EFFECT OF DICYANDIAMIDE (DCD) AND PYRETHRUM FLOWER-WASTE ON GROWTH AND MENTHOL-CONTENTS OF *MENTHA ARVENSIS L.*

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ABSTRACT

Pyrethrum (Chrysanthemum cinerariefolium) flowers have been observed to have insecticidal properties and could be used as indigenous nitrification inhibitors for increasing N-use efficiency and growth. A field experiment was conducted at National Agricultural Research Centre, Islamabad, during 1998 and 1999, to evaluate the relative performance of pyrethrum flower-waste and Dicyandiamide (DCD) as nitrification inhibitors, applied with prilled urea (PU) to Japanese mint (Mentha arvensis L.) The results revealed that application of the nitrification inhibitors with prilled urea significantly increased the growth and menthol contents of the crop, compared to that of prilled urea alone. Addition of DCD and pyrethrum flower-waste gave 30% and 23% more herb-yield than prilled urea alone, the corresponding increase in oil-contents being 27% and 22%, respectively. Application of nitrogen at 200 kg ha^{-1} in dicayndiamide or pyrethrum flower waste-treated soil enhanced the growth and menthol contents of crop significantly more than that for 300 kg N ha^{-1} with prilled urea. Both the materials improved the N use-efficiency one and half times, compared to that with PU at 100 kg N ha^{-1}. The results indicate that pyrethrum flower-dust can be effectively used as a potential nitrification inhibitor.

INTRODUCTION

Japanese mint is an important essential-oil-bearing crop, cultivated for menthol, used in cosmetic and pharmaceutical industry. It is generally planted in January-February in the plains of Punjab, Pakistan. *Mentha arvensis* is a herbaceous plant, usually grown in loamy to clayey loam soil. On the average, it requires 120 kg ha^{-1} N for optimum growth. Frequent irrigations are generally given during the entire growth-period of this crop, till the monsoon comes.

A loss of N due to NO_3 leaching is a serious problem in the medium-textured soils of Punjab. This loss is considered to be greater during the rainy season. This results in a very poor N-use efficiency.

Commercial nitrification-inhibitors are recommended for application with ammonium and ammonium-producing fertilizers, to retard the formation of nitrate by nitrifying bacteria and thus reduce the loss by leaching and denitrification. Many plant-products and by-products have also been reported to have nitrification-inhibitory properties and have successfully been used to retard nitrification in soil (Sivapalan & Fernando, 1985., Prakasha and Puttana, 1994., Sharma and Prasad, 1996).

Pyrethrum flowers are grown for their insecticidal and ornamental properties. Preliminary investigations have indicated that pyrethrum also has unique nitrification inhibitory properties (Ram *et al.*., 1993). The aim of the present work was to evaluate the relative performance of pyrethrum flower-waste and DCD as inhibitors for reducing N losses and increasing growth and menthol-contents of mint.

MATERIALS AND METHODS

A field experiment was conducted for two years, during 1998 & 1999, at NARC, Islamabad, Pakistan. The soil of the experimental plot was loam in texture and had pH 7.8, EC 0.25dSm^{-1}, available N 0.04%, available K 0.76 mg kg^{-1}, and P 4.5 mg kg^{-1}.

The treatments consisted of three combinations of nitrogen and nitrification inhibitors, viz prilled urea + no inhibitor, urea + dicyandiamide (DCD) and urea + pyrethrum flower waste, with three levels of nitrogen (100, 200 and 300 kg ha^{-1}) and one control. The statistical design was a randomized block-design with three replications.

Suckers of Japanese mint were transplanted end-to-end in the last week of January in 5 cm deep furrows, 40 cm apart and covered with 5 cm soil. Nitrogen was applied in two equal splits i.e., at planting and after first harvest. Dicyandiamide was applied at planting time @ 15 ppm on soil-basis, considering the plough-depth having a bulk density of 1.47 g cm^{-3}. This was thoroughly mixed with the soil. Pyrethrum flower-waste, a by-product of medicinal plant (100 ppm on soil basis) was also applied at planting-time and thoroughly mixed with the soil. The crop, both in the control and N plus inhibitor-treated plots, received a uniform application of 60 kg ha^{-1} each of P and K at the time of planting, as single super-phosphate and muriate of potash, respectively. Two harvests of the herb, 15 days after planting (DAP) and 75 days after first harvest, were taken during 1998. However, in 1999, only first harvest, 115 days after planting, was taken because a second harvest from the regenerated crop was not possible due to heavy rains.

