Coriander (*Coriandrum sativum* L.) Seed Production: Nitrogen, Row Spacing, Sowing Rate and Time of Sowing.

K.Reddy and M.P. Rolston[1]

ABSTRACT

Coriander (*Coriandrum sativum* L.) seed production was investigated to determine the effects of nitrogen (N) fertiliser, row spacing, sowing rate and time of sowing on seed yield and quality. There were no significant differences in seed yield for N application rates ranging from 50 to 200 kg N ha^{-1}. Seed yield did not differ between row spacings of 15 and 30 cm for a lighter Templeton soil, or 30 and 45 cm for a heavier Wakanui soil but was reduced at a 60 cm row spacing for both soil types. Seed yields did not differ significantly between sowing rates of 20 to 40 kg ha^{-1} but were reduced at 10 and 50 kg ha^{-1}. Seed yield and seed quality were very sensitive to sowing date. Seed yield declined 36 kg ha^{-1}day^{-1} from the first sowing on 17 September to the last sowing on 1 December. Seed weight and seed germination also declined as sowing dates were delayed from 17 September. The harvest index (HI) ranged from 33 to 44%. Seeds per umbel were relatively constant among treatments and were usually in the range of 11 to 12. Umbels per plant declined with increase in plant density in the row spacing and sowing rate trials. Seed yield increases with N were associated with increased umbels per plant, while seeds per umbel were not affected.

Additional index words: coriander, *Coriandrum sativum*, density, nitrogen, row spacing, seed production, sowing rate, time of sowing.

INTRODUCTION

Coriander (*Coriandrum sativum* L.) is an annual herb belonging to the carrot family, Umbelliferae. It is a native of the Mediterranean region. It is one of the earliest species used by mankind and is cultivated extensively for seed and as a herbal crop in India and to a lesser extent in the former Soviet States, central Europe, middle East, South America and South and Western Australia. The young plants have a unique flavour and are used in chutneys, sauces, curries and soup. The dried fruits are an important ingredient of curry powder. Coriander is used medicinally for a number of purposes, particularly as a carminative. The fruits and the oil are used as a flavouring agent to cover the taste or correct the nauseating or griping qualities of other medicine.

There have been few studies in temperate environments on the agronomy of coriander seed production. The studies reported have covered seed development Wati (1981), defining the optimum time of harvest (Rolston and Reddy, 1997), and sowing date effects (Arganosa, Sosulski and Slikard, 1998). Seed production studies in other Umbelliferae species such as carrot (Noland, Maguire, Oliva, Bradford, Nelson, Grabe and Carrans, 1988) may provide useful principles for coriander. This project was undertaken to evaluate seed production of coriander in Canterbury, New Zealand in studies on the effects of row spacing, plant density, time of sowing and nitrogen (N) responses. This research supports trials on the potential of coriander seed and foliage as possible finishing feeds for livestock to impart desirable flavours to meat (W. Rumball, AgResearch, pers. comm., 1996).

MATERIALS AND METHODS

General

All trials were conducted at Lincoln (43°S) in either 1996/97 or 1997/98. Plots were drilled with an Oyjord cone seeder. The crop was sprayed with linuron at 500 g ai ha^{-1} six weeks after sowing for the control of annual broadleaf weeds and grasses. All the trials were irrigated. The plots were harvested at 45 % seed moisture content (Reddy and Rolston, 1997) when the seeds were golden brown in colour. The seed moisture content at each harvest was measured from fresh seeds from plants selected at random, using an infra-tester. A sub-sample of 10 randomly selected plants was taken to determine the number of umbels per plant. The crop was harvested by cutting the plants at ground level and drying in hesian bags. All samples were dried at ambient temperature and then hand threshed. The seeds were cleaned using a 'Westrup' air-screen seed cleaner, before weighing to determine seed yield. For the time of sowing trial, thousand seed weight (TSW) was determined using 100 seeds from the air-dried sample from each sowing date. Seed germination was determined by placing the seeds on moist germination papers under continuous light at 20°C and counting germinated seeds at 7 and 21 days (ISTA, 1993).

