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THE RELATIONSHIP BETWEEN PLANT DENSITY, YIELD AND QUALITY IN VIRGINIA BUNCH PEANUTS IN SOUTH-EAST QUEENSLAND

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SUMMARY

The effect on yield of plant population level and spatial arrangement of Virginia Bunch peanuts was studied over 3 years in the South Burnett area of Queensland.

The three population levels used were 24 700, 32 580 and 49 000 plants ha^{-1} and at each population level, three planting arrangements were used: 1:1 (square planting), 1:2.5 and 1:5 (extreme rectangularity).

Yield generally increased both with increase in plant population level and with decreases in inter-row space. Thus 49 400 plants ha^{-1} planted at 45 x 45 cm was the highest yielding treatment in 2 out of the 3 years.

I. INTRODUCTION

As with most crops in the South Burnett region, peanuts (*Arachis hypogaea* L.) are grown in rows 91 cm apart. The recommended intra-row plant spacing for Virginia Bunch types is 25 to 40 cm (Rawson *et al* 1972) and this gives populations of 28 000 to 44 000 plants ha^{-1}.

Traditional row spacings have been dictated, at least in part, by the necessity for inter-row cultivation for weed control (Stickler and Anderson 1964). In recent years, the growing awareness of the value of effective herbicides and their increasing availability have reduced the dependence upon mechanical means of weed control in many crops (Rawson 1962; Stickler and Anderson 1964; Fallon 1971). As a result, certain traditional agronomic practices can be reconsidered. The aspect of interest in the current investigation is that of plant population level and spatial arrangement.

There are many reports in the literature of yield and quality improvements being obtained in a variety of crops, as a result of increasing plant populations and decreasing inter-row spacings. For example, Lutz *et al.* (1971) found the grain yield of corn increased as row width decreased. With cotton, yield increases and more uniform quality have been obtained by decreasing inter-row spacings and increasing population levels (Anon 1971). Likewise, grain yields of sorghum grown in 50 cm rows have been higher than from sorghum grown in 100 cm rows (Stickler and Wearden 1965). In peanuts, Perry *et al.* (1955) suggest that, as the major portion of the fruit is produced in a circle of only 10 to 15 cm from the tap-root, inter-row spaces could be reduced from 90 cm to between 45 and 60 cm. Furthermore, close spacing suppresses formation of late flowers (Bunting, 1956), and this is an important factor in producing uniform peanut quality. Saint-Smith (1969) doubled commercial peanut population densities both by bed, planting systems, and by decreasing within-row width. In years of adequate rainfall, he obtained yield increases with the doubled population

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levels, but in an extremely dry year, yield was decreased. He concluded that better moisture utilization may be possible by reducing row width to less than 91 cm.

The object of the experiment reported in this paper was to determine, in the South Burnett area of Queensland, the effects on Virginia Bunch peanut yield of plant population level and spatial arrangement.

II. METHODS AND MATERIALS

The experiments were carried out at Kingaroy, which has an altitude of 432 m, an average annual rainfall of 768 mm (73% of which falls between October and April), and an average maximum and minimum temperature of 25°C and 10°C respectively. Frosts are expected between May and September.

The experiments were conducted on a red friable earth, Gn 3.11 (Northcote 1971) of basaltic origin, with a 40 cm A horizon, typical of many areas of peanut production in the South Burnett.

Soil analyses indicated 22 p.p.m. of available P in the 0 to 15 cm soil layer and 18 p.p.m. below 15 cm. Twenty kg P ha^{-1} was applied as superphosphate. The experimental sites each year were treated with pre-planting incorporated trifluralin at 0·70 kg a.i. ha^{-1}. In 1971-72 a post-emergence application of dinoseb at 1·13 kg a.i. ha^{-1} was used to control broad-leaved weeds. Very little hand chipping of weeds was required in any year.

The treatments used are shown in Table 1. The average commercial population level used in the South Burnett is 36 000 plants ha^{-1}. The three spatial arrangements common to each population level range from square planting (1:1), theoretically the optimum planting arrangement, to extreme rectangularity (1:5). Having the same range of spatial arrangements at all population levels provides a common ground for comparison between population levels. The experimental design used was a 3 x 3 factorial with three replications. Plots comprised 5 rows, each 12 m long. A 10 m section from each of the centre three rows was the datum area.

TABLE 1

TREATMENTS USED IN THE EXPERIMENTS

Treatment No.	Within Row (cm)*	Inter-row (cm)*	Spatial Arrangement	Area $Plant^{-1}$ (cm^2)*	Plants ha^{-1}
1	63	63	1 : 1	4 050	24 700
2	100	40	1 : 2·5	4 050	24 700
3	142	28	1 : 5	4 050	24 700
4	55	55	1 : 1	3 037	32 580
5	87	35	1 : 2·5	3 037	32 580
6	123	25	1 : 5	3 037	32 580
7	45	45	1 : 1	2 025	49 400
8	71	28	1 : 2·5	2 025	49 400
9	100	20	1 : 5	2 025	49 400

* Converted from Imperial units and rounded to nearest unit.

