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Effect of water table management and irrigation regimes on the physiological responses of potato crop grown on sandy soil

(Kesan pengurusan aras air bawah tanah dan rejim pengairan terhadap gerak balas fisiologi tanaman ubi kentang yang ditanam di tanah berpasir)

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Key words: water table, capillary rise, lysimeter, leaf area index (LAI), stomatal conductance, root density

Abstract

Appropriate water table management scenarios for sandy soil have been investigated by an experimental approach. Drainage lysimeters were used in a glasshouse environment to investigate the effects of water table management and irrigation regimes on crop water use, root development, crop growth and yield of potato. Irrigation application methods namely surface, sub-surface and static water table treatments were tested. In surface irrigation method, water was applied at the soil surface until water table was raised to 0.45 m from soil surface, whereas in sub-surface irrigation, water table was raised rapidly from below to 0.45 m from soil surface.

Surface irrigation produced crops with 7–14% higher leaf area index (LAI), 10–15% higher shoot dry matter, 6–25% more root mass and 5–24% more fresh tuber yield than sub-surface irrigation, whether from a fluctuating or static water table. However, crop water use was the highest in a surface irrigated treatment.

Introduction

The effect of capillary rise in sub-surface irrigation on crop physiological responses, growth and yield was considered. In a controlled drainage system for water table management, there are several suitable irrigation methods for supplementing water to fulfil crop water requirement during critical growth stages. There is, however, little information on the sensitivity of the crop to capillary rise irrigation under a fluctuating water table situation.

Effects of crop water use and crop responses to water table have been reported from several lysimeter studies (Pitts et al. 1991; Madramootoo et al. 1993; Alvino et al. 1994). However, previous studies, besides yield, have not provided any parameter for the root zone environment or the root growth and development, that might be a better indicator for water table effect on crop production.

In a recent study, Mohammud (1997) discovered that by lowering the water table depth from 0.25 m to 0.75 m from soil surface, the rhizosphere environment was improved, enhancing the root growth and thus increasing the crop yield of potatoes. However, under deep static water table conditions, the crop was shown to

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experience water shortages at certain stages of growth. Although a fraction of the root system then was able to extract water, most of the surface roots experienced water stress. The potato crop is known to be sensitive to water stress (MacKerron 1993).

Applying irrigation water either from the surface or the sub-surface, may overcome deficit water stress problem, thus crop growth may be enhanced. Surface and sub-surface irrigations have long been used to maintain high yields of certain crops but the effects on soil and crop of a fluctuating water table are not known.

The main aim of this lysimeter experiment was to evaluate the effects of different irrigation regimes involving fluctuating water tables on the physiological responses and yields of a potato crop. It was expected that such information could be used to determine the appropriate irrigation water management for crops grown in a shallow water table situation.

Materials and methods

The lysimeter experiment was conducted in the Silsoe College glasshouse during the 1996 summer season.

Lysimeter construction

The experiment was designed to use drainage lysimeters that have been fabricated and installed at Silsoe College. The lysimeters are made of circular plastic containers of 0.56 m diameter (5 mm thick wall) and 1.0 m deep with enclosed bottom. A 0.025 m diameter perforated PVC tube was placed horizontally at the bottom of the lysimeter. This tube was used for water supply cum drainage when raising and lowering the water table. A water tank made of plastic container (450 mm x 300 mm x 300 mm) with float mechanism was installed for each lysimeter to maintain the desired water level in the lysimeter. Then, each float tank was connected to a graduated water-supply tank (450 mm x 300 mm x 600 mm) for volumetric measurement. The details of the lysimeter facilities have been described by Mohammud (1997) and as shown in *Figure 1.*

Experimental design and statistical analysis

Sandy loam soil (63% sand, 19% silt and 18% clay) from the farm was used to fill up the lysimeter. The soil was air dried and passed through 5 mm sieve. The soil was then packed into the lysimeters to achieve 1.10–1.20 g/cm^3 dry bulk density. The lysimeters were kept in a glasshouse and placed on a wooden platform in three rows (as a block) consisting of three lysimeters of each row at a spacing of 1 m x 2 m. This gave a single factor experiment with

