෙදක්කා කොළ මිශ්‍රණය යොදා ගත හැකි බව ප්‍රතිඵල වලින් පෙනී ගියේය. පොල් පුන්නාක්කු යොදගත් පාලකා ආහාර සලාකය හා සසඳා බැලීමේදී, මංකෙදක්කා කොළ 20% සහ 30% යන අනුපාත වලින් මිශ්‍රකොට වැඩෙන ඌරන්ට කෑමට දීමෙන් වර්ධක අනුපාතයේ සහ පෝෂක පරිවර්තන කාර්යක්ෂමතාවේද සැලකිය යුතු වර්ධනයක් දැකගත හැකි විය. මේ ප්‍රභාධය ඇතිවීමට හේතු වූයේ මංකෙදක්කා කොළ ආහාර මිශ්‍රණයේ පවතින අධික ලයිසින් ප්‍රමාණය නිසාය.

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இந்த இதழின் கட்டுரைகளின் சுருக்கங்கள்

வெண் குறளுடுக்களின் உட்காந்தப் புலங்கள்: சுற்றேட்ட விளைவுகள்

ஜீ. சண்முகம்; எம். மகேஸ்வரன்

J. Natn. Sci. Coun. Sri Lanka 1979 7(2): 75–77

வெண் குறளுடுக்கள் பற்றி மேற்கொள்ளப்பெற்ற இந்த ஆய்வில் அவ்வுடுக்களின் வலுமிக்க உட்காந்தப் புலங்களை உற்றுநோக்குதற்குத் தடையாகச் சுற்றேட்ட விளைவுகள் இருக்க முடியாதென்பது காட்டப் பெற்றுள்ளது.

பேராதனையில் மாணாக்கர் சிலரது தோல் வெப்பநிலை

வீ. பஸ்நாயக்கா; எஸ். ஏ. எஸ். குணவர்த்தனு; வீ. சேனரத்தினு; ரீ. தலகல

J. Natn. Sci Coun. Sri Lanka 1979 7(2): 79–84

வளர்ந்த இளம் பருவத்திலுள்ள இலங்கை வாழ் 26 ஆண்களின் (மருத்துவம் பயிலும் மாணாக்கரின்) உடம்பிலுள்ள 20 இடங்கள் (புள்ளிகள்) 24.4 சென்றிகிறேட்டுப் பாகைகளை (76 பரன்கைட்டுப் பாகைகளை)க் கொண்ட வளிச் சூழலில் கதிர்வீசல் வெப்பமானியின் மூலம் சோதிக்கப் பெற்றுத் தோல் வெப்பநிலை கண்டறியப்பட்டது. உடம்பின் பல்வேறு இடங்களிலுள்ள வெப்பநிலையினை ஆய்ந்தவிடத்து நெற்றியும் கீழுதரமும் மிகுந்த வெப்ப நிலைக்குள்ளான இடங்களாக இருப்பது புலனாகியது. தாம்பு வெதுவெதுப்பாக இருந்தது. கைகால்கள் மிகக் குளிர்ச்சியான பகுதிகளாகக் காணப்பட்டன. உடல் வெப்பநிலை சார்ந்த மேற்சொல்லிய பகுதிகளின் மாறல் வீதமானது உலகில் ஏனைய இடங்களில் கண்டறியப்பட்டுள்ள வெப்ப நிலை மாறல் வீதத்தோடு பெரும்பாலும் ஒத்திருந்தது.

தானிய—அவரையம் இடைப்பயிர் முறைகள்

எச். பீ. எம். குணசேனு; ஆர். சங்கக்காரா; பிரீதி விக்கிரமசிங்கா

J. Natn. Sci. Coun. Sri Lanka 1979 7(2): 85–93

உள்ளூர்ப் பாவனையாளர்கட்கு இன்றியமையாத தானிய—அவரையம் இடைப்பயிர் முறைகள் நிலவற்றின் நிலப்பயிரியல் மற்றும் பொருளியல் ஆற்றல் வளத்தை மதிப்பிடும் முகமாக, குண்டசாலையிலும் பேராதனையிலும் சில ஆய்வுகள் மேற்கொள்ளப்பட்டன. ஒருசேர செய்கை பண்ணப்

