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The root system and N uptake of a safflower crop (*Carthamus tinctorius* L.)

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ABSTRACT

Field experiment was conducted to study the root system and nitrogen (N) uptake of safflower crop, using three levels of N (0, 40 and 80 kg N ha^{-1}). N application has increased root dry matter and length. When there was shortage of rainfall, the crop roots extended in the deeper layers of the soil. Root and shoot N content also increased with the application of N. In the early stages of growth, it was found that most of the N in the plant was present in the leaves and stems but as the plant matured this N would shift towards the seeds but around 6-10% of the N in the plant would also be present in the roots.

Key words : *Carthamus tinctorius*, N uptake, root dry matter, root length, root N, safflower, shoot N

INTRODUCTION

Safflower (*Carthamus tinctorius* L.) is very important oilseed crop in many parts of the world. India is the largest producer in the world (Knowles, 1958).

Safflower is grown mostly during **rabi** season as a rainfed crop. It is mostly grown in mixture with other crops like **rabi** sorghum and wheat. As a pure crop, it is rotated with crops like sorghum. Although it can be grown in many soils, it is best suited in black soils where the soil can retain more water to sustain the growth of **rabi** crops.

Owing to its deep root system and spiny leaves, safflower is one of the most suitable oilseed crops for drylands. Knowledge of growth and distribution pattern of roots contributes to understanding of nutrient and water uptake behaviour of the crop. Root dry matter information also helps in calculating nutrient balance sheets.

The present study was taken up with two objectives : (1) to obtain information on root dry matter and length and (2) to study root and shoot nutrient uptake at different stages of growth.

MATERIALS AND METHODS

The experiment was conducted at ICRISAT Asia Center (IAC), India, on a deep vertisol in a developed watershed. Chemical properties of the field prior to sowing are shown in Table 1. Measurements were made during post-rainy seasons of 1994-95 and 1995-96. The monthly rainfall and mean maximum and minimum temperature for the experimental period are given in Table 2.

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The experiment was laid out in a randomized complete block design (RCBD), with three replications. Three levels of N (0, 40 and 80 kg N ha^{-1}) were applied. The crop received the complete dose at the time of sowing. Also the crop received a basal phosphorus (P) application of 20 kg P ha^{-1} at the time of sowing. The variety grown was Manjira which is a medium duration variety.

Plant Dry Matter Measurements

An area of 1 m^2 was marked, and plants in that area were cut. Sample plants were then oven dried at 60°C to constant weight and their dry weights were recorded. The dry plants were then ground prior to laboratory analysis.

Measurements of Root Growth

Root samples were taken from 1 m^2 sub-plots in N 0 and N 80 treatments. For root sampling, soil cores of 7 cm diameter were taken to a depth of 120 cm. Two cores were taken between rows and two cores on the rows between plants. A fifth core was taken on top of one plant.

Samples were combined and soaked in water overnight. Subsequently roots were washed over a sieve of 1 mm mesh, and then hand picked and stored in a mixture of ethyl alcohol and water at the ratio of 2 : 1 at 5°C. Root length of the total sample was determined using a Comair root length scanner. Then roots were oven-dried at 60°C to constant weight, and dry weights were determined.

Nitrogen concentration of shoot and roots was determined by Kjeldahl method followed by colorimetric determination, using a Technicon Autoanalyser (Technicon Industrial System, 1994).

RESULTS AND DISCUSSION

There was adequate rainfall at the time of sowing in both the years. In 1994, the crop received some rain during the flowering stage.

Root Dry Matter

Nitrogen application had a considerable effect on root mass of the crop. Differences in root dry matter between N 80 and N 0 plants were significant in both the years. However, in 1994 safflower root dry matter was slightly lower compared to 1995 (Fig. 1).

In both the years, root growth of the crop continued till shortly before maturity, but the rate of growth was less compared to the early stages. This could be due to the shortage of rainfall in the later part of the season, and the crop tended to extend its roots in deeper layers to extract water. Hashemi (1994) found that safflower crop grown under water stress penetrated its roots to greater depths to obtain water compared to irrigated crop. In both the years, the highest safflower root biomass was recorded at 130 days after sowing (DAS).

Fig. 1 shows average root organic matter returns to the soil profile by the crop. Most of the root organic matter (60-70%) returning to the soil is deposited in the upper 0-30 cm layer.

Root Length

Fig. 2 shows the total root length of the crop and its distribution in the soil profile. The crop has a strong tap root system. In both the years, the roots penetrated upto 120 cm, particularly in the later part of the season to exploit deeper soil layers.

