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Varietal and density effects on vegetable corn and forage production

(Kesan varieti dan kepadatan terhadap pengeluaran jagung sayur dan makanan ternakan)

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Key words: vegetable corn, by-products, forage, varieties, planting density

Abstrak

Satu ujikaji tentang kesan kepadatan penanaman jagung terhadap pengeluaran putik jagung daripada varieti Suwan 1, Manis Madu dan Thai Supersweet menunjukkan bahawa kepadatan 159 999 pokok/ha mampu menghasilkan 247 553 tongkol/ha, sama dengan 1.55 tongkol/pokok. Pengeluaran varieti Suwan 1 lebih tinggi daripada kedua-dua varieti jagung manis. Pada kepadatan 159 999 pokok/ha, potensi pengeluaran Suwan 1 ialah 8.47 t putik jagung sebelum diproses atau 1.71 t selepas diproses, 7.23 t kulit jagung, 2.27 t bunga jantan dan 30.80 t daun dan batang jagung sehektar.

Abstract

An experiment on the effects of plant density on the production of vegetable corn from Suwan 1, Manis Madu and Thai Supersweet varieties showed that the density of 159 999 plants/ha could yield 247 553 cobs/ha, equivalent to 1.55 cobs/plant. Variety Suwan 1 is superior to the two sweet corn varieties. At 159 999 plants/ha, it has the potential to yield 8.47 t of vegetable corn cobs or 1.71 t of the processed vegetable corn, 7.23 t of husks and silk, 2.27 t of tassels and 30.80 t of green stover per hectare.

Introduction

Vegetable corn is a popular and common vegetable (Lim and Singh 1976), and more so because it is tasty and highly marketable (Lee and Zameri 1983). By all accounts, it is an easily grown and highly profitable crop, since an ex-farm price of 1¢/piece will easily cover the estimated production cost of about $1 000/ha (Lee and Zameri 1983). Yet, why the status quo of limited local production and high imports from Thailand and Taiwan, remains so is enigmatic.

Previous records of vegetable corn production in Malaysia are scarce. Van (1964) mentioned that *Zea mays* var. *rugosa* was used mainly as a vegetable but he was not specific as to what was meant by "vegetable". Perhaps the production of vegetable corn *per se* is not attractive enough. Although there are a few reports on the performance of various sweet and grain corn varieties in Malaysia (Lim and Singh 1976; Lee and Zameri 1983) and in neighbouring Thailand (Lekagul et al. 1980) for vegetable corn production, there is a dearth of information on the utilization of corn by-products as animal feed. Izham (1988) reported the use of ensiled sorghum plants in Kelantan and Perlis. With this as the precursor, it is envisaged that an integrated programme of vegetable corn production and utilization of corn husks, stems and leaves as the integral component of a ruminant diet would make an enterprise

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of this nature more viable and attractive. This paper reports the effects of planting density on the yields of vegetable corn, stover and other by-products.

Materials and methods

Two sweet corn varieties, Thai Supersweet and Manis Madu, and one grain corn variety, Suwan 1, were used as they are readily available. Thai Supersweet was designated the check variety. Planting densities of 106 666, 159 999 and 213 333 plants/ha were tested. The experiment was laid out in a 3^2 factorial randomized complete block design with three replications.

Following standard practices, the row spacing was 75 cm and the within row spacing 50 cm. To achieve the required planting densities, 4, 6 and 8 plants were maintained per planting point. Fertilizers were applied at 180 kg N, 90 kg P_2O_5 and 60 kg K_2O per hectare. The fertilizers were applied 7 days after planting except for 90 kg N which was split equally and top-dressed 3 and 5 weeks after planting. Treatment plot size was 3 m x 5 m giving rise to four rows and 40 planting points per treatment plot.

Alachlor and *Gesaprim* were sprayed immediately after planting as pre-emergence weedicides. Mounding carried out at the time of fertilizer applications was sufficient for later post-emergent control as well as providing support to the plants.

Data collected, on a whole-plot basis (3 m x 5 m), consisted of numbers and weights of cobs (husked and dehusked), and tassel weight as well as weights of husks, and the remaining leaves and stems (after all cob harvests were completed).

