Annals of the Sri Lanka Department of Agriculture. 2005. 7: 145-156.

EFFECT OF GROWTH MEDIUM ON THE PRODUCTION OF HIGH QUALITY PRE-BASIC SEED POTATO TUBERS UNDER POLYTUNNEL CONDITIONS

R.J.K.N. KULARATHNE[1], A.M.C. MAZEEN[1], M.M. NUGALIYADDE[1], A.V.C. ABEGUNASEKARA[2], H.M.S. HERATH[2] and D.ARIYARATHNE[3]

[1]*Agricultural Research Station Sita Eliya, Nuwara Eliya.*
[2]*Faculty of Agriculture, Mapalana, Kamburupitiya*
[3]*Faculty of Agriculture, University of Peradeniya*

ABSTRACT

Potato is the most economically important crop among farmers in the up country regions of Sri Lanka. The high cost of imported seeds and transmission of pests and diseases through the seeds are the main constraints in potato production. The Department of Agriculture initiated a basic seed potato production project in 1998 using tissue culture and rapid multiplication techniques. A mixture of jungle soil and decomposed cattle manure was used to produce pre-basic tubers under polytunnel conditions. It was observed, after a few cropping cycles that a high percentage of pre basic seeds produced in polytunnels were rejected or down-graded due to various diseases, especially common and netted scab. Low multiplication rates were recorded in this medium. An investigation carried out revealed that soil was the source of contamination and sterilization methods were not effective in controlling these diseases. Since these problems are related to the soil medium, two experiments were conducted in a protected house at Agricultural Research Station, Sita Eliya to determine a suitable growth medium for pre-basic seed production. Six planting media *viz.* Coir dust, Coir dust + Half burnt paddy husk (1:1), Coir dust + Sand (1:1), Tea refuse + Sand (1:1), Metal chips + Coir dust (1:3), Tea refuse + Half burnt paddy husk (1:1) were tested with two controls, Cattle manure + Jungle soil and Used Seed Bed Soil, in raised beds. The results showed that the tea refuse + half burnt paddy husk (1:1) gave the highest tuber yield of 1186 per m^2 followed by coir dust + half burnt paddy husk (1:1) medium of 1008 per m^2, while the cattle manure + jungle soil and used seed bed soil gave 283 and 160 tubers per m^2. In another experiment carried out using Coir dust + Half burnt paddy husk (1:1), Coir dust + Tea refuse (1:1) and Half burnt paddy husk + Coir dust + Tea refuse (1:1:1) used as treatments with Cattle manure + Jungle soil as control, it was shown that the combination of half burnt paddy husk, tea refuse and coir dust (1:1:1) medium gave the maximum number of tubers (23 tubers/plant/treatment) followed by tea refuse + half burnt paddy husk (1:1), coir dust + half burnt paddy husk (1:1) (16 per plant), while the soil medium gave the minimum number of 7 tubers per plant. The increment in yield was 2 to 3-fold over the control. Therefore, this medium can be introduced for pre-basic seed production in polytunnel conditions.

KEYWORDS: Coir dust, Half burnt paddy husk, Pre-basic seed, Potato, Rooted stem cutting, Tea refuse

INTRODUCTION

Potato, (*Solanum tuberosum* L.) is the most popular crop among the farming community in the up country regions of Sri Lanka due to its high net return. The annual requirement of seed potato has been met mainly by imported seeds. The Department of Agriculture also supplies a considerable amount of certified seed tubers of early generations to the seed potato production programme. In this programme, rooted stem cuttings and mini tubers are used as the initial planting material and planted in polytunnel seed beds, filled with a mixture of jungle soil and decomposed cattle manure.

Potato can be produced under a wide range of soils, and therefore, soil texture affects potato growth due to water availability and soil compaction. Inadequate water availability in the root zone affects plant growth, development and final yield and also favours the development of certain diseases such as common scab, verticillium wilt and tuber disorders (Malik, 1995). Manure can increase the incidence of common scab disease (Vitosh, 1990) through increased bacterial survival rates (Hooker, 1981).

