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GROWTH RHYTHMS OF LINSEED (*LINUM USITATISSIMUM* L.)

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Abstract

A field experiment was conducted at the Marfa Mwar field station, Univesity of Wales Aberystwyth, UK on a sandy loam soil during 1993 to evaluate the seed density and row spacing effects on the growth rhythms of linseed cv Antares. The treatments comprised of four seeding densities (250, 500, 750 and 1000 seeds/m^2) and three row spacings (12, 15, and 20 cm). Crop growth rate (CGR) was not affected by seed density during early growth period, while lower seed density gave higher CGR later in the season. A progressive reduction in relative growth rate (RGR) was observed with the age of the crop, giving the lowest values during maturity. A higher net assimilation rate (NAR) was observed with lower desnities, however the magnitude of difference was smaller at later growth stages. Row spacing effects and interactions remained statistically non significant

Introduction

Linseed is used throughout the world in a variety of different ways and forms. It contains 36-42% oil and 34-35% proteins, though the oil percentage depends upon the method of extraction. The cake which has an adequate amount of calcium and is rich in phosphorus also contains 7-8% crude fibre, but is deficient in amino acids such as methionine, cytine and lysine. It is a beneficial source of vitamins such as thiamine, riboflavin, nicotinamide, pantothenic acid and choline (Gill, 1987; Turner, 1987).

Information concerning the physiology of growth and development of *linum usitatissimum* are very limited. The practical objective of a growth analysis approach on crop physiology includes the determination of plant factors or the environment which control the production of useful dry matter (Watson, 1968). In crop improvement, growth analysis may be used to identify factors important to the development of economic yield in a particular environment. Bazzaz & Harper (1977) described the life histories of leaves in demographic analysis of growth. Marshall *et al.*, (1988) studied growth and development of oilseed flax in relation to crop canopy development. Potter & Jones (1977) related NAR with the position and orientation of leaves in the canopies. Diepenbrock & Porksen (1992) studied the NAR at plant densities of 200, 400, 600, 800 and 1200 plants/m^2 and found higher and effective NAR at lower densities. The present report describes the effects of seeding density and row spacing on growth rhythms of linseed cv. Antares.

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Materials and Methods

A commercial linseed cv. Antares was used to study the effects of both interplant and interrow competition on growth characteristics. Treatments included all combinations of four seeding densities (250, 500,750 and 1000 seeds/m^2) and three row widths (12, 15 and 20 cm) arranged in a randomized block design with four replications. The experiment was carried out at Marfa Mwar field station some 20 Km south of the University of Wales, Aberystwyth, UK. on a deep sandy loam soil belonging to the Cegin series with significant gravel content and moderately well drained. Prior to the experiment the field was grazed as a temporary lay for three years.

The experimental area was sprayed with glycphosate (Roundup, Schering) in August, 1992 and ploughed in September 1992. Potassium and phosphorus fertilizers were incorporated in March 1993 @ 250 Kg/ha each of K_2O and P_2O_5. Regrowth was sprayed with Paraquat (ICI, Gramoxone) prior to final seedbed preparation. Linseed was drilled at the appropriate seeding densities on 28th April, 1993, with an Oyjord drill. Plots were 8m x 1.2 m and comprised of 10,8 and 6 rows respectively at 12, 15 and 20 cm row spacings. Nitrogen was applied @ 40 Kg/ha by hand immediately after drilling. Plots were sprayed with Bentazone (Basogran) on 5th June, 1993 to control broad leaf weeds. Subsequently, weeds were controlled by hand when required. Plant establishment was assessed from two 0.5 m row lengths of center rows, three weeks after sowing. Plant samples for growth analysis were taken at four stages during the growth season. At each stage, on two 0 5 m lengths of center rows were sampled. The plants were pulled by hand with care to retain as much root as possible then washed to remove traces of soil. A sample of five plants was selected at random for leaf area and dry weight measurements. Leaf area was measured with a leaf area meter (Delta-T Devices Ltd.). Dry weights were recorded after drying at 80°C for 48 hours in a ventilated oven as described by (Jenkins & Leitch, 1986). The leaf area index (LAI) crop growth rate (CGR), relative growth rate (RGR) and net assimilation rate (NAR) were calculated as described by Evans (1972) and Hunt (1990). All the data were analysed using a standard analysis of variance technique.

Results and Discussion

The direct effects of row spacing and interactions with seeding density in all the parameters studied were statistically non-significant so only the effects of seeding density on the perameters under study are presented here.

Leaf Area Index (LAI): Leaf area index is the ratio between leaf area and soil area covered by them. The date showed taht LAI increased with the increase in seeding density at initial stage (Table 1). At 21 days after seeding (DAS) the differences among the seeding densities for LAI were statistically (P=0.05) significant. Lowest LAI (0.09) was observed at 250 seeds/m^2 which increased gradually to maximum (0.28) at 1000 seeds/m^2. Higher LAI values with higher densities were due to increased number of plants per unit area. There was a gradual increase in LAI with the age of the crop in all the seeding densities which attained a peak at 81 DAS. The differences in LAI due to seeding desnities and crop age were visible at 49 and 81 DAS. The difference in LAI

Table 1. Effect of seeding density on growth parameters of linsed *Linum usitatissimum* L.).

