EFFECT OF N FERTILIZER AND IRRIGATION ON YIELD OF POTATO IN NORTH WESTERN REGOSOL BELT OF SRI LANKA

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ABSTRACT

In an attempt to examine the factors contributing to low productivity of irrigated potatoes in warm lowlands, the extent to which the method of irrigation, and level and frequency of N application affect growth and tuber yield of potato under Kalpitiya agroecological conditions was studied in maha 1988/89 and maha 1989/90. With conventional overhead irrigation, about 10 - 15 mm of water moved down the profile after each irrigation. The tuber yield however was not influenced by any leaching losses of nutrients which could have occurred due to the downward movement of water following irrigation. Nitrogen levels up to 300 N kg/ha failed to improve dry matter production significantly and it was assumed that the N content of the irrigation water masked the effect of applied N.

KEY WORDS: Drip irrigation, Overhead irrigation, Potato

INRODUCTION

Recent studies have revealed the scope for extension of potato to warm tropical conditions, previously considered unsuitable for potatoes (Midmore and Rhoades, 1987). Non-traditional areas such as Kalpitiya peninsula in the north western coastal belt of the country were brought under potato cultivation due to crop saturation in the traditional highland potato growing areas. Although potato cultivation was introduced to Kalpitiya area about 15 years ago, yield analysis have shown that tuber yields have been very low and highly variable both from season to season and from one location to another.

The main advantages of growing potatoes in Kalpitiya area are, ease in handling operations related to cultivation and harvesting; relatively low incidence of pest and diseases; availability of irrigation water with acceptable quality; and close proximity to primary market. On the other hand, the low nutrient and water retention capacity of the sandy soils, and the high temperature prevailing throughout the year are limitations to successful potato production in the area.

The above limiting factors necessitate large and frequent applications of irrigation and fertilizer. However, high quantities of N can delay tuber initiation when long-day cultivars are grown under short-day conditions (Chapman, 1965). On the other hand, this might facilitate better canopy development which is a prerequisite for higher tuber yield. Van der Zaag *et al.* (1986) have shown that the P requirement of the potato is high due to its limited root system, and short growing season. Application of high quantities of potassium, to soils low in this nutrient has increased the marketable tuber yields by more than 60% (Paterson and Henningen, 1980).

In a series of experiments conducted previously in the Kalpitiya area, N, P and K rates up to 400 kg/ha failed to improve tuber yield of potato appreciably (D.S.P.Kuruppuarachchi, 1986, Unpubl.). It was suspected that the frequent application of irrigation water in large quantities (20 - 25 mm per application) which was practised, might have transported the soluble nutrients beyond the extraction zone of a poorly-rooted potato crop. Therefore two experiments were conducted with the objective of examining the leaching losses beyond the root zone under conventional overhead irrigation, and in case the leaching losses were significant, to examine whether crop productivity could be improved by controlled (i.e. application of irrigation at a relatively lower rate and more frequent intervals) irrigation and frequent application of N in small doses.

MATERIALS AND METHODS

Two field experiments were carried out at the Agricultural Research Station, Kalpitiya in maha 1988/89 and maha 1989/90 (October-February). The climate at Kalpitiya is characterised by high day temperature (>27°C) throughout the year with some cool nights (18 -20°C) in December and January. Pan evaporation ranges from 3 mm/day (November) to 6.5 mm/day (August). Average annual rainfall is about 1000 mm, 80% of which is received during maha season. The soil at Kalpitiya is classified as a regosol (De Alwis and Panabokke, 1973) and is extremely permeable, consisting of 90 -98% fine and coarse sand. The soil had a pH of 6.5, electrical conductivity of 0.01 dS/m, available water capacity of 7% (by volume), bulk density of 1.56 g cm^{-3}, organic matter content of 0.4%, Olsen P of 2.5 ppm and exchangeable K of 0.04 ppm. The chemical analysis of irrigation water at the Kalpitiya experimental site is given in Table 1.