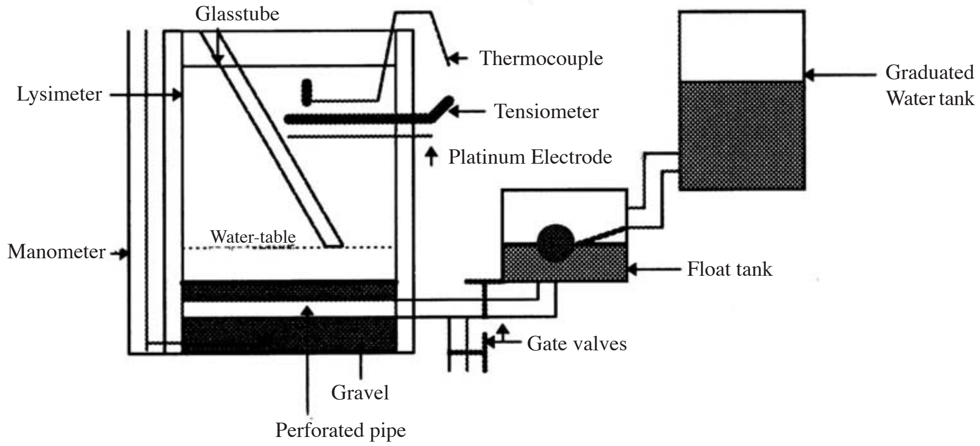

Figure 1. A schematic diagram of the lysimeter set-up

Randomised Complete Block Design (RCBD) in which nine lysimeters were used for three treatments with three replications.

Treatments

The experimental variables were the irrigation application methods on the crop with the presence of water table. Treatments were:

- Static water table at 0.75 m from the soil surface (STAT)
- Surface application (SURF). Initially, the water table was 0.75 m from the soil surface. Subsequently water was applied at the soil surface until the water table was raised to 0.45 m from the soil surface. The water table was then allowed to drop to 0.75 m through evapotranspiration.
- Sub-surface application (SUB). The water table was raised rapidly from below (from 0.75 m) to 0.45 m by sub-surface irrigation, and maintained at this level for 24 hours. Then, due to evapotranspiration, the water table gradually decreased to 0.75 m from soil surface.

Propagation and seedling management

The early variety potato seeds (*Solanum tuberosum* cv. 'Duke of York') were used. The potato seedlings were introduced into the lysimeter at the beginning of the experiment at 46 days after sowing (DAS). Three potato seedlings were transplanted at a depth of 0.1 m in each lysimeter, in an equilateral triangle of 0.2 m distance. Fungicides (copper compound, contains 58.8% w/w copper oxychloride) and insecticides (6% w/w dimethoate, 0.95% w/w permethrin) were used to control blight disease and insect pests respectively. No chemical fertilizer was applied at the beginning or throughout the crop growth. The crop was uniformly surface irrigated with 1.5 litres of water per lysimeter every other day until 65 DAS, the lysimeters had free drainage at a depth of 0.9 m. After 65 DAS, the water table was set and maintained at 0.75 m from the soil surface by means of a float tank. When the crop reached 73 DAS, the irrigation treatments were imposed 4 times and lasted for 4 weeks.

Water use management

The amount of water applied in each surface and sub-surface application was recorded when the treatments were imposed. In the SURF, the amount of water applied was initially measured by measuring cylinder. Whereas, the amount of water applied in the SUB was measured by recording the changes in the graduated reservoir tank before and after treatment. The water table in the STAT treatment was maintained at 0.75 m depth throughout the experiment; hence a reservoir tank was used to record the water use in this treatment.

Destructive and non-destructive measurements

The responses of the crop to irrigation treatments are described in terms of their physiological changes [leaf area index (LAI), stomata conductance, root development] and crop yield.

Leaf area index (LAI) The LAI of the crop canopy was measured weekly using a Sunfleck Ceptometer (Delta-T Device Ltd, Burwell, Cambridge). This equipment was used to take measurements of incident radiation in the photosynthetically active radiation (PAR; 300–700 nm) during the cloudy days (Decagon 1989). Ten readings of PAR underneath the plant canopy were made for each measurement. These readings were averaged and divided by incident PAR, measured outside plant canopy. This gave the fraction of PAR transmitted through the canopy. All these measurements were used to calculate the leaf area index.