Nitrogen fertiliser and row spacing

This trial was sown on 1 October 1997. The soil type was Templeton silt loam, and soil quick test (Cornforth and Sinclair, 1984) values prior to sowing were pH = 5.9, P=17, K=11, S=16. Superphosphate (0-9-0-11) at 100 kg ha^{-1} was applied before sowing.

Four row spacings (15, 30, 45 and 60 cm) were the main plots. These were sown at 20 kg ha^{-1} with the same intra-row density as used for the 15 cm row spacing. Sub-plots were

[1] *AgResearch, P.O.Box 60, Lincoln, Canterbury, New Zealand.* *Accepted for publication 29 September 1999.*

Table 1. Effect of nitrogen on coriander seed yield and yield components.

Nitrogen (kg ha^{-1})	Seed yield (kg ha^{-1})	Dry matter (kg ha^{-1})	Umbels per plant	Seeds per umbel	Plant population at harvest (m^{-2})	N use efficiency
0	1950	5090	16.0	12.0	219	-
50	2210	5660	19.6	11.6	207	5.2
100	2440	5960	22.3	11.8	222	4.9
150	2430	6510	22.4	11.8	209	3.2
200	2370	5820	20.9	12.1	221	2.1
LSD (P<0.05)	252	1060	1.1	NS	35	1.8

Table 2. Effects of row spacing on coriander seed yield and yield components at two sites.

Row spacing (cm)	Seed yield (kg ha^{-1})	Dry matter (kg ha^{-1})	Umbels per plant	Seeds per umbel	Plant population at harvest (m^{-2})
Templeton soil					
15	2440	6790	17.4	12.0	333
30	2570	5880	20.2	11.3	286
45	2140	5540	26.8	12.2	138
60	1960	5030	24.6	11.9	106
LSD (P<0.05)	226	953	4.2	NS	31
Wakanui soil					
15	2400	7110	15.4	11.5	292
30	2720	6940	22.5	12.6	190
45	2720	6220	29.4	12.8	149
60	2230	5210	28.6	12.8	98
LSD (P<0.05)	300	1398	9.3	NS	19

Table 3. Effect of sowing rate on coriander seed yield and yield components.

Sowing rate (kg ha^{-1})	Seed yield (kg ha^{-1})	Dry matter (kg ha^{-1})	Umbels per plant	Seeds per umbel	Plant population at harvest (m^{-2})
10	2130	6480	40.6	12.3	82
20	2750	7950	27.1	11.6	222
30	2660	7810	25.3	10.6	243
40	2740	8120	20.5	10.3	278
50	1880	7000	16.5	10.5	317
LSD (P<0.05)	501	1719	7.3	1.1	87

nitrogen (N) at 50, 100, 150 and 200 kg N ha^{-1} applied as urea in a split application during vegetative growth (when plants were10-12 cm in height) and at the beginning of stem elongation. There were four replicates of each treatment in a factorial randomised complete block design.

Row spacing

A separate row spacing trial was sown on 17 September 1997 on a Wakanui silt loam soil. The row spacing and sowing rate were the same as for the trial described above, with four replicates of each row spacing treatment arranged in a randomised complete block design. One hundred kg superphosphate ha^{-1} was applied before sowing, and 96 kg N ha^{-1} applied as urea in a split application during vegetative growth and the beginning of stem elongation.

Sowing rate

This experiment was also sown on 17 September 1997 at the same site as the row spacing trial and with the same fertiliser regime. Sowing rates of 10, 20, 30, 40 and 50 kg ha^{-1} at 15 cm row spacing were replicated four times.