படும் பயிர்வகைகளின் விளைச்சல் குறைவுறுமியல்பு உண்டெனினும் சோளம்—சோயாபோஞ்சி இடைப்பயிரின் மொத்த விளைச்சல் வீதம் அதிகரித்தது. சோளம்—கவ்பீ இடைப்பயிர் முறையாலும் சோளம்—பயற்று இடைப்பயிர் முறையாலும் ஒத்தியலான பெறுபேறுகள் கிடைத்தன. நிலச் சமவலுவிகிதமும் (நி.ச.வி.) மொத்தப் பொருளியல் வருவாயும் இடைப்பயிர் முறையால் அதிகரித்தது. இடைப் பயிர் முறைகளின் தேறிய புரதப் பயன்பாட்டுப் பெறுமானம் உயர்ந்த மட்டத்தில் உள்ளபடியால் வளர்முக நாடுகளில் நுகர்வுக்கென உணவுப் பயிர்களைச் செய்கை பண்ணும் கமக்காரர்களுக்கு இவ்விடைப்பயிர் முறைகள் பெரிதும் பயன்படக்கூடிய நிலையில் உள்ளனவென்பது உறுதி.

புரேற்ருகிலான்டீன் $F_{2\alpha}$ உபயோகத்தின் மூலம் பன்றிகளின் குட்டிப் பேற்றினைத் தூண்டுதல்

ஆர். ராசமகேந்திரன், டபிள்யு. ஏ. ரீ. விக்கிரமசிங்கா, ஜே. தர்மவர்த்தனா

J. Natn. Sci. Coun. Sri Lanka 1979 7(2): 95–100

பேற்றினைத் தூண்டும் முகமாகப் புரேற்ருகிலான்டீன் $F_{2\alpha}$ உபயோகத்தின் வெற்றி பற்றியும் குட்டி போட்ட பின்னர் பன்றி மீதும் ஓரீற்றுக் குட்டிகளின் மீதும் அம்மருந்து செயல்படும் முறை பற்றியும் ஆராய்வதற்கு நாற்பத்திரண்டு கலப்பினப் பெண்பன்றிகள் சோதனைக்குள்ளாக்கப்பட்டன. கருவுற்று 109 ஆந் நாளுக்கும் 111 ஆம் நாளுக்கு மிடைப்பட்ட காலப்பகுதியில் புரேற்ருகிலான்டீன் $F_{2\alpha}$ மருந்தின் 20 மிலிகிராம் தசைக்குள் ஒரு முறை செலுத்தப்பட்டது. இச் சிகிச்சைக்குக் காட்டப்பட்ட தூண்டப்பேறு 89% ஆகவிருந்தவிடத்து சராசரிக் குட்டி போடல் இடைவெளியானது 33.3 ± 5.5 மணித்தியாலங்களாகவும் இருந்தது. சிகிச்சைக்கு உட்படுத்தப்பெற்ற பெண்பன்றிகளின் சூற்காலம் கட்டுப்பெண்பன்றிகளின் (110 ± 0.8 vs 114.3 ± 1.6 நாட்களைக் கொண்ட) காலத்தை விட மிகவும் குறுகியதாக ($P < 0.001$) க் காணப்பட்டது. சிகிச்சை பெற்ற பெண்பன்றிகள் ஈன்ற குட்டிகளின் சராசரி பிறப்பு நிறையானது கட்டுப்பெண்பன்றிகள் ஈன்ற குட்டிகளுக்குரிய (2.62 ± 0.33 vs 2.84 ± 0.81 இரு.) நிறையினை விட மிகவும் தாழ்வுற்ற நிலையில் ($P < 0.05$) இருந்தது. குட்டிகளின் சராசரிப் பிறப்புப் பருமன், பால் மறப்பு நிறை, ஓரீற்றுக் குட்டிகளுள் பால் மறக்கும் பன்றிகளின் வீதம் ஆகியன புரேற்ருகிலான்டீன் சிகிச்சையால் வித்தியாசமடையவில்லை. கருவுற்று 109 ஆம் நாளன்று மருந்து செலுத்துதல் காரணமாகப் பிறந்த குட்டிகளுட் பல சாப்பிறவுடையனவாக இருந்தன. சிகிச்சையளிக்கப்பட்ட பெண்பன்றிகளின் பால்மறத்தலுக்குப் பின்னை இனப்பெருக்க ஆற்றலானது புரேற்ருகிலன்டீன் சிகிச்சையால் பாதிக்கப்படவில்லை.