The experiment was conducted over two seasons and in two fields. The first season was from 26 May to 3 August 1988 and the second from 7 March to 9 May 1989. In the combined analysis of variance, season (S) and replication (Block) effects are random while variety (V) and density (D) are considered as fixed effects. The EMS (expected mean squares) for each of the sources of variation are shown in *Table 1* where the appropriate error mean squares (denominator) for the F-test can be determined.

Table 1. ANOVA combining two seasons

Source	df	Expected mean squares*
Season	1	Var (Error)+ 9 Var [Rep. (Season)] + 27 Var (Season)
Rep (season)	4	Var. (Error) + 9 Var [Rep (Season)]
Variety	2	Var. (Error) + 9 Var (Variety x Season, + Q (Variety)**
Variety x season	2	Var (Error) + 9 Var (Variety x Season)
Density	2	Var (Error) + 9 Var (Den. x Season) + Q (Density)**
Density x season	2	Var (Error) + 9 Var (Den. x Season)
Density x variety	4	Var (Error) + 3 Var (Den. x Var. x Season) + Q (Variety, Density)**
Density x variety x season	4	Var (Error) + 3 Var (Den. x Var. x Season)
Pooled error+	32	Var (Error)
Total	53	

* Expected mean squares for a mixed effect model, with variety and density as fixed effects, and season and replication as random effects

**Q (Variety), Q (Density) and Q (Variety, Density) are quadratic terms for variety, density and their interactions respectively

\+ Pooled errors consisting of the sum of Rep. x Variety (Season), Rep. x Density (Season) and in the Rep. x Variety x Density (Season) which are found to be homogeneous in the two seasons

Results of the analysis of variance for the total weight and number of mini cobs are as shown in *Table 2*. Subsequently, all other sets of data were tested similarly.

Results and discussion

Stages of crop growth and harvesting

Tasselling began at 43–44 days after planting and the tassels were harvested as they emerged. At this stage, 3.38, 1.72 and 1.28% of the total tassels had emerged for Suwan 1, from the lowest to the highest density. Similarly, for Thai Supersweet it was 15.28, 8.78 and 3.72% while for Manis Madu it was 16.21, 13.59 and 10.30%. Harvesting of the vegetable corn (cobs) commenced 47–50 days after planting. The harvesting period of the young cobs lasted 16–19 days and 14–18 days for the tassels. After this, green stover was available as forage for the stall feeding of sheep.

Vegetable corn yields

The young corn cobs were harvested as soon as the silk emerged to a length of about 1– 3 cm. Bigger cobs and higher yields will be obtained if harvesting was delayed, but this may be undesirable quality-wise. Lee and Zameri (1983) suggested harvesting 5–7 days after silking. This is considered too late and besides day-counting is impractical because of the large numbers of cobs. The easiest method to determine the time to harvest is through visual observation of the emerged silk lengths. However, it should be noted that the silk of some cobs may not emerge at all. These cobs are usually the third or even second cobs in rare cases, or late bloomers. Even when they do silk, their quality is inferior.

As can be seen from the analysis *(Table 2)*, no interaction effects were statistically significant and of the two main factors, varietal effect was insignificant on the number of cobs produced, but density effect was highly significant. While this is expected, the regression analysis, however, indicated that this increase in number of cobs is linearly significant *(Figure 1)*. This puts a damper on our expectations as both Lim and Singh (1976), who experimented with 66 667 and 100 000 plants/ha, and Lee and Zameri (1983), who used 100 000 and 200 000 plants/ha, suggested 100 000 to be optimum. Their range of the treatments may have been limited and too wide, and the densities employed here were expected to show a plateauing effect. The present

Table 2. Combined analysis of variance for the total weight (unhusked) and number of mini cobs over two seasons