Design of the experiment was a split-plot with three replications where main treatments were five levels (0,40, 80, 160, 320 kg N/ha) in maha 1988/89 and four

Table 1. Chemical analysis of irrigation water at Kalpitiya *

Property	*Content*
pH at 25°C	7.85
EC at 25°C (dS/m)	0.42
Total dissolved solids (mg/1)	40.0
Chloride (mg/1)	40.0
Total nitrogen (as N) (mg/l)	11.5
Ammonia(as NH_3) (mg/1)	2.8
NO_3 - N (mg/1)	9.6
Phosphate (as P) (mg/1)	2.4
Potassium (as K) (mg/1)	11.0

* Analyzed at CISIR (Colombo)

levels (0,100,200,300 kg N/ha) in maha 1989/90 of nitrogen applied at two frequencies (basal plus one top dressing at 4 weeks aftèr planting, and basal plus four top dressings at two weekly intèrvals) and sub treatments were two irrigation practices. These were daily irrigaiton of 25 mm of water applied per day with hose pipe (to simulate farm practice) and 20 mm of irrigation per day (10 mm in the morining and 10 mm in the evening) with a drip irrigation system (Wimpey's low pressure gravity fed bi-wall system with emitter discharge of 0.5 l/h). Irrigation water was not applied when the rainfall during the previous 24 hours exceeded 10 mm.

Uniform-sized (35 - 55 mm), pre-sprouted seed tubers of variety, Desiree, were used as seed material for both experiments. Tubers were planted at a spacing of 70 cm x 30 cm. Carbofuran 3G at a rate of 20 kg/ha was basally applied, and sulphur and Selecrone were used for controlling mites.

Moisture movement through the soil profile was monitored throughout the growing season. Soil moisture content was measured weekly, using a Wallingford MK2 neutron probe at 10 cm depth intervals (the soil moisture content of the top 20 cm was determined by the gravimetric method). The neutron probe data were collected one hour after irrigation at each sampling date. Two plants, surrounded by guard rows, were sampled each week, and separated into their component parts. Leaf area index (LAI) was measured using the disc method and 1 x 0.3 m grid was used to measure ground cover (GC) at weekly intervals.

RESULTS AND DISCUSSION

Profile moisture content and irrigation regime

Table 2 shows the fluctuation of % volumetric moisture content in the soil profile on five different dates during the growth period. There has been considerable variation in the soil moisture content with overhead irrigation up to a depth of 150 cm. The fluctuations were mainly restricted to 50 cm with drip irrigation, indicating that with overhead irrigation a fairly large proportion of applied water moved beyond the root zone (Fig.1). The data indicate that with overhead irrigation, the 100 cm soil profile contained appproximately 10 -15 mm of water in excess of field capcity water content. This water moved down the profile after each irrigation, while with drip irrigation the downward movement of water was minimal.

Table 2. Fluctuation of percentage volumetric moisture content of the soil profile under drip and overhead irrigation methods

Soil depth (cm)	*% Volumetric moisture content*									
	Drip irrigation					*Overhead irrigation*				
	15/11	*24/11*	*6/12*	*12/12*	*22/12*	*15/11*	*24/11*	*6/12*	*12/12*	*22/12*
20	2.3	4.6	7.3	3.1	3.3	2.8	8.2	7.8	2.9	1.7
30	7.1	7.1	8.4	5.5	6.0	5.3	8.2	7.7	7.0	3.0
40	8.7	7.3	6.4	7.7	7.8	5.6	7.1	7.3	7.9	3.9
50	7.3	6.1	5.5	8.1	7.4	6.4	6.7	6.3	9.1	5.6
60	5.0	4.6	5.4	5.1	6.9	6.9	6.0	6.7	8.5	4.9
70	4.5	5.0	5.1	5.2	5.2	7.0	5.6	5.7	8.1	5.3
80	4.5	4.6	5.2	5.7	4.9	6.6	5.6	6.8	6.8	5.2
90	4.6	5.4	5.3	5.3	5.6	6.2	5.3	6.8	7.0	5.5
100	4.7	4.1	5.0	5.3	4.8	5.6	5.3	6.5	5.9	5.8
120	3.9	4.1	4.6	4.5	4.2	6.0	6.2	7.1	6.1	6.2
140	4.3	4.9	5.1	4.8	4.3	6.6	6.8	7.3	6.4	7.8
160	5.6	5.7	5.8	5.7	5.1	6.8	6.4	6.6	6.8	7.8
180	5.7	6.1	6.0	5.9	5.7	7.1	6.7	7.2	7.0	8.2
200	6.1	6.5	5.9	6.9	6.3	9.7	9.3	7.6	6.6	7.4