Sri Lanka is rich in agricultural by-products such as coir dust, paddy husk, saw dust etc, which can be used as media for planting many crops, instead of the expensive potting/bedding media like peat and vermiculate perlite, which have better physical properties. Coir dust is one of the most commonly used agricultural by-product as a growing medium, especially in tropical countries for bedding plant production. Coir dust, which has a high water holding capacity, is a by-product of coconut fiber milling industry and is widely used in foliage pot plants (Mazeen *et al.*, 2002). Its physiochemical properties are very favorable for rooting in containers. Coir dust is characterized with high C:N ratio (Mohotti,1999) and is resistant to microbial degradation under natural conditions. Coir dust has some advantages over other organic substances and soil, such as low resistance to root penetration (Uyenco and Ochoa, 1984). Paddy husk, which is also another by product is used to improve properties of growth media. Application of tea refuse to soil elevates pH, organic carbon content, soil K and leaf K (Mohotti, 1999). Tea refuse is also rich in potassium (K).

It was observed that after several cropping cycles, high percentage of seed tubers was rejected or down-graded by the Seed Certification Service due to various diseases, mainly common scab and netted scab. Results of a previous study revealed that soil was the source of contamination (Nugaliyadde *et al.*, 2000). Methods of soil sterilization were costly and may not effectively control these diseases. Low number of seed tubers (4-5) produced per plant, formation of deformed tubers and aerial tubers and damage to tubers during harvesting were other problems encountered in relation to the growth medium (personal communication). Search for an alternative growth medium could be a remedy to overcome these problems in seed potato production under controlled environments. Sri Lanka, being an agricultural country, produces millions of tons of agricultural waste such as coir dust, paddy husk, tea refuse, paddy straw, sugar cane trash *etc.*, which could be used as potential growth media.

Considering the above facts, two experiments were conducted during January 2003 to March 2004, at Agricultural Research Station, Sita Eliya to find the possibilities of using the above organic waste to increase the productivity and quality of pre-basic seeds under protected conditions.

MATERIALS AND METHODS

Experiment I

The following treatments were used as growth media.

(i) Coir dust (CD)

(ii) Coir dust + Half burnt paddy husk (HBPH) (1:1)

(iii) Coir dust + Sand (S) (1:3)

(iv) Tea refuse (TR) + Sand (1:1)

(v) Metal chips (MC) + Coir dust (1:3)

(vi) Tea refuse + Half burnt paddy husk (1:1)

They were steam sterilized for 3 hours at 80° – 100°C. Two controls, i.e. sterilized Cattle manure (CM) + Jungle soil (JS) (1:1) and Used Seed Bed Soil were used in this experiment. Raised seed beds were prepared in a protected house (24±10°C day; 12±4°C night and RH 80–90%) where the plot size was $1m^2$ with a height of 20cm. A polythene sheet was laid out at the bottom of the bed to avoid ground soil contamination and plots were filled with the prepared media.

Basal dressing of N, P and K fertilizers were applied at a rate of 75:125:75 kg/ha as N, P_2O_5 and K_2O and rooted stem cuttings (RSC) of commercial potato variety Isna was planted with 25cm x 7.5cm spacing. The experiment was arranged in a randomized complete block design (RCBD), with three replicates at the Agricultural Research Station, Sita-Eliya in the up-country wet zone (UCWZ) during January–June, 2003. The pH of each medium was measured at planting and at harvesting.

Plots were manually irrigated to maintain adequate water content in each medium. N and K fertilizers were applied at the rate of 75kg/ha as the top dressing and earthing up was done 21 days after planting. Pests and diseases were controlled as per the departmental recommendations. Dehaulming was done at ground level after two and half months of planting. The crop was harvested 14 days after dehaulming.

Data was collected from plants in the centre of the plot avoiding the border plants. Plant height was measured from the collar region to apical bud at flowering. Stem thickness was measured at 10 cm height from the collar region using a venire caliper, fortnightly, beginning from the 1st week after planting (WAP). Number of main stems was counted at flowering. Number of shoots arising from below the soil surface was considered as main stems. A separate sample was taken to measure root length at dehaulming. Crop senescence was recorded visually in terms of % yellowing of the canopy. Plots were harvested at 14 WAP and the number and weight of tubers were recorded from each plot separately. Data were analyzed using SAS computer package.

Experiment II

Selected growing materials from Experiment I, i.e. CD, TR and HBPH were steam sterilized separately for 3 hours at 80 – 100°C, and mixed in different ratios as given below.