Source of variation	df	Total wt. of mini cobs		Total no. of mini cobs	
		ms	F-value[a]	ms	F-value[a]
Season = S	1	31.88	10.59*	17 137.85	2.99ns
Rep (Season)	4	3.01	–	5 739.63	–
Variety = V	2	18.62	2.8 ns	2 633.46	0.90ns
V x S	2	0.71	0.11ns	2 305.35	0.79ns
Density = D	2	2.40	0.37ns	40 832.30	13.96**
D x S	2	0.72	0.11ns	1 175.41	0.40ns
D x V	4	8.21	1.25ns	4 685.46	1.60ns
D x V x S	4	3.48	0.53ns	1 414.91	0.48ns
Error (pooled)	32	6.53		2 924.57	
Total	53				

a The error ms to test each of the sources of variation e.g. variety, is the pooled error (32 df) since Variety x Season effect, for example is not significant and its F-value is less than 1

ns = not significant at 5% level

* significant at 5% level

** very significant at 1% level

findings indicate that a wider density range need to be studied to determine an optimum density for baby corn or vegetable corn production. On the other hand, density effect on the production of vegetable corn could be viewed from the quality angle, but not on number and weight *(Table 3)* production *per se*.

The linear influence of planting density (r = 0.94**) on the number of cobs produced is as shown in *Figure 1* where:
y = number of cobs produced
x = plant density

The estimated yield of vegetable corn cobs averaged over both seasons from the second highest planting density was 247 553 cobs/ha. This works out to about 1.55 cobs/plant as opposed to 1.87 and 1.21 cobs/plant at the lowest and highest planting densities respectively, giving credence to the observations made by Lim and Singh (1976). They reported that at the higher planting density fewer shoots per plant would be obtained (production-wise, a bigger number per unit area would compensate for this, but only up to a point). They compared two varieties of divergent background but reported no significant differences in shoot yields while pointing out that one variety was noted for its prolificacy. This could be due to the fact that under high population per unit area, the multiple-eared character of prolific tend to disappear (Crow and Fleming 1965).

With regard to treatment effects on cob weight, only seasonal variation was significant *(Table 2)*. With respect to varietal response *(Table 3)*, variety Suwan 1 (a grain corn variety) was observed to be better than the two sweet corn varieties. Although statistically not significant, Suwan 1 yielded 11.63 and 13.99% more than Manis Madu and Thai Supersweet respectively.

As statistical differences were not detected from the plant density effect on mean cob weights, this means that at lower plant densities, bigger or heavier cobs were produced. Taking the mean number and weight of variety Suwan 1, the best yielder, the average weight of a single vegetable corn cob works out to 46.26, 37.81 and 34.00 g from the lowest to the highest plant densities respectively. In the case of the processed vegetable corn, where only the season effect was significant, the weights per unit were 8.79, 7.64 and 7.30 g. This gives further credence to the above mentioned observation where the resultant recovery of vegetable corn from a whole corn cob were 19.00, 20.21, 21.47% from the lowest to the highest plant density.

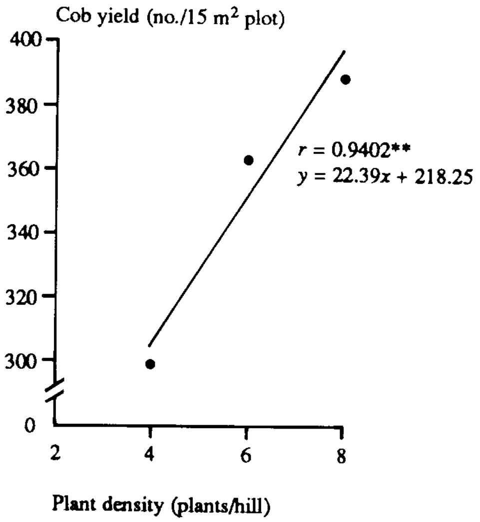

Figure 1. Relationship between plant density and number of vegetable corn cobs

Table 3. Effect of planting density and variety on the production of vegetable corn on 15 m² plots

Treatment	Mean wt. of cobs (kg)	Mean no. of cobs
Density (plants/ha)		
213 333	12.32a	388.00b
159 999	12.82a	371.33b
106 666	12.12a	298.44a*
Variety		
Thai Supersweet	11.68a*	342.50a
Manis Madu	12.00a	366.00a
Suwan 1	13.58a	349.28a

*Means in the same column with different letters are significantly different from one another at $p < 0.05$

Taking this further, the numbers of vegetable corn cobs per 1 kg are 21.62, 26.45 and 29.41 from the lowest to the highest plant densities. Likewise for the processed vegetable corn, 1 kg would number 113.77, 130.89 and 136.99 respectively. Estimated yields of vegetable corn cob and processed vegetable corn are 8.47 and 1.71 t/ha respectively, if planted at a mid-density of 159 999 plants/ha, giving a yield of 224 113 cobs/ha for the variety Suwan 1.