% volumetric moisture contents are average values of four replicates on each date under drip and overhead irrigation methods

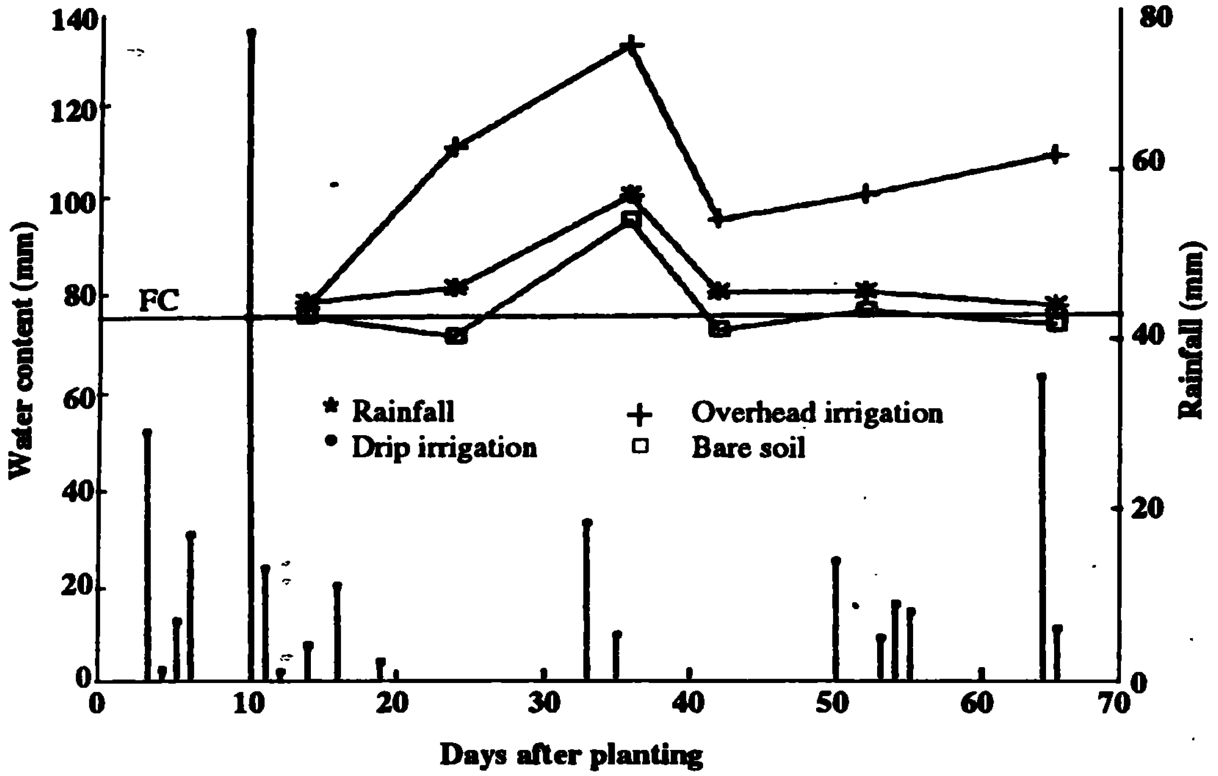

Fig. 1. Rainfall and profile moisture content over the growing period-maha 1988/89 (to 100 cm depth). FC = Field capacity (average values of 4 replicates)