வளரும் பன்றிகளின் பங்கீட்டுத்தீனில் புரதநிறைவாக்கியாக றப்பர் விதைப் பருப் பினைச் சேர்த்துக் கொள்ளல்

ஏ. எஸ். பீ. ராஜகுரு; வீ. ரவீந்திரன்;

J. Natn. Sci. Coun. Sri Lanka 1979 7(2): 101–104

வளரும் பன்றிகளுக்கு வழங்கப்படும் பங்கீட்டு உணவில் பல்வேறு அளவுக ளில் கலக்கப்பெற்ற றப்பர் விதைப் பருப்பின் செயற்றிறன் பற்றியும் தாக்கம் பற்றியும் அறிதற்கு ஆய்வொன்று மேற்கொள்ளப்பட்டது. றப்பர் விதைப்பருப்பு 10% அளவு வரை பன்றி உணவில் கலக்கப்படலாமென்பது அந்த ஆய்வுகளின் பெறுபேறுகளால் அறியப்பட்டது. நூற்றுக்கு 20 என்ற வீதத்திலும் நூற்றுக்கு 30 என்ற வீதத்திலும் றப்பர் விதைப் பருப்பினைச் சேர்த்த உணவுப்பங்குகளை உட்கொண்ட பன்றிகளின் வளர்ச்சி குறைதலுற்றது. இதற்குக் காரணம் றப்பர் விதைப் பருப்பிலுள்ள சயனசன் குளுகோசைட்டு அல்ல. அவ்விதைகளில் இலைசீனும் சல்பர் அமினோவமிலமும் இல்லாமையாகும்.

மரவள்ளி (மனிகொட் எஸ்குயுலான் ரு கிருன்ட்ஸ்) இலைக் கூழ் இறைச்சிக்காக வளர்க் கப்படும் பன்றிகளுக்கான புரதமூலமாகப் பயன்படுத்துதல்

எஸ். ஏ. பீ. ராஜகுரு; வீ. ரவீந்திரன்; ஆர். எம். ரணவீர பண்டா

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வளரும் தறுவாயில் அல்லது வளர்ச்சி முடிவுறும் பருவத்திலுள்ள பன்றிக ளுக்கான உணவிற்குப் புரத வளத்தை ஊட்டும் ஒரு மூலமாக மரவள்ளி இலைக்கூழின் ஆற்றலை மதிப்பிடற்கு ஆய்வுகள் சில மேற்கொள்ளப்பட்டன. மிருகங்களின் வளர்ச்சி வேகத்திற்கு ஊறு விளைவிக்காதவாறு, இறைச்சிக் காக வளர்க்கப்படும் பன்றிகளுக்கான உணவில் 30% வரை மரவள்ளி இலைக்கூழ் சேர்க்கப்படலாமென்பது இப்பெறுபேறுகளால் கண்டறியப் பட்டது. தெங்குப் பிண்ணாக்கைக் கொண்டு ஆக்கப் பெற்ற கட்டளை உணவுப் பங்கோடு ஒப்பு நோக்கப்படுமிடத்து 20%, 30% ஆகிய வீதங்களில் மரவள்ளி இலைக்கூழ் சேர்க்கப்பட்ட உணவினைப் பன்றிகளுக்கு வழங்கப்படு தலால் வளர்ச்சி வீதத்திலும் ஊட்டல் பரிமாற்றுத் திறனிலும் குறிப்பிடத் தக்க முன்னேற்றம் ஏற்பட்டது. வரவள்ளி இலைக் கூழில் அதிகமாகவுள்ள இலைசீன் பதார்த்தம் இவ்விளைவுக்குக் காரணமாயது.

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