Stomatal conductance Stomatal conductance (g_s) was measured using an Analytical Developments portable LCA-2 Infra-red Gas Analyser (IRGA), combined with a Parkinson leaf chamber designed for broad leaves and ASUM-2 air supply unit with mass flow regulator (IRGA, Analytical Development Company, Hoddesdon, Herts). The Parkinson leaf chamber was attached with its light source operated by a 12-volt battery which gave a constant radiation income of 2,000 μmol/m^2/s. The stomatal conductance measurements were made between 1000 and 1600 hours on six healthy mature leaves fully exposed to the incident sunlight. The readings were taken from two leaves of the same developmental stage on each plant making a total of six leaves from each lysimeter. Measurements were taken on consecutive days during irrigation events.

Root growth Root distribution and root density were determined by minirhizotron and destructive core sampling techniques. Minirhizotron technique was employed during the crop growth stage on a weekly basis. The destructive core sampling technique was undertaken at the end of the experiment when the crop was harvested. From each 0.05 m soil layer, three samples were collected from between plants.

Shoot growth The shoot (leaves and stems) was harvested, dried and weighed from each lysimeter at the end of the experiment (95 DAS). The above ground dry matter was determined from the samples. The fresh tubers were harvested, washed and weighed at 97 DAS, and on the same day the core samples were taken for the determination of root density.

Results and discussion

Irrigation applied and water table behaviour

Figure 2 illustrates the amount of water applied to the crop during experimental period (the SURF and SUB). The interval for each irrigation treatment was between 4 and 5 days. For each irrigation event, 13–24 litres was applied to the SURF and 9–15 litres to the SUB. These amounts of water were used to raise the water table level from

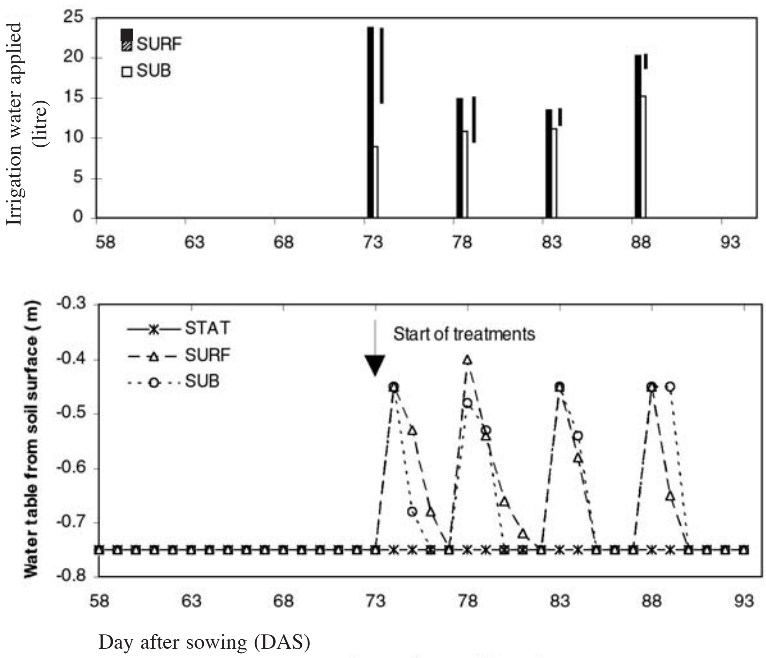

Figure 2. Amount of irrigation water applied and fluctuation of water table throughout experimental period (values were the means of three replicates, bars indicate LSD between treatment means at 5% level)

0.75 m to 0.45 m from soil surface. Generally, the data showed that more water (about 1.5 times) was always required in the SURF than in the SUB. In the SURF, as water was applied from the above and the drainage outlet was closed, the soil profile above 0.45 m was briefly saturated during infiltration. The excess water from this layer flowed downward to the water table. In the SUB, less water was required to raise the water table to 0.45 m, as the water was only needed to saturate the soil layer between 0.45 m and 0.75 m from the soil surface.

