THE EFFECT OF TIME OF APPLICATION AND CHEMICAL FORMULATION OF NITROGEN FERTILISERS ON THE MORPHINE PRODUCTION OF POPPIES (PAPAVER SOMNIFERUM L.) IN TASMANIA.

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Abstract

In Tasmania poppies (*Papaver somniferum L.*) are mainly grown on krasnozem soils of the north west region of the State. A series of field experiments investigated the effect of high rates of nitrogen applied either banded at drilling or top-dressed at various times between emergence and flowering. In addition various chemical formulations of nitrogen fertilizer were compared under a wide range of irrigation regimes.

In two field experiments factorial combinations of ammonium sulphate at N1=50, N2=100, N3=150 and N4=200 kg N/ha were band placed with superphosphate at the same four rates of P. 100 kg N increased dry matter yield of poppy heads by 20 - 40% and morphine concentration by about 10% - 20% compared with the general commercial rate of 20 kg N/ha.

Other field experiments have compared the effect of ammonium nitrate at 0, 40, and 80 kg N/ha applied top-dressed 28 days before flowering (early stem elongation), 14 days before flowering and 1 week after flowering. The optimum time of application tended to be 14 days before flowering and yields increased up to the 80 kg N/ha rate. Dry matter yields of capsules were increased by about 10-20%.

A third series of experiments compared the effect of different forms of N : ammonium nitrate, ammonium sulphate, potassium nitrate, calcium nitrate, and urea at 0, 40 and 80 kg N/ha top-dressed 2 weeks before flowering. These comparisons were made under a wide range of irrigation regimes. All ammonium and nitrate forms of N had similar effects on dry matter and morphine and the maximum effect on morphine concentration of capsules occurred at a high rate of irrigation which was continued until a month after flowering.

1. Introduction

In Tasmania nitrogen fertiliser is usually applied at about 20 kg N/ha band-placed directly below the seed when the crop is drilled (Laughlin, 1978). In some seasons pale green colouration of the leaves has suggested that nitrogen supply was inadequate. Because of this a series of field experiments were carried out to investigate the effect of (i) higher rates of nitrogen band-placed at drilling, (ii) different times of top-dressed N application, (iii) different chemical formulations of nitrogen fertiliser, top-dressed with a wide range of irrigation regimes.

2. Materials and Methods

2.1. The effect of band-placed nitrogen fertiliser on dry matter yield and morphine production

Nitrogen fertiliser in the form of ammonium sulphate was band-placed 60 mm directly below the seed at 50, 100, 150 and 200 kg N/ha in factorial combination with concentrated superphosphate at 50, 100, 150 and 200 kg P/ha. In addition two other treatments were incorporated in this experiment: a nil fertiliser and a mixture of 20 kg N and 50 kg P/ha. All the treatments were set out in a randomised block with four replications. The experiment was irrigated when the soil moisture deficit fell to 35 mm until flowering and the heads (capsule + seed) were harvested at dry commercial maturity (12% moisture of capsules). This experiment was repeated at two sites: one low and the other high fertility. This experiment, along with all others described in this paper, were carried out on krasnozem soils (Stace 1966).

2.2. The effect of time of application of top-dressed nitrogen fertilisers on dry matter yield and morphine.

In this experiment 20 kg N/ha was band-placed 50 mm directly below the seed at drilling with 40 kg P and 50 kg K/ha. Later, additional nitrogen in the form of ammonium nitrate was top-dressed (uniformly distributed over the soil surface) at 0, 40 and 80 kg/ha at (i) early stem elongation (4 weeks before flowering), (ii) 2 weeks before flowering and (iii) 1 week after flowering. All applications were immediately followed by overhead sprinkler irrigation (30 mm) and irrigation, continued until about one month after flowering. The experiment was harvested at dry commercial maturity.

2.3. The effect of different chemical formulations of nitrogen fertiliser on dry matter yield and morphine.

In this experiment 20 kg N/ha (as ammonium nitrate) was band-placed 50 mm directly below the seed at drilling along with 40 kg P and 50 kg K/ha. Additional nitrogen fertiliser at 0, 40 and 80 kg N/ha was top-dressed at 2 weeks before flowering onto plots which had all received 20 kg N/ha banded below the seed. The later top-dressed N was applied as ammonium nitrate (NH_4NO_3), ammonium sulphate $(NH_4)_2SO_4$, calcium nitrate ($CaNO_3$), potassium nitrate (KNO_3), sodium nitrate ($NaNO_3$) and urea ($CONH_2$). Nitrogen application was immediately followed by overhead sprinkler irrigation which was applied at rates of zero, 14, 30 and 44 mm/hour. The top-dressed nitrogen treatments were set out in a randomised block design with four replications and the irrigation treatments were applied from a line source system (Hank 1978). Irrigation was applied at zero, 14, 30 and 44 mm/hour whenever the soil moisture deficit fell to 35 mm. This cycle of irrigation commenced about one month before flowering and continued until about one month after flowering. In Table 4 the four irrigation regimes are expressed as the total amounts of water i.e. 0, 100, 200 and 300 mm applied over a period of 2 months. The experiment was harvested at dry commercial maturity.

3. Results

3.1. Banded nitrogen applied at drilling

At the low fertility site there was a large response to nitrogen application which was similar and consistent at all levels of phosphorus (Table 1). 100 kg N increased the dry matter yield of poppy heads by 40 and 20% at the low and high fertility sites compared with the standard application of 20 kg N/ha. Capsule and seed were increased by a similar fashion and morphine increased by 20% and 10% respectively at the two sites.