Soil samples were collected at 0-15 cm and 15-25 cm depth, randomly, from five sites in each plot at 30 days after planting, 60 days after planting and after first harvest, and analysed for ammoniacal and nitrate form of N, by the procedures described by Jackson (1967) and Black *et al.* (1965). Mineral N is presented in kg ha^{-1}, taking bulk density of the soil 1.47 g cm^{-3} and soil depth 15 cm; 1 hectare soils weighs 2.205 x 10^6 kg. The soil pH, EC, mineral N and soil-texture was determined by the method described by Winkleman *et al*. (1990). Values for tissue P and K were obtained by atomic absorption spectrophotometer.

RESULTS AND DISCUSSION

Growth and Menthol Contents

Dicyandiamide (DCD) and pyrethrum flower-waste significantly increased the growth and menthol contents in Japanese mint, over prilled urea (Table 1). The increase in growth was in the order of 37 and 27 % by DCD and pyrethrum, respectively, over prilled urea (PU) in 1998. The corresponding increase in 1999 was 23 and 18 %, respectively. On application of 300 kg ha^{-1} N, the maximum growth observed was 17 t ha^{-1}, compared to 4.1 t ha^{-1} of control (Table 1). It might be due to high utilization of N by the crop, as a result of retardation-loss of fertilizer N by the nitrification inhibitors. The usage of DCD as a potential inhibitor has been reported by several workers in upland condition. (Sharma and Prasad, 1996; Arshad *et al.,* 1999). Pyrethrum flower-waste application significantly improved the growth, compared to the prilled urea, although rate of increase was low compared to DCD. Pyrethrum flower-waste is thought to have some nitrification inhibitory properties (Ram *et al.*, 1993), as in several naturally occuring plant-materials (Sahrawat, 1982; Sharma and Prasad, 1996). The inhibitory properties of pyrethrum flower-waste may be attributed to the residual quantity of pyrethrin, which is known to be a domestic insecticide. The same insecticidal properties have played a vital role in limiting the process of nitrification.

Dicyandiamide and pyrethrum flower-waste increased the menthol contents over prilled urea by 23% and 20% in 1998 and 31% and 21% in 1999. Both growth and menthol-contents increased with increasing rate of nitrogen application. Substantial increases in herb and essential-oil yield of Japanese mint, due to high levels of N, have been reported by Sharma and Singh (1980) and Ram *et al.* (1989).

Interaction effects, amongst nitrification-inhibitors and N-rates, showed that growth and menthol-contents were significantly increased at 200 kg N ha^{-1} applied with DCD or pyrethrum flower-waste, compared to 100 kg N ha^{-1} urea applied alone or with DCD or pyrethrum waste and 200 and 300 kg N ha^{-1} applied as PU alone, during both the years (Table1). Obviously, application of N at 200 kg ha^{-1} with DCD or pyrethrum flower-waste economized 100 kg N ha^{-1}. Higher growth and menthol-contents with inhibitor may be due to inhibition of nitrification-process in soil, resulting in reduced nitrogen-losses through different mechanisms.

Mineral nitrogen status of soil

The data on status of NH_4–N and NO_3–N, estimated at 30 and 60 days after planting (DAP), and at first harvest (115 DAP), reveal that NO_3–N was the lowest in DCD-treated plot, followed by that in pyrethrum-treated plots (Table 2 and 3). This indicates retardation of nitrate formation by both the nitrification inhibitors. Many studies have shown that nitrification inhibitors can be used to enhance NH_4–N, supply, particularly when reduced nitrate-movement to groundwater is increasing the proportion of N supplied to the crop as NH_4–N (Ball-Coelho, 1999). In 1999, however, the nitrate content, which was lower in DCD treated soil than in the pyrethrum treated soil in the early stages, was found at par during the later stages (60 DAP and first harvest). Our results are in agreement with those of Puttana *et al*. (1999), which indicated that concentrations of the inhibitors in soil delayed the nitrification up to 60 days. Another reason behind that is reduced N-leaching, because restricted post-

Table – 1: Growth and Menthol Contents of Japanese mint, as affected by different nitrification inhibitors and nitrogen level