Time of sowing

At the same site as the row spacing and sowing rate trials, coriander was sown at two weekly intervals beginning on 17 September 1997 and continuing until 1 December 1997. All

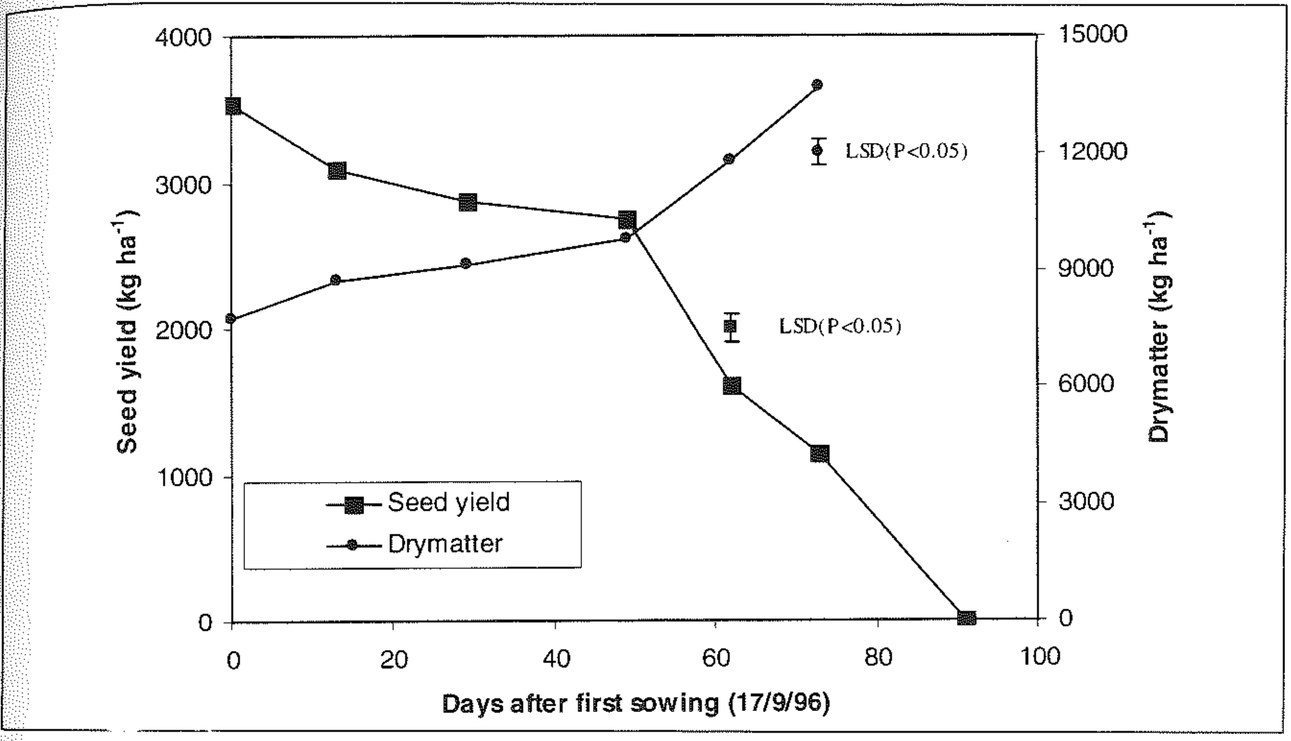

Figure 1. Effect of time of sowing on coriander seed yield and dry matter.