(i) HBPH + TR (1:1)

(ii) HBPH + CD (1:1)

(iii) HBPH + TR + CD (1: 1: 1)

Cattle manure mixed with jungle soil (1:1) served as the control. The mixture was filled in 28cm diameter plastic pots.

One tissue cultured plantlet of potato variety Granola was planted in each pot in the protected house (22±10°C day; 10±4°C night and RH 80–90%) at the Agricultural Research Station, Sita-Eliya in the up-country wet zone (UCWZ) during October 2003-March 2004.

This experiment was arranged in a randomized complete block design (RCRD) with 5 replicates. One pot for each treatment served as one replicate. 2.3g each of N and K (K_2O) were added, beginning at planting and followed by weekly intervals for 3 weeks. P (P_2O_5) was added at planting and one week after planting at the rate of 1.9g per pot. A foliar fertilizer, "Bayfolan", was sprayed at weekly intervals at the dilution rate of 2ml/l of water and the crop was irrigated as required.

Plant height from the collar region to apical bud was measured and canopy diameter was recorded at flowering. Number of main stems was counted at flowering and root length was also measured at harvest. Crop senescence was recorded visually in terms of days when 85% of the canopy became yellow. Pots were harvested at 14 WAP and the number and weight of tubers were recorded from each pot separately. Data were analyzed using SAS computer package.

RESULTS AND DISCUSSION

Experiment I

Plant height

Results showed that the plant height (38.3cm) was observed in plants grown in TR + S but not significantly different from HBPH + TR. The lowest plant height (16.1cm) was in the used seed bed soil (Table 1). Plant height rapidly increased after the third week in all media tested except in the two controls.

Table 1. Average plant height (cm).

Treatment	*Weeks after planting*				
	1	*3*	*5*	*7*	*9*
Coir Dust	12.1ab	15.4bc	18.9bc	24.9bcd	26.0bcd
Half burnt paddy husk +Coir dust	12.3ab	15.8bc	19.0bc	24.3bcd	25.5bcd
Sand + Coir dust	13.6a	19.13a	23.0ab	27.1abc	27.6abc
Tea refuse + Sand	11.7ab.	17.1ab	27.8a	37.1a	38.3a
Metal chips + Coir dust	12.9ab	18.1a	20.9bc	23.9bcd	24.8bcd
Half burnt paddy husk+ Tea refuse	12.6ab	16.6c	16.7dc	31.7ab	35.3ab
Cattle manure + Jungle soil	12.1ab	15.1bc	17.1dc	20.2dc	20.7dc
Used seed bed soil	11.9ab	14.4c	14.6e	14.9d	16.1d
CV%	8.4	7.7	16.5	24.7	23.2

Values followed by same letter in each column are not significantly different at p=0.05.

Number of Main Stems

The highest number of main stems was observed in HBPH + TR followed by coir dust and TR + S. The lowest number of main stems was in used seed bed soil (Table 2).

Stem thickness

Stem thickness in plants grown in TR + S medium was significantly higher than those of all the other tested media (Table 2).

Root length

The highest root length was observed in plants grown in HBPH + coir dust, followed by HBPH + TR (Table 2).

Canopy diameter

TR + S gave the largest canopy diameter (38.3cm), followed by HBPH + TR (35.5cm). The lowest canopy diameter was observed in used seed bed soil (Table 2).

Time to senescence

Yellowing percentages observed by visual estimation are shown in Table 3. Plants grown in CD, S + CD and MC + CD gave early senescence compared to other treatments.

Table 2. Effect of growing media on number of main stems per plant, stem thickness, root length and canopy diameter.

Treatment	*# of main stems*	*Stem thickness (mm)*	*Root length (cm)*	*Canopy diameter (cm)*
Coir dust	7.7 ab	4.6 b	15.7 c	27.4abc
HBPH + Coir dust (1:1)	7.0 bc	4.4 b	26.3 a	26.0bcd
Sand + Coir dust(1:3)	6.7 bcd	4.9 b	14.0 c	27.6abc
Tea refuse + Sand(1:1)	7.3 abc	5.8 a	14.7 c	38.3a
Metal chips + Coir dust(1:3)	6.7 bcd	4.7 b	15.3 c	24.8bcd
HBPH + Tea refuse (1:1)	8.7 a	4.6 b	21.7 b	35.5ab
Cattle manure + Jungle soil(1:1)	6.0 dc	4.5 b	14.7 c	20.9dc
Used seed bed soil	5.3 d	4.5 b	12.0 c	16.1d
CV %	13.37	7.1	12.67	23.6

Values followed by same letter in each column are not significantly different at p=0.05

Table 3. Yellowing of leaves (%).