Root N Content

When adequately fertilized (80 kg N ha^{-1}), maximum root N content was 3.4 kg N ha^{-1} in 1994, but in case of N 0, N returns through roots were around 1.7 kg N ha^{-1} (Fig. 3). In 1995, root N content of safflower was higher than in 1994. Even though root N uptake started slowly, it continued to increase in the N 80 treatment. In the N 0

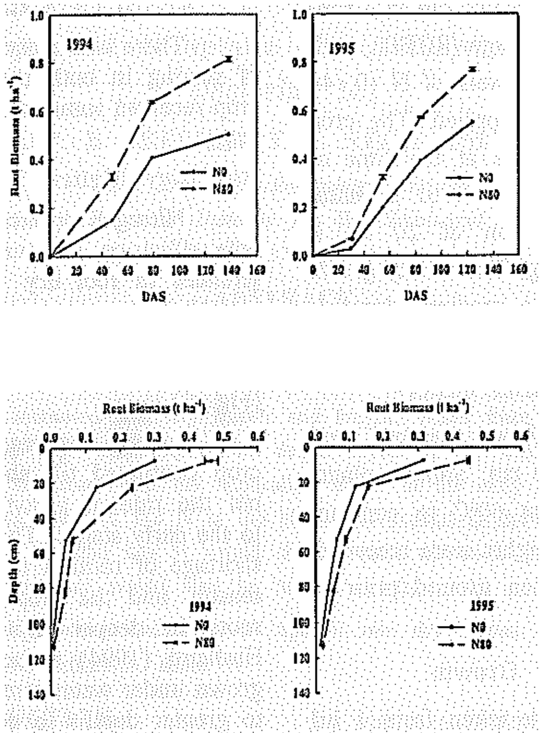

Fig. 1. Root biomass of safflower at the different stages of growth and its distribution in soil profile.

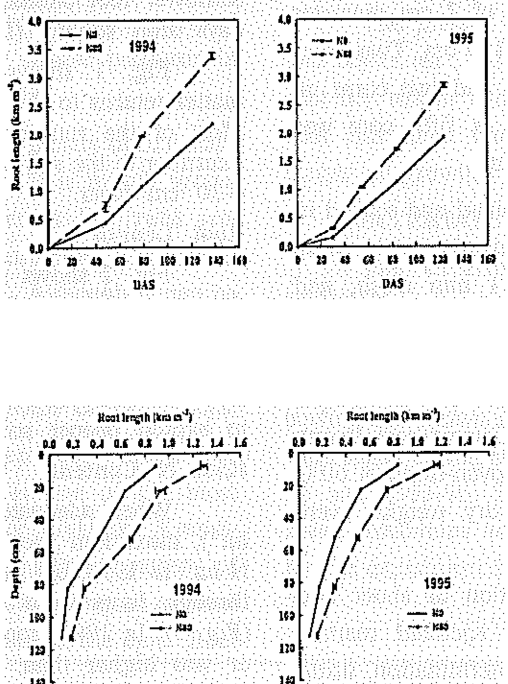

Fig. 2. Root length of the safflower crop and its distribution in the soil profile.

Table 1. Chemical properties of the experimental field used prior to crop growth period

Soil depth (cm)	pH	E. C. (dS m^{-2})	NO_3 (mg kg^{-1})	Total N (mg kg^{-1})	OC (%)
0-15	8.19	0.26	2.67	639	0.62
15-30	8.33	0.17	<1	434	0.47
30-60	8.39	0.16	<1	370	0.44
60-90	8.23	0.23	<1	331	0.39

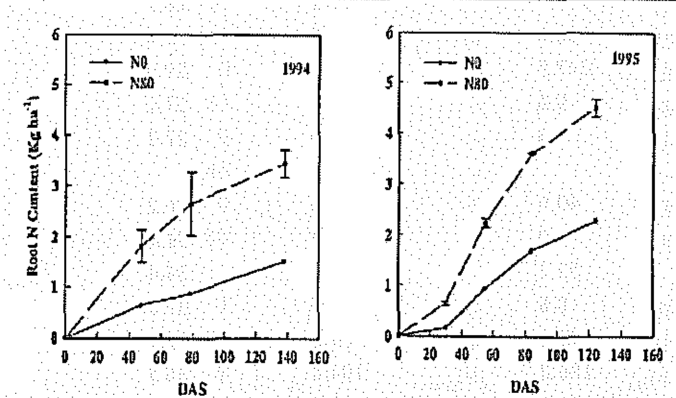

Fig. 3. Root N content of safflower at the different stages of growth.