3.2. Time of application of top-dressed nitrogen

Nitrogen fertiliser top-dressed before flowering gave higher yields of poppy heads than when applied post flowering (Table 2). Of the two times of application before flowering tested that at 14 days before flowering tended to give higher yields of both head and morphine. Both the capsule and the seed component responded similarly.

3.3. Comparative effects of different nitrogen formulations

The mean effect of the 40 and 80 kg N/ha rates gave small increases over the zero control and all forms of nitrogen had a similar effect (Table 3). In contrast the effect on leaf nitrogen levels at early flowering was much more substantial and all forms of nitrogen gave 28% increase over the control. The effects of the different forms of nitrogen on morphine concentration were also very comparable and the mean increase was of the order of 20% above the zero N control.

3.4. The effect of top-dressed nitrogen at different irrigation regimes.

Top dressed nitrogen had a relatively small effect on the dry matter yield of poppy heads at the high fertility site (Table 4). In fact at the 100 mm and 200 mm regimes there was a slight trend towards a decrease in yield with nitrogen application. However the application of irrigation *per se* gave a very large increase of about 35% in head yield between the 100 mm and 200 mm total irrigation. Both capsule and seed gave similar patterns of response.

In contrast to dry matter yield, top-dressed nitrogen gave very substantial increases in morphine concentration of capsules as irrigation increased. The maximum effect (about 20% increase) was at the 200 mm irrigation but at the highest irrigation (300 mm) morphine concentration started to decrease.

Discussion

In contrast to previous experiments on the Tasmanian krasnozem (Laughlin 1978) there were no interaction effects between banded N and P (Miller 1974). Banded N increased both dry matter yield and morphine concentration at all levels of banded P in this experiment. The increase in morphine concentration of capsules on the high fertility site was relatively small compared to the impact on dry matter yield.

Time of application of top-dressed nitrogen is of some biological and practical significance. On the one hand it should be early enough to influence the plant's growth before any substantial deficiency of nitrogen has occurred. On the other it should not be so early that undue leaching of nitrogen may occur or cause excess vegetative growth to the detriment of capsule growth. However the later application of top-dressed nitrogen imposes problems of some crop damage by the passage of tractor drawn applicators. Alternative methods which can be used are the application through the irrigation system or by aerial top-dressing. In Experiment 2 there was no evidence of nitrogen deficiency from leaf colour at either 28 or 14 days before flowering although nitrogen deficiency symptoms showed up clearly soon after this.

All forms of nitrogen: nitrate, ammonium or urea gave comparable increases in leaf N at flowering and capsule morphine at dry commercial maturity. This contrasts to the findings of Costes et al (1978) who obtained the greatest effect with nitrate N. All forms of N also had comparable effects in the proportion of seed and capsule in the heads with no effect of increasing the seed component as found by Van Roon (1962) or Turkede et al (1981).

It is quite clear from experiment 4 (Table 4) that the effectiveness of top-dressed N is very dependant on the amount of soil water available to the plant. This is illustrated by the large increase in morphine between the 100 mm and 200 mm treatments but the decrease after this point suggests that some leaching of morphine may have occurred at higher rates of irrigation (Loftus Hills 1944).

In Experiment 4, irrigation was applied up till about one month after flowering. In current practical farming it is not commonly feasible to irrigate poppies as late as this because of competing demands for limited irrigation water from other cash crops. Thus future research will explore the responses to top dressed N in the situation where irrigation ceases at flowering or alternatively continues at a much reduced frequency.

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Table 1 - The mean effect of banded nitrogen on head yield and relative capsule morphine concentration (max. 100). Experiment 1

Treatment	Low fertility		High fertility	
kg N/ha	Head t/ha	Morphine max. 100	Head t/ha	Morphine max. 100
0	0.7	81	2.4	92
20	1.6	86	2.5	90
50	1.8	97	2.8	98
100	2.3	98	2.9	98
150	2.2	100	2.9	100
200	2.3	100	3.0	99

Table 2 - The effect of time of nitrogen application on head yield and capsule morphine yield. Experiment 2.

Days pre (-) or post (+) flowering	Head t/ha			Morphine kg/ha		
	ON	4ON	8ON	ON	4ON	8ON
-14	3.17	3.30	3.75	12.1	14.0	17.1
-28	3.17	3.21	3.55	12.1	13.1	16.0
+7	3.17	2.80	3.20	12.1	12.9	14.0

Table 3 - The mean effect of nitrogen formulation on head yield, leaf nitrogen and relative capsule morphine concentration (max. 100) Experiment 3.

Form of N	Head t/ha	Leaf nitrogen % N	Morphine max. 100
Nil	4.0	2.5	80
Ammonium sulphate	4.0	3.2	98
Ammonium nitrate	4.1	3.2	100
Potassium nitrate	4.2	3.2	99
Calcium nitrate	4.0	3.2	97
Urea	4.3	3.2	98

Table 4 - The mean effect of nitrogen on head yield and relative capsule morphine concentraiton (max. 100) at various irrigation regimes (mm). Experiment 4.

Treatment	0 mm		100 mm		200 mm		300 mm	
	Head t/ha	Morph. max. 100	Head t/ha	Morph. max. 100	Head t/ha	Morph. max. 100	Head t/ha	Morph. max. 100
0	3.0	83	3.4	80	4.6	79	3.2	83
40	3.2	85	3.3	86	4.5	93	4.5	88
80	3.1	87	3.2	87	4.4	100	4.5	90