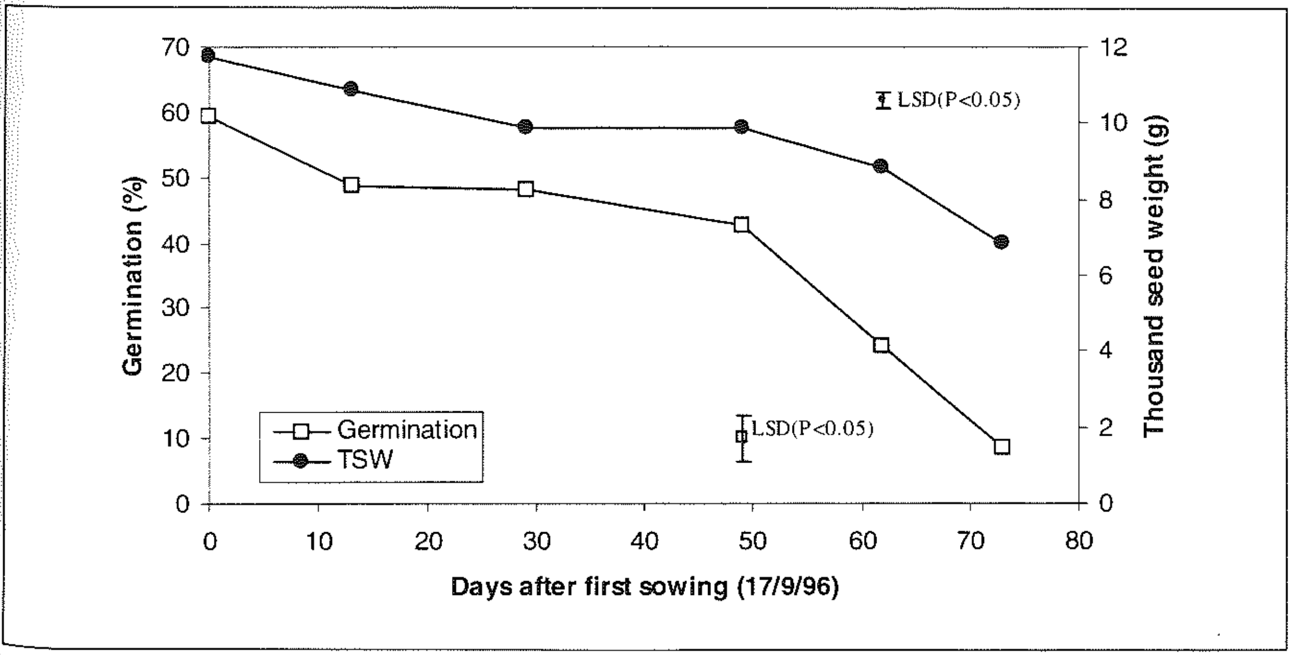

Figure 2. Effect of time of sowing on coriander germination and thousand seed weight.

sowings were at a 15 cm row spacing and the sowing rate was 30 kg ha^{-1}. The fertiliser regime was the same as that for the row spacing and sowing rate trial.

RESULTS AND DISCUSSION

Seed yield

Seed yields in this set of trials were high, averaging 2400 kg ha^{-1} for all four trials (Tables 1-3; Figure 1), with a range from 1880 to 3500 kg ha^{-1}. In previous trials Reddy and Rolston, (1997) reported yields of 1100 to 2860 kg ha^{-1}, while other New Zealand work on coriander has resulted in seed yield ranging from 624 to 2100 kg ha^{-1} (Wati, 1981; Smallfield, 1993). These yields compare with Canadian results of between 1300 and 2340 kg ha^{-1} (Arganosa *et al.*, 1998).

Nitrogen

There was no significant interaction between N and row spacing, and therefore results are presented separately. There was no significant seed yield difference among the four N rates applied (Table 1). The efficiency of N usage (kg seed per kg N applied) declined from 5.1 at 50 kg N to 2.1 at 200 kg N ha^{-1}. In economic terms the price the seed growers receive for coriander seed per kg is equivalent to the price of 0.8 to 1.0 kg N, indicating that there was a positive cost benefit from using N at all rates evaluated.

Row Spacing

For the Templeton soil seed yield was greatest and did not differ between the 15 and 30 cm row spacings, while on the heavier Wakanui soil type seed yield did not differ significantly between the 30 and 45 cm row spacings (Table 2). As these two sites were only 1 km apart, the difference in response is unlikely to be climatic, but due to soil type and in particular moisture retention. A direct yield component comparison can not be made, because the populations differed at the two sites (Table 2). However the result is consistent with previous work (Reddy and Rolston, 1997) where higher yields were obtained on a heavier soil. On the heavier soil type the crop produced 4 to 18 % more dry matter (Table 2) at the same row spacings even though the plant density was lower.

Sowing Rate

Seed yields did not differ among the 20, 30, and 40 kg ha^{-1} sowing rates, but were reduced at the highest and lowest sowing rate (Table 3). This was because the 10 kg ha^{-1} sowing rate produced only 82 plants m^{-2}, and although umbels per plant and seeds per umbel were increased, this could not compensate for the lack of plants. A similar response has been reported for carrot (Gill, Singh and Singh, 1981). Similarly, at the 50 kg ha^{-1} sowing rate only 17 umbels were produced per plant, and although plants m^{-2} were increased, this could not compensate for the lack of umbels (Table 3).