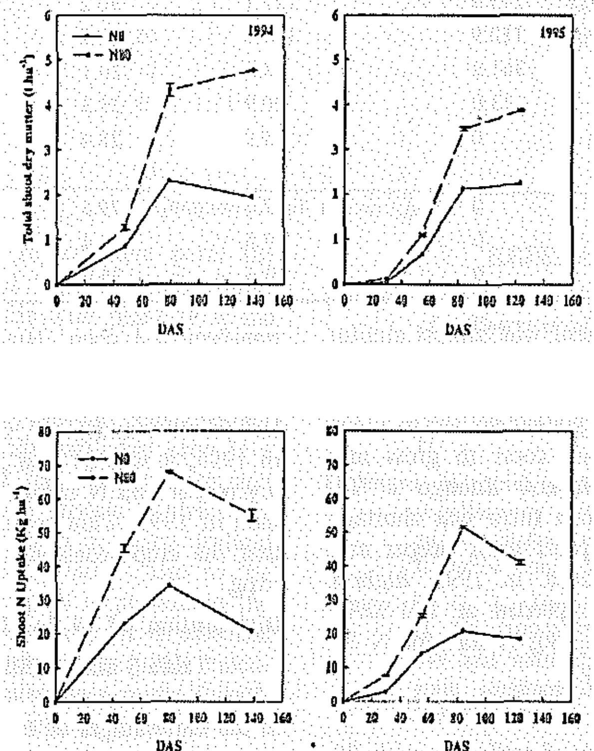

Fig. 4. Shoot biomass and N uptake of safflower.

Table 2. Monthly rainfall (mm) and average maximum and minimum temperatures (°C) at ICRISAT Asia Center, June 1994-March 1996

Month/Year	Rainfall during the season (mm)	Normal rainfall (mm)	Temperature (°C)	
			Maximum	Minimum
1994				
June	144.4	104.4	33.7	23.6
July	142.9	191.2	29.4	22.4
Aug.	196.9	127.1	28.9	22.1
Sept.	66.0	162.6	30.4	20.9
Oct.	247.5	83.5	29.5	20.7
Nov.	9.6	20.9	27.1	15.6
Dec.	0	5.9	27.1	10.3
1995				
Jan.	40.0	7.6	26.2	13.2
Feb.	0	9.5	31.0	16.0
Mar.	52.2	10.6	34.4	20.2
Apr.	8.8	28.5	37.0	22.6
May	43.8	31.2	36.9	23.7
June	136.2	104.4	36.5	25.0
July	252.0	191.2	30.1	22.8
Aug.	245.6	127.1	30.2	22.8
Sept.	112.9	162.6	30.2	22.1
Oct.	361.0	83.5	29.1	20.4
Nov.	13.0	20.9	29.3	16.2
Dec.	0	5.9	28.4	13.9
1996				
Jan.	0	7.6	29.6	15.4
Feb.	0	9.5	31.4	16.8
Mar.	0	10.6	36.0	19.3

crop, the root N content was almost similar to that of same treatment in 1994. Because of the lack of fainfall in the later part of the season, the wetting front tended to move deeper. This can cause roots to grow and exploit deeper soil layers. Zaongo *et al.* (1994) found that, when there was shortage of rainfall, sorghum roots grew deeper and their N uptake increased. In 1995, highest root N content was recorded at 120 DAS and it was 4.7 and 2.3 kg N ha^{-1} for N 80 and N 0, respectively.

Shoot N Uptake

Nitrogen uptake of safflower with 80 kg N ha^{-1} was significantly higher than the non-fertilized crop. Highest N uptake was recorded at 80 DAS (Fig. 4). In 1994, the maximum N uptake was 38 and 68 kg N ha^{-1} for N 0 and N 80, respectively, whereas in 1995, it was 21 and 52 kg N ha^{-1}. Shoot dry matter and N uptake was higher in 1994 than in 1995. This could be due to the rain that the crop received at the time of flowering.

Distribution of N in the Plant Parts

Table 3 shows distribution of N in the different plant parts as percentage of total N. In the early stages of the plant growth, most of the N in the plant is present in the leaves and stems, but as the plant progresses to-

Table 3. N content of the different plant parts as percentage of total N in the plant during 1994 and 1995 cropping seasons

Plant part	N applied ($kg\ N\ ha^{-1}$)	Days after sowing		
		55	84	124
1994				
Leaves	0	80	27	27
	80	76	23	34
Stems	0	15	17	11
	80	18	25	12
Grain	0	-	53	50
	80	-	48	45
Chaff	0	-	-	5
	80	-	-	3
Roots	0	5	3	7
	80	6	4	6
1995				
Leaves	0	79	20	24
	80	68	22	21
Stems	0	14	14	12
	80	24	12	11
Grain	0	-	58*	48
	80	-	59*	53
Chaff	0	-	-	5
	80	-	-	5
Roots	0	7	8	11
	80	8	7	10

*Complete head (Grain+chaff).

wards formation of reproductive parts the bulk of N is shifted towards seeds. Roots represent 6-10% of the total plant N at the time of harvest which is a considerable amount which returns to soil.

From this study we can conclude that the roots system of the safflower crop is a very integral part of the plant growth and it is one of the major factors contributing to the success of the crop in many dryland of the world particularly India. Also as the 6-10% of the total crop N is present in the roots at the time of maturity, it is essential to take that into consideration while calculating the nutrient requirement or the following crop or nutrient balance sheets.

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