Yield parameters at harvest

Total tuber yield incresed with increasing N fertilizer levels. The highest yield was obtained at 160 and 200 kg N/ha, respectively in maha 88/89 and maha 89/90. Further increase in N rate had a negative effect on total tuber yield (Table 3). Marketable yield too followed a similar trend. In maha 89/90, the effects of irrigation and N level on tuber yield were not significant; however the yield trends were similar to those found in maha 88/89. In maha 88/89 there was a significant interaction between irrigation and N level for total tuber yield (Table 3). From these, it appears that the effect of N level on tuber yield is influenced by the method of irrigation. The response to N fertilizer with two methods of irrigation is presented in Fig.2. When these two curves are extrapolated to the left, the curves for overhead and drip irrigation meet the X axis at about - 200 kg N/ha. This is an indication of the amount of N available to the crop from sources other than fertilizers (Holiday, 1970). Since

Table 3. Some yield and growth parameters as influenced by N application and methods of irrigation

Treatment	Total tuber yield (t/ha)		Marketable yield (t/ha)		Emergence (%)	Maximum LAI
	maha 88/89	*maha 89/90*	*maha 88/89*	*maha 89/90*	*maha 88/89*	*maha 89/90*
Irrigation (I)						
I_1 overhead	14.0	16.2	10.1	13.1	79	1.0
I_2 drip	13.5	14.1	9.8	10.2	87	1.2
Frequency of N (T)						
T_1 2 dressings	14.4	-	10.5	-	86	1.1
T_2 5 dressings	13.2	-	9.3	-	81	1.1
Level of N (N)						
N_1 0	11.9	10.5	8.3	7.6	84	0.8
N_2 40	12.2	-	8.8	-	85	1.0
N_3 80	14.1	-	10.5	-	80	1.0
N_4 100	-	16.6	-	12.6	-	-
N_5 160	16.4	-	12.0	-	86	1.4
N_6 200	-	17.0	-	13.0	-	-
N_7 300	-	16.6	-	13.3	-	-
N_8 320	14.0	-	10.0	-	82	1.3
CV (%)	22.6	34.0	20.6	36.0	27.3	22.6
Effects						
I	ns	ns	ns	ns	ns	ns
T	ns	-	ns	-	ns	ns
N	*	ns	*	ns	ns	*
N X I	*	ns	ns	ns	ns	ns
N X T	ns	ns	-	ns	ns	ns
T X I	ns	-	ns	-	ns	ns
N X T X I	ns	-	ns	-	ns	ns
SED (N,T,I)	1.58	-	2.47	-	-	0.36

* significant at 0.05% level; ns = not significant; SED = standard error difference; LAI = leaf area index

the nutrient holding capacity of regosol is considered to be negligible and the organic matter content extremely low (0.4%), the only major source of additional N must

