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The effect of seeding rate and row spacing on seed yield and yield components of squarrosum clover and crimson clover in Southern Italy

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Summary - A trial was conducted for two years (1989 and 1990) at Gaudiano di Lavello (41° 06' 00'' N; 15° 51' 09'' E; 145 m. a.s.l.) with the objective to test the effect of seeding rate (5 – 10 –15 –30 kg ha^{-1}) and row spacing (20 – 40 – 60 cm) on seed production of squarrosum clover (two-year trial) and crimson clover (one-year trial: 1990). The year effect was very evident on seed yield and yield components (plants/m^2, heads/m^2, seeds/head) of squarrosum clover, mainly due to the difference in total rainfall (314 mm and 241 mm, respectively in 1989 and 1990) through the growing season (Nov. – June), although in the second year 250 m^3/ha of irrigation water were applied at the end of March. The seeding rate of 10 kg ha^{-1} and the row spacing of 20 cm gave the highest seed yield in both species. However, the increase in row spacing strongly reduced the seed yield in crimson clover (0.78, 0.63, and 0.51 t ha^{-1} with 20, 40 and 60 cm, respectively), much less in squarrosum clover (0.69, 0.67, and 0.62 t ha^{-1}). Among the yield components studied, seeds/head seems to be the most effective in determining seed yield in both species.

Key-words: *Trifolium incarnatum* L., *Trifolium squarrosum* L., seeding rate, row spacing, seed yield

Résumé - *Une recherche a été conduite pendant deux ans (1989 et 1990) à Gaudiano di Lavello (PZ) (41° 06' 00'' N; 15° 51' 09'' E; 145 m.au-dessus du niveau de la mer.) dans le but d'évaluer l'effet de différentes densités de peuplement (5 – 10 –15 –30 kg ha^{-1}) et écartement des lignes (20 – 40 – 60 cm) sur la production de graines de trifolium squarrosum (deux ans de recherche) et trèfle incarnat (année de recherche: 1990). L'effet de l'année a été très évident sur la production et les composantes de la production de graines (plantes/m^2, capitules/m^2, graines/capitule) du trèfle squarrosum, dû surtout aux différences de pluie totale (314 mm en 1989 et 241 mm en 1990) au cours du cycle cultural (Novembre –Juin), même si au cours de la deuxième année on a appliqué 250 m^3/ha d'eau comme irrigation d'appoint. La dose de 10 kg ha^{-1} de graine et l'écartement des lignes de 20 cm ont permis d'obtenir la production la plus élevée de graines dans les deux espèces. Toutefois, l'augmentation de l'écartement des lignes a réduit d'une manière significative la production de graines du trèfle incarnat (0.78, 0.63, et 0.51 t ha^{-1} avec 20, 40 et 60 cm respectivement), beaucoup moins la production du trifolium squarrosum (0.69, 0.67, et 0.62 t ha^{-1}). Parmi les composantes de la production testées, le nombre de graines/capitule semble influencer d'une manière évidente la production de graines des deux espèces.*

Mots-clés: Trifolium incarnatum *L.*, Trifolium squarrosum *L.*, *densité de peuplement, écartement des lignes, production de graine*

Introduction

Crimson clover (*Trifolium incarnatum* L.) and squarrosum clover (*Trifolium squarrosum* L.) are two species commonly used for annual winter fodder crops, the major forage source in Southern Italy, where they are regarded with some interest also as crops specialised in seed production under favourable ecological conditions.

Plant density plays a crucial role to obtain high seed yields.

Extensive research conducted on squarrosum clover in different Apulian locations (Corleto, 1970; Iannelli, 1977, Martiniello, 1990), pointed out that the optimal seeding rate for seed yield is 10 kg ha^{-1} whereas the effect of different row spacings is not well defined.

For crimson clover there are no reliable experimental data in Italy.

This note reports on the results of a research, conducted for two years on squarrosum clover, and for one year on crimson clover, with the aim to test the seed yield potential with different stand densities.

Materials and methods

The trials were run for two years (1989 and 1990) at Gaudiano di Lavello (PZ), in the demonstration-experimental farm of Basilicata region (41° 06' 00'' N; 15° 51' 09'' E; 145 m.a.s.l.), on a sandy-clay (65% sand, 8% silt, 27% clay), sub-alkaline (pH 7.4) soil, poor in total nitrogen (0.78 ‰), rich in available phosphorus (127 p.p.m.) and exchangeable potassium (622 p.p.m.).

The influence of four different seeding rates (5, 10, 15, 30 kg ha^{-1} corresponding respectively to 115, 230, 345, 690 seeds m^{-2} for squarrosum clover and 125, 250, 375, 750 seeds m^{-2} for crimson clover) on seed yield was studied in both years on squarrosum clover and only in 1990 on crimson clover, in combination with three row spacings (20, 40, 60 cm). For each species, the split plot design with four replicates was used; the sub-plot area was 7.2 m^2 with the seeding rate effect in the plot and the row spacing effect in the sub-plot.