Several seeds of 'Selection 5', a Virginia Bunch type cultivar, were sown by hand at each plant position, and the resulting stands thinned to single plants.

Monthly rainfall figures for the 3 years are given in Table 2. Total rainfall in each season was greater than the long-term average for the Kingaroy area. Despite this, there were periods in each season when the crops suffered moisture stress.

TABLE 2

MONTHLY RAINFALL (MM) FOR THE THREE EXPERIMENTS

Month	1969–70	1970–71	1971–72
Oct	76	58	99
Nov (pre-planting)	129	61	23
Nov (post-planting)	0	3	66
Dec	66	406	153
Jan	174	226	83
Feb	136	217	106
Mar	44	28	34
Apr (pre-harvest)	1	2	94
Total	626	1 001	658

III. RESULTS AND DISCUSSION

Plant responses

Time to flowering was not noticeably affected by variations in either plant population levels or spatial arrangements. Plant growth habit was affected. As both plant population level and intra-row space decreased, plant size, as measured by both height and spread, increased.

Total yield of nut-in-shell

Results are given in Table 3.

In the three experiments, yield increased with increases in population levels, and with decreasing row width (Table 3). These factors were not independent in their effects. To obtain maximum yield responses with increased population levels, it was necessary to reduce row width. The interaction between plant population level and spatial arrangement was significant in 1969-70 ($P < 0 \cdot 05$) and in 1971-72 ($P < 0 \cdot 01$). These effects can be demonstrated by considering comparisons between individual treatments.

1. Treatment 7, the highest population level in the narrowest rows (square planted), outyielded all other treatments significantly ($P < 0 \cdot 01$) in 1970-71 and 1971-72 (Table 3). In 1969-70, treatment 7 yielded slightly less than treatments 1 and 4, and significantly less ($P < 0 \cdot 05$) than treatment 8. Apart from treatment 7, treatments 8 and 4 consistently outyielded the remaining treatments, many of these differences being significant at the 1% and 5% levels.

2. Treatment 4 had the same population level as treatment 6, but narrower row width, and outyielded treatment 6 significantly ($P < 0 \cdot 01$) in two seasons (Table 3).

3. Treatments 2 and 9 both had row widths of 100 cm, but the population level of treatment 9 was double that of treatment 2. Despite the twofold variation in populations, the yield differences were very small.

TABLE 3

YIELD OF NUT-IN-SHELL (kg ha^{-1}) (TREATMENT NUMBERS IN BRACKETS)

a 1969–70

Spatial Arrangement	Population (plants ha^{-1}) 24 700	32 580	49 400	Arrangement Means
1:1	(1) 3 852·4	(4) 3 805·3	(7) 3 752·7	3 803·5
1:2·5	(2) 3 195·1	(5) 3 571·0	(8) 4 234·8	3 667·0
1:5	(3) 2 596·4	(6) 3 096·0	(9) 3 332·2	3 008·4
Population Means	3 214·6	3 491·0	3 773·2	..

	Significant Differences P < 0·05	P < 0·01
Population and Arrangement	269·2	371·5
Individual	467·0	643·4

b 1970–71

Spatial Arrangement	Population (plants ha^{-1}) 24 700	32 580	49 400	Arrangement Means
1:1	(1) 2 924·8	(4) 3 376·5	(7) 3 787·8	3 363·0
1:2·5	(2) 2 768·5	(5) 3 189·4	(8) 3 283·6	3 080·5
1:5	(3) 2 306·1	(6) 2 565·1	(9) 2 942·2	2 604·5
Population Means	2 666·5	3 043·6	3 337·9	..

	Significant Differences P < 0·05	P < 0·01
Population and Arrangement	196·3	270·5
Individual	340·0	468·5

c 1971–72

Spatial Arrangement	Population (plants ha^{-1}) 24 700	32 580	49 400	Arrangement Means
1:1	(1) 2 472·4	(4) 2 848·0	(7) 3 730·0	3 016·8
1:2·5	(2) 2 624·4	(5) 2 870·4	(8) 3 099·9	2 864·9
1:5	(3) 2 366·9	(6) 2 584·7	(9) 2 762·8	2 571·4
Population Means	2 487·9	2 767·7	3 197·6	..

	Significant Differences P < 0·05	P < 0·01
Population and Arrangement	157·8	218·2
Individual	273·4	377·9

Quality

Quality was expressed by percentage of edible kernel (E.K.) and percentage of oil kernel (O.K.).

Results are given in Table 4.