	Weeks after planting		
Treatment	*8*	*9*	*10*
Coir Dust	15	25	75
HBPH + Coir dust (1:1)	0	5	50
Sand + Coir dust(1:3)	10	20	85
Tea refuse + Sand(1:1)	5	15	40
Metal chips + Coir dust(1:3)	20	50	85
HBPH + Tea refuse (1:1)	0	5	20
Cattle manure + Jungle soil(1:1)	0	0	5
Used seed bed soil	0	0	0

Total tuber number

There was a significant difference in total tuber number among the tested media. The highest tuber number was recorded from HBPH + TR (1186 tubers per m^2 i.e.22 tubers per plant) followed by HBPH + CD (1008 tubers per m^2 i.e.19 tubers per plant). Both controls gave the lowest number of tubers (Table 4).

Total tuber weight

There was no significant difference in tuber weight among tested media (Table 4).

Table 4. Tuber weight (kg/m^2) and tuber number per m^2.

Treatment	*Weight*	*Number of tubers*
Coir dust	4.4	631.0c
HBPH + Coir dust (1:1)	5.0	1008.0ab
Sand + Coir dust(1:3)	4.6	615.7c
Tea refuse + Sand(1:1)	5.0	734.0bc
Metal chips + Coir dust(1:3)	4.5	498.7cd
HBPH + Tea refuse (1:1)	4.3	1186.3a
Cattle manure + Jungle soil(1:1)	3.7	283.7de
Used seed bed soil	3.8	160.7e
CV %	ns	26.23

Values followed by same letter in each column are not significantly different at p=0.05.

Experiment II

Main stems

There was no significant difference among the treatments in the number of main stems (Table 5).

Plant height

The highest plant height of 20.68cm was recorded in HBPH+TR+CD and the lowest in CM + JS (Table 5).

Canopy diameter

The largest canopy diameter of 37.42cm was recorded from HBPH+TR+CD (Table 5).

Root length

The highest root length (16.45cm) was recorded from the plants grown in HBPH + CD media, followed by HBPH+TR+CD (12.51cm) and HBPH + TR (10.74cm). The lowest root length (6.23 cm) was recorded from the plants in CM+JS media (6.23cm) (Table 5).

Time to senescence

Early senescence was observed in HBPH + TR and HBPH+TR+CD (96 and 94 days respectively) followed by HBPH + +CD (100days). In CM + JS media senescence took 105 days (Table 5).

Table 5. Number of main stems, Plant height (cm), Canopy diameter (cm), Root length (cm) and Time of senescence.

Treatment	*# of main stems/plant*	*Plant height (cm)*	*Canopy diameter (cm)*	*Root length (cm)*	*Time to senescence (Days)*
HBPH + Tea refuse	3	15.74ab	27.30b	10.74a	96c
HBPH + Coir dust	3	15.97ab	27.40b	16.45a	100b
HBPH + Tea refuse + Coir dust	4	20.68a	37.42a	12.51a	94c
Cattle manure + Jungle soil	3	14.42b	25.00b	6.23b	105a
CV%	ns	22.68	18.06	32.37	14.95

Values followed by same letter in each column are not significantly different at p=0.05.

Tuber number

The highest number of tubers (23 tubers/plant) was recorded from the plants grown in HBPH+TR+CD, followed by HBPH+TR and HBPH+CD of 16 tubers/plant each and the minimum number was recorded from CD + JS (Table 6).

Tuber weight

As in tuber number, the highest total tuber weight (170.35g/plant) was recorded from the plants grown in HBPH+TR+CD, followed by HBPH+CD (129.6g/plant) and HBPH+TR (119.07g /plant) (Table 6).

Table 6. Tuber weight and number (per plant) of different treatments.

Treatment	*Tuber weight (g/plant)*	*Tuber number per plant*
HBPH + Tea refuse	119.07b	16b
HBPH + Coir dust	129.60b	16b
HBPH + Tea refuse+ Coir dust	170.35a	23a
Cattle manure + Jungle soil	68.34c	7c
CV%	25.98	25.32

Values followed by same letter in each column are not significantly different at p=0.05.