In both years sowing was effected in the second decade of December, using an Italian commercial cv. for squarrosum clover, and an American commercial cv. for crimson clover, both supplied by the agricultural Consortia.

Prior to sowing phosphatic fertilization was performed applying 80 kg ha^{-1} of P_2O_5.

Hoeing was effected in the second decade of March of both years.

The first test year was more rainy than the second one (respectively 314 and 241 mm measured in the November - June period corresponding to the cropping cycle). The particularly dry pattern of winter 1990 (22 mm rainfall recorded in the January-March) made necessary a supplemental irrigation application of 250 m^3 ha on 28/3/90.

The temperature pattern of the two years was quite similar, with negligible deviations from plurennial means.

Crimson clover was harvested on 17/6/90 whereas squarrosum clover was harvested on 10/7/89 and 6/7/90. A plot combine harvester Mod. "Vignoli" was used excluding the external rows of each plot.

Measurements included the seed yield, the no. of plants m^{-2}, the no. of heads m^{-2}, the no. of seeds $head^{-1}$, 1,000 seed weight.

Data were subjected to the ANOVA and the significance of mean differences was assessed applying the SNK test.

Results and discussion

- *Year effect*

This effect was assessed only for squarrosum clover.

The higher rainfall of the first year and the better rainfall distribution through the cropping cycle as compared to 1990, had favourable effects on seed yield (equalling 0.78 and 0.55 t ha^{-1} respectively) and all the yield parameters considered (Tab. 1).

In the second year, besides a lower rainfall, a long period of winter drought was also recorded with 22 mm rainfall in the three-month period from January to March and a poor effect of the supplemental irrigation, applied on March 28th, 1990 with 250 m^3 ha^{-1} of water, was observed on seed yield.

Table 1 – Year effect on seed yield and yield components of squarrosum clover.

Year	Rainfall (mm)	Seed yield (t ha^{-1})	Plants m^{-2} (n.)	Heads m^{-2} (n.)	Seeds head^{-1} (n.)	1,000 seed weight (g)
1989	314	0.78 A	215 A	932 A	54.0 A	5.3 A
1990	241	0.55 B	148 B	659 B	40.7 B	3.5 B

Values not having any letter in common are significantly different at 0.01P – SNK,s test

- *Seeding rate effect*

The mean data of the two-year period of seed production for squarrosum clover and those relating to 1990 for crimson clover showed very similar values between the two species, equalling about 0.65 t ha^{-1} (Tab. 2).

Table 2 – Seeding rate effect on seed yield and yield components of squarrosum clover and crimson clover.

Seeding rate (kg ha^{-1})	Seed yield (t ha^{-1})	Plants m^{-2} (n.)	Heads m^{-2} (n.)	Seeds head^{-1} (n.)	1,000 seed weight (g)
Squarrosum clover (two-year mean)					
5	0.59 C	72 D	596 D	56.6 A	4.4
10	0.86 A	130 C	767 C	52.2 B	4.5
15	0.73 B	203 B	855 B	45.4 C	4.3
30	0.47 D	321 A	964 A	35.2 D	4.3
mean	0.66	182	795	47.4	4.4
Crimson clover					
5	0.65 ab	88 D	429 B	72.5 A	3.7
10	0.78 a	180 C	508 AB	58.4 B	3.9
15	0.61 b	273 B	652 A	41.1 C	4.0
30	0.52 b	389 A	669 A	27.7 D	4.1
mean	0.64	232	564	49.9	4.0

Values not having any letter in common are significantly different at 0.05P (small letters) and 0.01P (capital letters) – SNK test

For both species the highest seed yields were observed with 10 kg ha^{-1} of seed (0.86 t ha^{-1} for squarrosum clover and 0.78 t ha^{-1} for crimson clover). Crimson clover showed actually satisfactory yields also with the lowest seeding rate (5 kg ha^{-1}). Such results are in agreement with a research conducted in Oregon, U.S.A. (Rampton, 1969).

Increasing the seeding rate per hectare, for both species, an increase in the number of plants/m^2 and heads/m^2 and a reduction in the no. of seeds/head were observed, whereas the 1000 seed weight was not affected (Tab. 2)

- *Row spacing effect*

The row spacings (20, 40, 60 cm) (Tab. 3) greatly affected seed yield of crimson clover that tended to decrease as the spacing increased (0.78 t ha^{-1} with 20 cm, 0.63 t ha^{-1} with 40 cm, 0.51 t ha^{-1} with 60 cm), whereas they had a slight depressing effect on squarrosum clover only with 60 cm (0.62 t ha^{-1}).

The number of plants/m^2 of crimson clover tended to reduce as row spacing increased whereas it did not vary significantly in squarrosum clover.

The number of heads/m^2 and the number of seeds/head tended to reduce in both species as the row spacing increased.

No evident effect was observed on the 1,000 seed weight in both species.