TABLE 4

QUALITY : % E.K. AND % O.K. (TREATMENT NUMBERS IN BRACKETS)

a 1970–71

Spatial Arrangement	Population (plants ha^{-1})						Arrangement Means	
	24 700		32 580		49 400			
	% E.K.	% O.K.	% E.K.	% O.K.	% E.K.	% O.K.	% E.K.	% O.K.
1:1	(1) 65·20	6·80	(4) 64·90	6·90	(7) 64·90	7·30	65·00	7·00
1:2·5	(2) 64·60	7·47	(5) 64·57	7·80	(8) 64·73	7·70	64·63	7·66
1:5	(3) 65·00	7·83	(6) 65·37	7·30	(9) 65·50	7·10	65·29	7·41
Population Means	64·93	7·37	64·94	7·33	65·04	7·37	..	

	Significant Differences P < 0·05	Significant Differences P < 0·01
Population and Arrangement ..	% E.K. 1·08; % O.K. 0·86	% E.K. 1·48; % O.K. 1·19
Individual	% E.K. 1·86; % O.K. 1·49	% E.K. 2·75; % O.K. 2·06

b 1971–72

Spatial Arrangement	Population (plants ha^{-1})						Arrangement Means	
	24 700		32 580		49 400			
	% E.K.	% O.K.	% E.K.	% O.K.	% E.K.	% O.K.	% E.K.	% O.K.
1:1	(1) 54·60	17·37	(4) 54·44	17·72	(7) 59·73	13·37	56·26	16·15
1:2·5	(2) 54·00	18·37	(5) 56·33	16·77	(8) 56·87	16·20	55·73	17·11
1:5	(3) 54·27	18·00	(6) 54·17	18·23	(9) 57·17	15·87	55·20	17·37
Population Means	54·29	17·91	54·98	17·57	57·92	15·14	..	

	Significant Differences P < 0·05	Significant Differences P < 0·01
Population and Arrangement ..	% E.K. 2·62; % O.K. 2·37	% E.K. 3·61; % O.K. 3·27
Individual	% E.K. 4·54; % O.K. 4·11	% E.K. 6·26; % O.K. 5·66

In 1969-70, no quality determinations were made. In 1970-71 and 1971-72, there were no significant differences between spatial arrangements in percentages of E.K. or O.K. (arrangement means, Table 4). As population increased, the percentage of E.K. increased, the differences in 1971-72 being significant (population means, Table 4).

In 1971-72, treatment 7 produced the highest E.K. and lowest O.K. percentage, the difference between treatment 7 and treatments 2, 3, 4 and 6 being significant at the 5% level (Table 4). High E.K. and low O.K. are an indication of uniform crop set. The square planting treatments, particularly treatment 7, grew less vegetatively than other treatments. This is in agreement with Bunting (1956), who found that close spacing suppressed the formation of late flowers, thus promoting more uniform quality.

Yield components

Results are given in Table 5.

TABLE 5

COMPONENTS OF YIELD (1971–72) (TREATMENT NUMBERS IN BRACKETS)

a 100-kernel weight (g)

Spatial Arrangement	Population (plants ha^{-1}) 24 700	32 580	49 400	Arrangement Means
1:1	(1) 93·35	(4) 91·78	(7) 89·90	91·68
1:2·5	(2) 94·73	(5) 90·49	(8) 88·24	91·15
1:5	(3) 94·46	(6) 92·32	(9) 88·59	91·78
Population Means	94·18	91·53	88·91	..

	Significant Differences P < 0·05	P < 0·01
Population and Arrangement	3·42	4·72
Individual	5·93	8·17

b Number —edible kernels per ɩ lant

Spatial Arrangement	Population (plants ha^{-1}) 24 700	32 580	49 400	Arrangement Means
1:1	(1) 66·89	(4) 58·26	(7) 55·22	60·12
1:2·5	(2) 69·26	(5) 60·69	(8) 44·59	58·18
1:5	(3) 61·41	(6) 52·60	(9) 40·83	51·61
Population Means	68·85	57·18	46·88	..

	Significant Differences P < 0·05	P < 0·01
Population and Arrangement	4·75	6·54
Individual	8·25	11·36

Some components of yield were affected by changes in plant poplulation levels and spatial arrangements. In 1971-72, as population level increased, 100-kernel weight decreased, the difference between the two extreme populations being significant at the 1% level (population means, Table 5A). Variations in arrangement had no effect on kernel size (arrangement means, Table 5A). The number of edible kernels per plant decreased with increasing population level and increasing row width (population and arrangement means, Table 5B).

Thus the yield per plant increased as the population level decreased because plants at low populations produced heavier kernels, and a greater number of kernels than plants at high populations. However, the greater yield per plant was insufficient to compensate for the lack of numbers of plants per unit area, and therefore total yield increased with increasing population. At the high population level, treatment 7 produced a greater number of E.K. per plant, and so its yield was greater than the other high population treatments (Table 5).

IV. CONCLUSIONS

Virginia Bunch peanut yields in the South Burnett area of Queensland will respond to variations in both plant population levels and spatial arrangements. These factors are not independent in their effects. In the present study, it was found that reduced row width was needed to gain maximum yield response to increased population levels.

The quality of peanuts produced, in terms of percentage of edible kernels may also be improved by decreasing row width and increasing population levels.

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