Seeding density (seeds/m^2)	Days after seeding (DAS) 21	49	81	106
		LEAF Area Index		
250	0.09 d*	2.03 c	2.68 c	1.41 NS
500	0.15 c	3.02 b	23.15 b	1.49 NS
750	0.20 b	3.49 ab	3.85 a	1.46 NS
1000	0.28 a	3.54 a	3.80 a	1.42 NS
		Crop growth rate (g/m^2/day)		
250	4.56 c*	25.22 NS	6.57NS	-3.34NS
500	6.40 b	23.79	8.78	-2.04
750	7.68 a	23.99	7.59	-3.31
1000	7.81 a	24.47	5.13	-3.31
		Crop growth rate (g/m^2/day)		
250	1.218c*	0.198a	0.0078NS	0.0029NS
500	0.889b	0.133b	0.0095	0.0014
750	0.786b	0.108b	0.0077	0.0025
1000	0.589c	0.110b	0.0053	0.0024
		Net assimilation rate (g/m^2/day)		
250	56.69c*	12.96a	2.81NS	2.34NS
500	44.24b	7.99b	2.98	1.16
750	41.01b	7.00b	2.11	-2.29
1000	28.26c	7.42b	1.53	-2.38

Values with similar letters are non-significant at 5%

between 750 and 1000 seeds/m^2 mitigated with the advancement in the crop growth suggesting that LAI at advanced stages cannot be increased by increasing the seeding density beyond a certain limit. The reduction in LAI after flowering may be attributed to senescence of leaves which began at the base of the canopy. All the seeding densities attained a peak LAI immediately prior to the start of flowering where the presence of maximum number of leaves is the reason for the greatest LAI. Mutual shading of the leaves would have reduced the light penetration to the base of the canopy, promoting faster senescence of lower leaves. According to Bazzaz & Harper (1977), the senescence of leaves begins when the biomass of the population exceeds the carrying capacity of the soil.

Crop Growth Rate (CGR): CGR is the increase in dry matter of crop per unit time per unit land area. The perusal of the data revealed that CGR increased significantly (P=0.05) as seeding density increased upto 750 seeds/m^2 during 21-49 DAS. The 750 and 1000 seeds/m^2 seeding densities were at par with each other. At 750 seeds/m^2 seeding density there was probably maximum light interception beyond which mutual shading increased and higher seeding density did not make any difference. In succeeding growth periods, the effect of seeding desnities was non-significant. Also an opposite trend of decreasing CGR with increasing seeding densities was apparent.

Crop growth rate increased with the age of the plants in all seeding densities attaining a peak at 49-81 DAS period. The progressive increase of CGR throughout plant development until floral bud initiation was also observed by Marshal *et al.*, (1988). Lower CGR during the early growth period by lower densities may be due to the lesser active leaf area which increased with the age of the crop and over rode the higher densities as there were greater number of large sized leaves. The larger and greater number of leaves at lower density has also been recorded by Bazzaz & Harper (1977). During the final growth period negative values indicated a loss of drying matter as the crop matured. The progressive reduction of CGR at later growth stages could be due to the loss of active leaves and translocation of photosynthates to reproductive part.

Relative Growth Rate (RGR): During the early growth stages (21-49 DAS), RGR decreased significantly (P=0.05) with the successive increase in the seeding density (Table 1). The RGR between 500 and 750 seeds/m^2 were at par with each other. During 49-81 DAS, RGR for 250 seeds/m^2 was significantly greater than all the others, while later in the season, the differences among the seeding densities were non-significant. Lower RGR at higher seeding densities may be attributed to the mutual shading causing lesser light penetration into the canopy. Another reason may be that the increasing part of the plant is structural rather than metabolically active tissue and as such does not contribute to growth (Ibrar, 1995). Higher RGR values at lower densities are in agreement with Bazzaz & Harper (1977).

Relative growth rate decreased progressively with the age of the crop. The progressive reduction of RGR may possibly be related to the efficiency of leaves because during the first phase of growth maximum active leaves were present on the plants. Later in the season those at the lower portion of the started to senesce. Marshall *et al.*, (1988) related the decline of RGR with reduction of NAR coupled with LAI.

Net Assimilation Rate (NAR): The leaf position and orientation in the canopies influence the NAR values as some leaves receive full illumination and in turn affect photosynthetic efficiency (Potter & Jones, 1977). NAR decreased as the seeding density increased at early stages. The differnces due to seeding densities were statistically (P=0.05) significant during 21-49 DAS and 49-81 DAS. However, the differences among seeding densities at later growth stages were non-significant. Higher NAR value with lower seeding densities are in accordance with Diepenbrock & Porksen (1992) who concluded that NAR was increasing effectively at low stand densities. In densely sown crops, leaf senescence started earlier thus limiting initiation and subsequent growth of capsules. The NAR decreased progressively with the age of the plants in all the seeding densities wih negative values at 106-138 DAS. It may be attributed to the leaf age and lower photosynthetic efficiency.

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