The results revealed that plants grown in CM + JS and used seed bed soils performed poorly with respect to all measured parameters, compared to plants grown in other tested growth media in Experiment I. Similarly, in Experiment II, CM + JS performed poorly. Among the soil-less growth media of Experiment I, TR + S and HBPH + TR gave better results in terms of plant height, canopy diameter and root length, whereas in Experiment II, HBPH + TR + CD gave better results in terms of plant height, number of main stems and canopy diameter.

The increased root length recorded in media with HBPH, could be attributed to favorable environment created for root growth due to its high porosity and nutrient content. Increased root growth facilitated the growth of stems, foliage and increased the tuber number. It was also observed that HBPH improved absorption, retention and infiltration of water and thereby increased root elongation. Further, coir dust has very good ability to enhance plant growth as reported by Dart *et al.* (1976); Ramaswami and Ramulu (1983); Jayalath and Van Holm (1987); Van Holm and Moors (1987); Mazeen and Van Holm (1989) and Mazeen *et al.* (1999). Tea refuse also elevates soil pH, soil organic carbon content, soil and leaf potassium (Mohotti 1999). Potato plants need a soil pH of 5.0-6.5 for better growth and effective nutrient absorption (DOA recommendation).

Larger canopy growth recorded in all the media which contained tea refuse in Experiment I may have been due to more light interception and ultimately higher tuber yield. Increased yield in potato in this study is supported by the findings of Hovekort *et al.* (1991) and Havekort and Harris (1987), in which they found that tuber yield increased with increasing photo-period and light intensity and the quantum of radiation intercepted by potato foliage. In addition, properties of tea refuse may have contributed to the high yield. The synergistic effect of all these organic wastes could be the reason for highest growth and yield obtained from plants grown in HBPH+TR+CD media in Experiment II. Soil-less media have desirable texture with less compaction during growing period that facilitates better environment for root growth and tuber formation.

Mazeen *et al.* (2002) found that the total tuber weight was 3 kg/m^2 when plants were grown in soil + cattle manure medium. This experiment also gave approximately the same value. Although the total tuber weight was not significantly different among treatments, total tuber number increased significantly in HBPH + CD and HBPH + TR media over the other treatments in Experiment I. This increase was about six to eight times over the control. In Experiment II, HBPH + TR + CD medium gave the highest tuber weight over the other treatments (Table 6). Proper aeration is a basic requirement for potato tuber formation and bulking, which is one of the important properties observed in these media. Further, pH of these media was within the range of

5-7 in both experiments, which is ideal for the growth of potato plants. The root environment in these media may have changed the plant morphology, which had an enhancing effect on more stolon formation and tuber development. Pozo (1997) also found that the number of tubers increased with the increase in number of main stems in potato. Higher stem thickness recorded in the medium TR + S in Experiment I may also be an additional advantage for translocation of assimilates.

All the media with CD showed early senescence in Experiment I, whereas in Experiment II, early senescence was recorded in HBPH + TR and HBPH + TR + CD. This may be due to high C:N ratio in coir dust. Later senescence is a positive factor for more biomass production and increase yield, if there is enough sink capacity. Senescence was delayed in both soil media in Experiment I, but it did not increase tuber weight because the number of tubers produced was significantly low (Table 4).

Even though tuber number per plant seems to be similar in HBPH+ TR and HBPH + TR + CD in both experiments, HBPH + TR + CD medium in Experiment II showed additional advantages over the HBPH + CD and HBPH + TR in terms of higher water holding capacity, number of main stems, plant height and canopy diameter.

The media are mainly agricultural waste or material available in the country. Unlike soil and cattle manure, sterilization of these media is easy and they are often free from soil born diseases. In addition, it was observed that tubers produced in soil-less growth media were clean, uniform and free from diseases.

It has been shown by these experiments that soil and cattle manure are not suitable for pre-basic seed potato production. Therefore, considering all these factors, soil can be replaced by other media to increase the tuber number in seed multiplication in protected houses. These findings will lead to further research in order to achieve even higher tuber production under protected conditions.