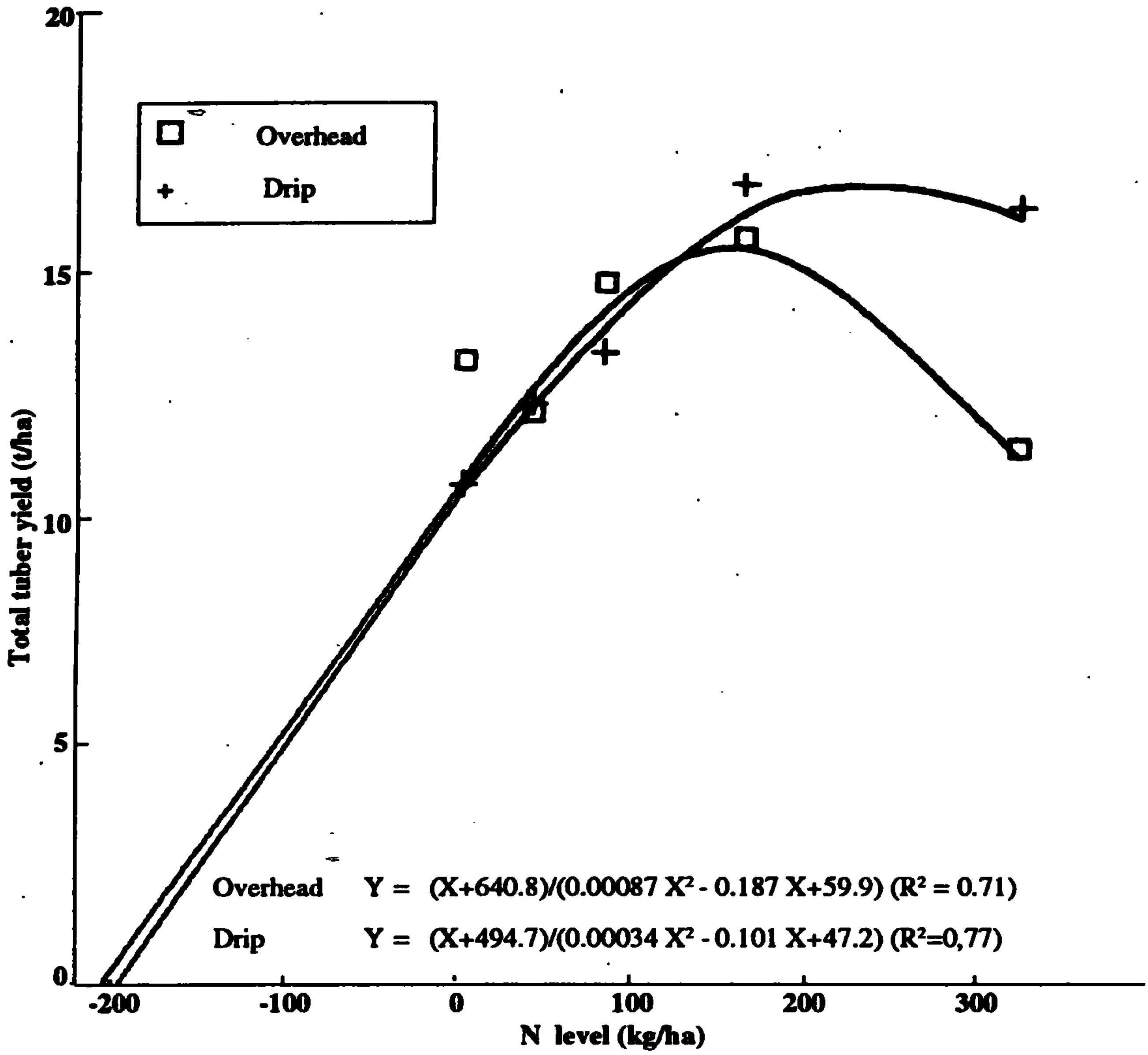

Fig. 2. Relationship between total tuber yield (fresh weight) and N level for two irrigation methods-maha 1988/89

be from irrigation water which contained 11.5 mg N/l (Table 1). Thus the amount of N supplied through the irrigation water was calculated to be 190 and 150 kg/ha in overhead (65 days of irrigation per 25 mm per day) and drip irrigation (65 days of irrigation with 20 mm per day), respectively. When the amount supplied through irrigation is added onto the amount applied as treatments, the relationship between N level and tuber yield can be expressed by a single common quadratic curve (Fig.3) and the highest yield was recorded with 360 kg/ha of total N in both seasons.