Forage production

The by-products of vegetable corn production that can be utilized for feeding sheep and other ruminants are

- husks and silk after dehusking of the young cobs,
- tassels harvested at the same time as the harvesting of the young corn cobs, or later together with the leaves and stems, and
- leaves and stems (green stover) which can be cut up after all the young corn cobs have been harvested.

For husks and silk, only varietal effects were statistically significant. Suwan 1 again produced more than the two sweet corn varieties *(Table 4)*. Taking the mean weight, the estimated yield of husks and silk from Suwan 1 was 7.23 t/ha. At an average of 17.5 harvesting days, the mean daily production was 0.41 t/ha. Assuming an intake of 2 kg/sheep per day (Mohd. Yusoff, A., MARDI, pers. comm. 1989), this amount would sustain about 206 heads of sheep per day or 29 heads for 1 week.

The mean numbers of tassels, harvested simultaneously with the harvesting of the vegetable corn cob are shown in *Table 5*. Plant density and varietal effects were statistically significant. This is expected as the numbers of tassels would increase in tandem with the plant density. Even so, it is possible that under such high planting densities not all the plants would produce a tassel compared with a normal planting density. Nevertheless, this increase was linear and positive ($r = 0.99^*$) as shown in *Figure 2* where
y = number of tassels produced
x = plant density

The significant varietal effect could be a reflection of the higher vigour of Suwan 1, a grain corn variety, over the sweet corn varieties.

The response of the mean tassel weight to all the treatments was insignificant, while the response to the density effect was similar to the response obtained from the vegetable corn cobs, the associated vegetable corn from the husks and silk. Similarly, lower plant densities would produce bigger and heavier tassels. The estimated yield of tassels was 2.27 t/ha based on the overall mean weight over both seasons. Nevertheless, depending on the requirements, needs and labour constraints, this operation of separately harvesting the tassels could be eliminated by harvesting them together with the green stover after all the young corn cobs have been harvested. However, the quality of this (green) tassel harvested earlier as fresh fodder warrants due consideration.

Table 4. Varietal effects on the production of husks and silk, and green stover from 15 m^2 plots

Variety	Mean wt. of husks and silk (kg)	Mean wt. of green stover (kg)
Thai Supersweet	9.14b*	10.38b*
Manis Madu	9.34b	9.77b
Suwan 1	10.84a	13.29a

*Means in the same column with different letters are significantly different from one another at $p < 0.05$ by LSD

Table 5. Varietal and planting density effects on the number of tassels produced from 15 m² plots

Treatment	Mean no. of tassels
Variety	
Thai Supersweet	186.94ab*
Manis Madu	174.56b
Suwan 1	199.33a
Density (plants/ha)	
213 333	227.39c
159 999	185.61b
106 666	147.83a

*Means in the same column with different letters are significantly different from one another at $p > 0.05$ by LSD

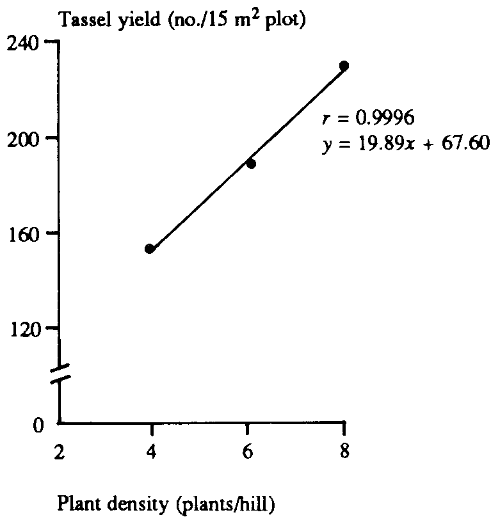

Figure 2. Relationship between plant density and tassel number

Table 6. Interaction effects of planting density and season on yield of green stover (10-hill sample, kg)