CONCLUSIONS

Half burnt paddy husk + Tea refuse and Half burnt paddy husk + Coir dust are the best treatments among the tested media of Experiment I, while Half burnt paddy husk + Tea refuse + Coir dust (1:1:1) is the best medium of Experiment II. Therefore, tea refuse, half burnt paddy husk and coir dust could be used to replace the presently used soil medium, in order to produce high quality seed tubers and to increase the rate of seed multiplication as well.

REFERENCES

Dart, P.J., Day, Islam and J. Dobereiner. 1976. Symbiosis in tropical grain legumes: Some effects of temperature and the composition of rooting medium. In: symbiosis N. fixation in plants. Ed. P.S.Nutam. University press, Cambridge Pp 361-384. .

Harverkort, A.J. and P.H. Harris. 1987. A model of potato growth and yield under tropical highland conditions. Agricultural and forest meteorology 39:271-282.

Harverkort, A.J., D. Uenk, H. Veroude and M. van de Waart. 1991. Relationship between ground cover, intercepted solar radiation, leaf area index and infrared reflection of potato crops. Potato Research 34:113-121.

Hooker, W.J. 1981. Compendium of potato diseases. American Phytopathological Society. Minnesota, USA.

Jayalath, M.N. and L.H.J. Van Holm. 1987. Effect of coir dust and inoculation with Rhizobium multistrain on dinitrogen fixation and yield. Proc. 1st workshop on nitrogen fixation and soil fertility. Ed. H.P.M. Gunasena, Faculty of Agriculture, University of Peradeniya, Sri Lanka Pp 18-23.

Malik, N.J. 1995. Potatoes in Pakistan. A Hand book: Pak-Swiss Potato Development Project, Pakistan Agricultural Research Council, Islamabad Pp 14-15.

Mazeen, A.C.M. and L.H.J. Van Holm. 1989. Effect of extracts of coir dust of different ages and concentrations on growth of common bean and maize seedlings. Proceedings of second workshop on Nitrogen Fixation and Soil Fertility, Ed. Gunasena, H.P.M., Katupitiya. S. and Van Holm, L.H.J., Faculty of Agriculture, University of Peradeniya, Peradeniya, Sri Lanka Pp 42-52.

Mazeen, A.C.M., H.M.W. Herath and L.H.J. Van Holm.1999. Use of coir dust as a soil amendment on growth and nitrogen fixation of winged bean. Proceedings of the annual symposium of Department of Agriculture, Ed. C. Kudagamage and S. Nagarajah., Department of Agriculture, Peradeniya, Sri Lanka Pp 109-119.

Mazeen, A.C.M., S.A.M.R. Abeykoon, M.M. Nugaliyadda, B. Marambe, R.J.K.N. Kularathna. and B.G.Amerasena. 2002. Effect of age of mother plants on growth, yield and senescence of rooted stem cuttings and basic seed in potato. ASDA 2002 4:161–168.

Mohotti, K.M. 1999. Bio management of tea nematodes. Proceeding of the 1999 experiment and extension programme, Tea Research Institute of Sri Lanka. Thalawekelle Pp 16 - 30.

Nugaliyadda, M.M., K.M.D.W.P. Nishantha, S. Karunasena, J. de Silva, and M.M. Padmawansa. 2002. Potential sources of *streptomyces scabies*. The cause of potato scab in polytunnels, ASDA 2002 4:307–311.

Pozo, M. 1997. Tuberization, seed size and cutting of seed tubers. Manual on seed potato production, International Potato Center, Lima, Peru. Pp 10.

Ramaswami, P.P. and U.S. Ramulu. 1983. Efficient utilization of an industrial waste for moisture conservation and yield. J.Core 27 (2): 16-17.

Vitosh, M.L. 1990. Potato fertilizer recommendations. Extension Bulletin E- 2220. Michigan State University Extension. Soils and Soil Management. USA.

Uyenco, F.R. and J.A.K. Ochoa. 1984. Microbial degradation of coconut coir dust for biomass production. Phil . J. of coconut studies 9(182):51-54.

Van Holm, L.H.J. and K.M.L. Moors. 1987. Effect of nodulation with a single rhizobium strain on different winged bean accession at two agro-ecology zones. Proceedings 1st workshop on Nitrogen Fixation and Soil Fertility. Ed. H.P.M. Gunasena. Faculty of Agriculture, University of Peradeniya, Peradeniya, Sri Lanka Pp 9-17.