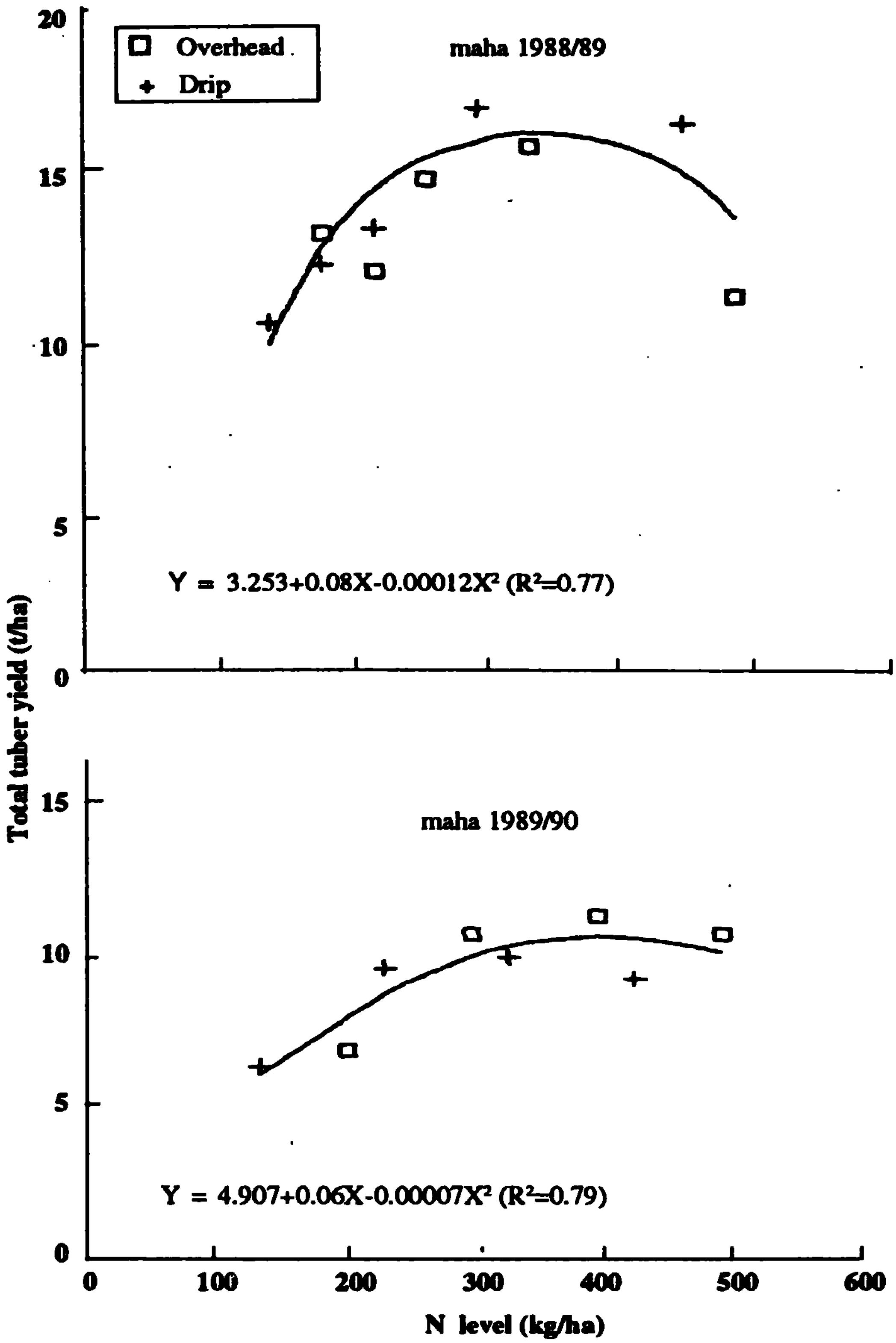

Fig. 3. Relationship between total N supply and tuber yield

Growth parameters

Emergence was unaffected by any of the treatment combinations; all the tubers eventually emerged about 3 weeks after planting. Leaf area indices (LAI) were significantly increased by N level (Table 3). Application of N increases canopy dry matter (Millard and Marshall, 1986); however, even with optimum levels of N and irrigation, maximum GC attained was less than 80% in maha 88/89 and 60% in maha 89/90 (Fig.4). After emergence, interception of solar radiation by the crop was dependant upon GC.

Fig.4 shows the influence of N level on the maximum GC obtained. Both the highest GC and the highest tuber yields (Figs. 3 and 4) were recorded with approximately 360 kg N/ha (equivalent to about 200 kg N/ha applied as fertilizer) in both seasons.