Time of sowing

Seed yield was very sensitive to sowing date (Fig. 1). Seed yield declined 36 kg ha^{-1} day^{-1} from the first sowing on 17 September. These results are very similar to studies carried out in Canada (Arganosa *et al.*, 1998) where the average seed yield decline for six cultivars evaluated for three years was 28 kg ha^{-1} day^{-1}. In most years in Canterbury it would be difficult to sow earlier than mid September, as soil temperatures are too low at the beginning of spring. As sowing date was delayed, the crop dry matter at harvest increased from 7730 kg ha^{-1} (17 September sowing) to 13700 kg ha^{-1} for the 1 December sowing. No seed was harvested when the crop was sown after 1 December, because plants produced only a few flowers which failed to mature into seeds before the first frosts.

Components of Yield

The harvest index (HI) was high, ranging from 33 to 44% in the N and row spacing trials. In the row spacing trial, HI averaged 34% for the 20 to 40 kg ha^{-1} sowing rates, while in the sowing date trial there was a strong relationship (R^2= 0.94) between declining seed yield and declining HI, as later sowings had more dry matter and lower seed yields.

Seeds per umbel did not differ with N or row spacing (Table 1 and 2) but with increasing sowing rate there was a small but significant decline in seeds/umbel from 12.3 to 10.5 when sowing rate was increased from 10 to 50 kg ha^{-1}, which was associated with an increased plant density at harvest (Table 3). Umbels per plant were more responsive to change and were closely associated (R^2 = 0.69) with plant density at harvest in the row spacing and sowing rate trials. Seed yield increases with N application were associated with increased umbels per plant (Table 1).

Both thousand seed weight and seed germination declined as sowing dates were delayed from 17 September (Fig. 2). Nearly two-thirds of the seed yield decline in the time of sowing trial was due to the decline in TSW. Reduced TSW indicates a failure for seeds to fully complete development, and this may explain the germination decline.

CONCLUSION

High seed yields of coriander (over 2000 kg ha^{-1}) can be achieved by using low rates of N fertiliser (50 kg ha^{-1}), by adjusting the row spacing from 15 to 30 cm on a lighter soil and to 30-45cm on a heavier soil, sowing at 20-40 kg ha^{-1} and by sowing early in spring. Delayed sowing resulted in lower seed yields associated with more crop bulk, lower HI and TSW, and reduced germination.

ACKNOWLEDGEMENT

This work was funded by the New Zealand Foundation for Research Science and Technology.

REFERENCES

1. Arganosa, G. C., Sosulski, F. W. and Slikard, A. E. 1998. Seed yields and essential oil of Northern-grown coriander (*Coriandrum sativam* L.). *Journal of Herbs, Spices and Medicinal Plants* 6 (2): 23-33.

2. Cornforth, I.S. and Sinclair, A.G. 1984. Fertiliser recommendations for pastures and crops in New Zealand. Agricultural Research and Advisory Services Divisions. New Zealand Ministry of Agriculture and Fisheries. Pp76.

3. Gill, G.S. Singh, H. and Singh J. 1981. Carrot seed production. II Spacing and umbel order on seed yield. *Vegetable Science* 8: 6-11.

4. ISTA. 1993. International rules for seed testing. *Seed Science and Technology* 21: 75-186.

5. Noland, T.L., Maguire, J.D., Oliva, R.N., Bradford, K.J., Nelson, J.L., Grabe, D. and Currans S. 1988. Effect of plant density on carrot seed yield and quality under seed to seed production systems in California, Oregon and Washington. *Journal of Applied Seed Production*. 6: 36-43.

6. Reddy, K. and Rolston, M.P. 1997. Achievement of maximum seed yield in coriander (*Coriandrum sativum* L.). *Proceedings of the Agronomy Society of New Zealand* 27:37-40.

7. Smallfield, B. 1993. Coriander-*Coriander sativum*. *Crop and Food Research, Broadsheet* No. 30. 4pp. Crop and Food Research Limited, Lincoln, New Zealand.

8. Wati, Maya. 1981. Seed production in coriander. *Fiji Agricultural Journal* 43(2): 69-74.