Table 3 – Row spacing effect on seed yield and yield components of squarrosum clover and crimson clover.

Row spacing (cm)	Seed yield (t ha^{-1})	Plants m^{-2} (n.)	Heads m^{-2} (n.)	Seeds head^{-1} (n.)	1,000 seed weight (g)
Squarrosum clover (two-year mean)					
20	0.69 A	189	829 A	50.3 A	4.3
40	0.67 AB	180	784 AB	47.7 B	4.5
60	0.62 B	176	773 B	45.0 C	4.4
Crimson clover					
20	0.78 A	265 A	662 A	57.8 A	3.8
40	0.63 B	222 B	514 B	49.7 B	4.0
60	0.51 C	210 B	518 B	42.2 C	4.0

Values not having any letter in common are significantly different at 0.01P – SNK test

Interaction effect

The seed yield of squarrosum clover was favourably influenced (fig. 1) by the most rainy year in the case of seeding rates between 5 and 10 kg ha^{-1}, where the highest values of the number of seeds/head (around 60) and 1000 seed weight (around 5.5 g) were observed .

With the highest seeding rates, yield decreased in both years due to a marked reduction in the number of seeds/head (52 and 45 respectively with 15 and 30 kg ha^{-1} of seed) and 1000 seed weight (5.2 and 5.0 g).

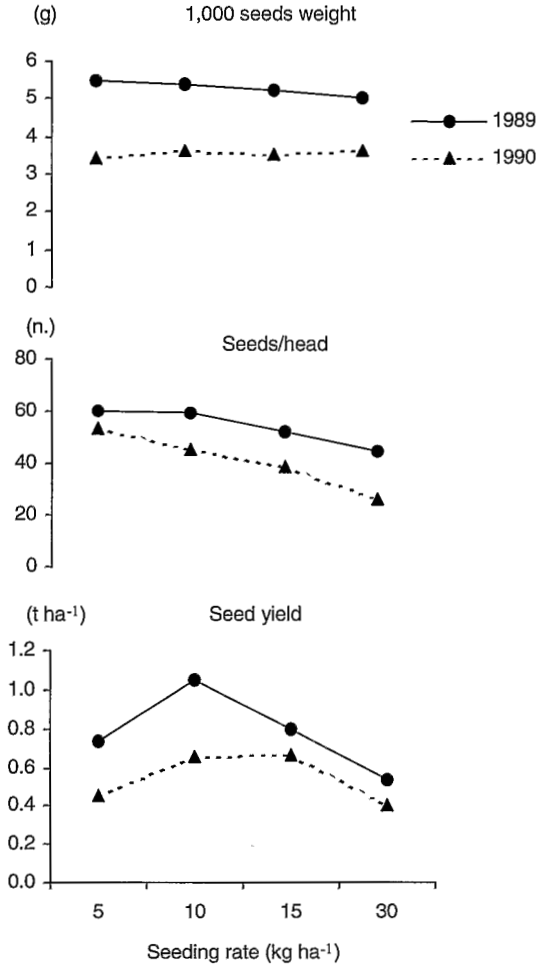

Fig. 1- Years x seeding rate interaction on seed yield, seeds/head, 1,000 seeds weight of squarrosum clover

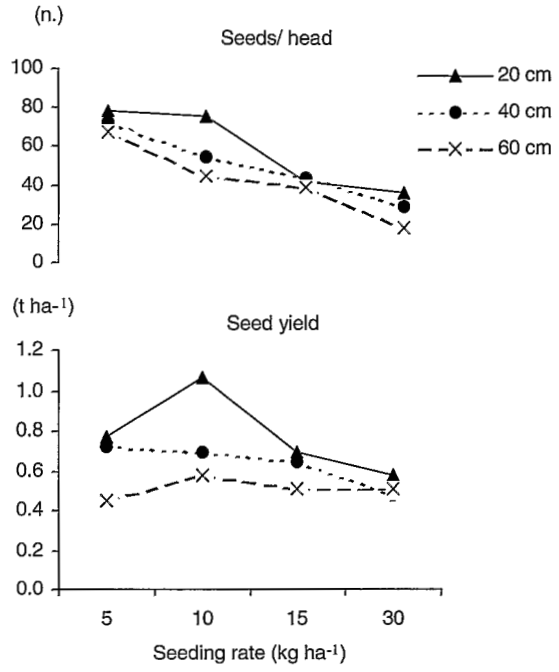

Fig. 2 - Seeding rate x row spacing interaction on seed yield and seeds/head of crimson clover

This could be attributed to a competition effect between plants for the soil available water that would not be enough to satisfy plant water requirements in the case of a high seeding rate.

The seed yields of crimson clover (fig. 2) were higher with 10 kg ha^{-1} and at a row spacing of 20 cm (1.0 t ha^{-1}). This should be related both to the increase in plants/m^2 that was observed shifting from 5 to 10 kg ha^{-1} and to the fact that the number of seeds /head showed the highest values in the above range.

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