Density (plants/ha)	Yield (kg)	
	1st season	2nd season
213 333	6.42	17.66
159 999	6.73	16.37
106 666	5.82	13.89
Mean (seasons)	6.32	15.97

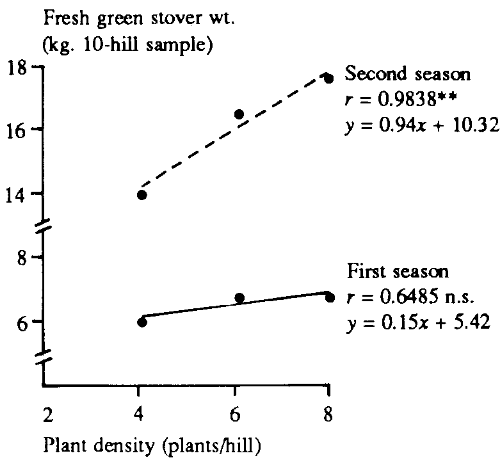

Figure 3. Interaction effects of plant density and season on production of green stover

For green stover, the varietal advantage of Suwan 1 was again significant *(Table 6)* as well as the density x season interaction.

Suwan 1 yielded more than Manis Madu (36.03%) and Thai Supersweet (28.03%). Seasonal effects were significant too. In the second season, stover yield was 152% more than that of the first season. Better management and more favourable weather conditions during the second season experiment were the reasons for the higher forage yield.

Plant density x season interactions are shown in *Figure 3* where in the first season there was no significant increase in total weight of leaves and stems with density. In the second season, a simple linear model was able to account for much of the observed variation attributable to planting density. The first season crop was established during the rainy season while the second season was planted during the dry season with supplemental irrigation and matured during the rainy period unlike the first season.

Although there were increases in the yields of green stover, vegetable corn cobs and the corresponding husks and silk, the yield of processed vegetable corn was not affected. This concurred somewhat with the results of Lim and Singh (1976), where increased nitrogen did not significantly increase the shoot weight. This is easily explained by the fact that the vegetable corn cobs are harvested before reaching full maturity and at a standard size which is attractive for marketing fresh or conducive for canning. So any added fertilizer or high inherent soil fertility would only enhance the size of the plant as a whole but would not increase the weight of young corn cob significantly. In this experiment, although conditions appeared to influence the mean weight of the vegetable corn cobs but this weight gain went towards the husks and silk leaving the weight of processed vegetable corn unaffected.

Using the mean over two seasons for Suwan 1 at 159 999 plant density, the estimated yield of green stover was 30.80 t/ ha. Assuming that 2 kg of this stover can be consumed by 1 sheep/day, a yield of 30.80 t/ ha can potentially provide a day's ration for 15 400 heads of sheep or 2 200 heads of sheep for 7 days, provided, however, that the hard lower portions of the stems are ameliorated, e.g. by mechanical shredding, to make them more palatable to the sheep. Alternatively, there is a lot of material for silage. This process of silage is already in practice, albeit with other materials like sorghum in Kelantan and Perlis (Izham 1988).

Conclusion

For an integrated enterprise of vegetable corn production-cum-stall feeding of ruminants with the resultant by-products and green stover, Suwan 1 variety should be planted. The optimum planting density could not be ascertained only as far as numerical production of cobs is concerned. However, taking into account other factors like green stover production in an integrated production approach, the indications are towards a density of about 160 000 plants/ ha. The quality of vegetable corn obtained from Suwan 1 or any other grain corn variety is not compromised. Sweetness of a "mature" sweet corn cob is expressed only after the grains are formed on the mature cob (Lee, C. K., MARDI, Bumbong Lima, pers. comm. 1988). As such, the young vegetable corn of both grain and sweet corn varieties should taste the same. Furthermore, the seed of sweet corn or glutinous corn is relatively expensive than Suwan 1 seed and has lower resistance to diseases (Lekagul et al. 1980).

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