N-rate (kg ha-1)	Growth ($t\ ha^{-1}$)				Menthol Content ($kg\ ha^{-1}$)			
	PU*	DCD	PF	Mean	PU	DCD	PF	Mean
1998								
100	8.6	10.2	9.9	9.6	59	68	70	66
200	10.5	14.9	13.9	13.1	80	101	96	92
300	11.8	17.0	15.5	14.8	91	111	105	102
Mean	10.3	14.0	13.1		76	93	90	
Control				4.1				25
C.D. 5% control vs N-rates				1.2				9
C.D. 5% for inhibitors				0.8				6
C.D. 5% for N-rates				0.8				6
C.D. 5% for N-rates x Inhibitors				1.4				11
1999								
100	11.9	14.5	14.0	13.5	96	126	114	112
200	13.2	15.8	15.3	14.7	110	138	128	125
300	13.3	16.7	16.2	15.4	110	149	143	134
Mean	12.8	15.7	15.2		105	138	128	
Control				3.8				33
C.D. 5% control vs N-rates				1.0				9
C.D. 5% for inhibitors				0.7				6
C.D. 5% for N-rates				0.7				6
C.D. 5% for N-rates x inhibitors				1.2				11

*Prilled urea, DCD – Dicyandiamide, PF – Pyrethrum Flower waste

Table – 2: Nitrogen forms in soil ($kg\ ha^{-1}$)

Treatment	1998				After first harvest	
	30 DAP*		60 DAP		115 DAP	
	NH^4	NO^3	NH^4	NO^3	NH^4	NO_3
Nitrification inhibitors						
Prilled urea	99	95	56	37	33	32
Dicyandiamide	101	75	47	30	26	25
Pyrethrum flower dust	96	86	55	35	30	28
C.D. 5%	3.92	4.12	3.45	2.63	1062	1.64
Nitrogen Levels ($kg\ ha^{-1}$)						
100	85	78	45	30	28	24
200	89	84	52	33	30	28
300	98	94	60	39	32	32
C.D. 5%	3.88	4.1	3.40	2.65	1.65	1.60
Control	88	48	23	22	23	18
C.D. %5 control vs N-levels	5.44	5.68	4.70	3.65	2.45	2.40

*DAP – Days After Planting

Table – 3: Nitrogen forms in soil ($kg\ ha^{-1}$)

Treatment	1999				After first harvest	
	30 DAP*		60 DAP		115 DAP	
	NH^4	NO^3	NH^4	NO^3	NH^4	NO_3
Nitrification inhibitors						
Prilled urea	148	123	103	67	96	56
Dicyandiamide	127	92	92	53	90	46
Pyrethrum flower dust	135	101	97	55	95	48
C.D. 5%	11	3.85	4.25	3.45	4.45	2.45
Nitrogen Levels ($kg\ ha^{-1}$)						
100	125	96	91	51	87	43
200	129	105	95	57	91	49
300	156	115	106	66	103	58
C.D. 5%	11.1	3.85	4.22	3.45	4.46	2.44
Control	94	71	70	51	38	26
C.D. %5 control vs N-levels	16	5	6.00	4.85	6.28	3.45

*DAP Days after planting

harvest leaching of N has been reported when DCD was applied as nitrification inhibitor (Chen *et al*., 1998). Not only this, but reduction in N_2O emission from soil-plant system is another effect of these inhibitors. (Chen *et al*., 1998). These inhibitory properties of pyrethrum flower-waste appear to have started later, compared to DCD. In general, the NH_4–N content was the lowest in the DCD treated soil, followed by the pyrethrum-treated soil and the highest with prilled urea. Lower NH_4 in the soil treated with inhibitors is unusual, but could be due to greater plant-growth and enhanced uptake of NH_4–N. The NH_4–N inhibition with DCD and pyrethrum seems to be the result of chemical properties possessed by the inhibitory compounds of both. On the other hand, urea has two amino groups in its molecular structure that, during NH_4–N inhibition, antagonize the chemical-configuration, thus curtailing the inhibition process.

CONCLUSION

The above results demonstrate an interrelation between N-rates and nitrification inhibitors on increasing N-use efficiency, with respect to yield of Japanese mint. There was a significant interaction between N-rates and inhibitors. Nitrogen applied at 200 kg N ha^{-1}, with inhibitors, showed a significant increase in growth and menthol-contents over the 200 and 300 kg N ha^{-1} applied as prilled urea (no inhibitor). Herb-yield significantly increased with an increase in the level of N up to 300 kg in DCD-treated plots. But the increase was restricted up to 200 kg N ha^{-1} with PU and pyrethrum. Mean of two years' data indicated an increase of 34% and 26% in herb-yield over prilled urea at 300 kg N ha^{-1} with DCD and pyrethrum, respectively. The corresponding increases in menthol-contents were 29% and 23%, respectively.

Our study shows that the use of nitrification-inhibitors is favourable for high-N demanding crops, particularly for those crops that are grown in N deficient, poorly structured and leaching-prone soils. The results reveal that pyrethrum flower-waste can be effectively used as a potential nitrification-inhibitor, although it is not as efficient as DCD.

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