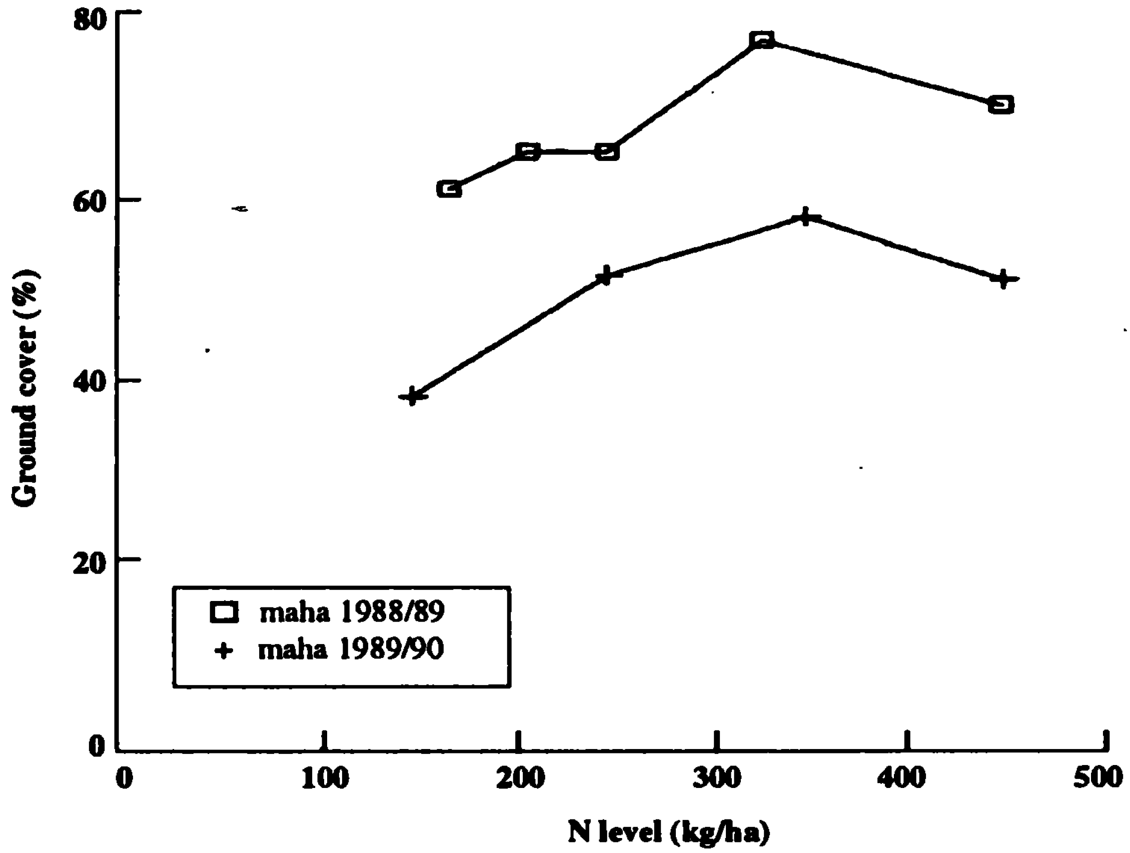

Fig. 4. Relationship between maximum ground cover (GC) and N supply from fertilizer

Effect of N and irrigation on growth and yield

When a soil is at or near field capacity there is a high tendency of soluble nutrients being leached (Gerdes, 1975). Gunasena and Harris (1971) have shown that when leaching occurs, yield could be increased by delaying the applicaiton of all or part of nitrogen fertillizer until tuberization. However, tuber yield showed no response to several top dressings of N fertilizer under Kalpitiya conditions. This may be due to the supply of N through irrigation water masking the effect of N fertilizers applied to soil. Tuber yields increased up to about 300 kg N/ha (supplied from fertilizers and the irrigaiton water). It declined with further addition of N. It is concluded that this response was independent of the method of irrigation (Fig.3). Therefore, leaching of applied N had no significant influence on the productivity of potato under Kalpitiya conditions.

There is a positive linear relationship between total dry matter yield and tuber dry matter yield of potato and the amount of radiation intercepted (Allen and Scott, 1980). To achieve maximum radiation interception a crop canopy capable of intercepting about 80 - 95% of the incoming radiation should be developed rapidly, early in the growing season and maintained throughout its duration (Midmore and Rhoades, 1987). Therefore, in order to improve the productivity of potato under Kalpitiya conditions it is important to study the factors that limit canopy development.

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