As the experiment progressed, the water requirement for both the SURF and the SUB increased with time. This occurred due to an increase in the crop water use with progressive growth and changes in the season with warmer and drier weather. Both effects tend to increase the potential rate of evapotranspiration.

Source and the total amount of water applied for each treatment are presented in *Table 1*. The total water use for surface irrigation and sub-surface irrigation during experimental period, ranged from 85.5–63.6 litres lysimeter. The data showed that during the treatment period the total crop water requirement under the SURF treatment was greater than the rest of the treatments. The data were not significantly different but it indicated a descending trend of SURF>SUB>STAT.

Surface water application under the SURF was significantly (p <0.001) more than the SUB whereas from the water table condition, the SUB treatment used 10.5 litres more water than the SURF (23.3 litres vs 12.8 litres) from the water table. The SUB used more water from the water table because during the sub-surface irrigation it used less surface applied water than the SURF treatment.

The results suggested that additional water to satisfy the evapotranspiration demand was supplied by an upward capillary flux from water table to the root zone. It was observed that the thickness of capillary layer was 0.2 m from water table. As the water source for the STAT treatment only came from the water table, it used more water from the water table than the other two treatments.

The fluctuation of the water table due to irrigation and evapotranspiration is also shown in *Figure 2*. The drop in the water table in the SUB treatment was faster than in the SURF. The water table in the SUB treatment reached its original position (0.75 m from soil surface) one day earlier than the SURF treatment. This indicated that more water was taken from the water table in the SUB than in the SURF. As in the SURF treatment, more water was stored throughout the soil profile within the root zone during irrigation. The crop roots in the SURF used these waters, and it took lesser water from

Table 1. The source and amount of water applied (litre) to each treatment for the period between 70–90 DAS

Source of water	Amount of water applied (litre) n = 3				
	STAT	SURF	SUB	Level of significance (p <0.001)	$LSD_{0.05}$
Surface water applied	Nil	72.7	45.8	***	11.8
Water table	63.6	12.8	23.3	***	17.6
Total	63.6	85.5	69.1	n.s	18.6
SE	8.5	3.7	0.8		

***Very significant at p <0.001
SE = Standard error (of mean) for total water applied
ns = Not significant at p = 0.05

the water table. Thus, the water table took a longer period to drop to its original position.

Physiological responses of plant to irrigation regimes

Leaf area index (LAI) Throughout the vegetative growth period, the LAI increased significantly (p <0.001) with time *(Figure 3)*. However, it started to decline after 87 DAS, as the plant has reached the early senescence stage. Siddig (1982) reported that sprinkler irrigated potatoes in his field experiment reached a maximum ground cover (85%, LAI = 1.7) after 77 DAS. Even though LAI was not significantly different between the treatments, the crop under the SURF treatment recorded the highest LAI than the other treatments, whereas the crop in the STAT treatment had the smallest LAI suggesting plant from the STAT treatment could be suffering from water deficit stress.

Stomatal conductance *Figure 4* shows the stomatal conductance during and after the irrigation treatments imposed on the crops. There were wide variations in the readings within each set and also within each irrigation event. Some workers (Furr and Magness 1930; Dwelle et al. 1981; Herbst 1995) reported that variation in stomatal conductance is due to environmental differences (solar radiation, room temperature, humidity, and soil moisture). But in this case, the measuring equipment (IRGA) was attached to the Parkinson leaf chamber that used an independent light source and produced constant light intensity (2,000 mol/m^2/s PAR). Silica gel was also used in the ASUM-2 air supply unit to produce constant air humidity.

There was no correlation observed in this study between stomatal conductance data and room air temperature although Dwelle et al. (1981) reported that stomatal conductance varies with temperature to a maximum of about 24 °C, and remains relatively constant at higher temperatures. The only probable factor causing variation in these readings could be the soil moisture. According to Pan et al. (1995), transpiration rate and stomatal conductance are significantly affected by water stress. Decreasing soil water content from 44% to 22% of the field capacity caused a marked decrease in transpiration rate and stomatal conductance. A similar finding was reported by Raza (1995) concluding that transpiration and stomatal conductance are significantly reduced by high light and high water stress condition.

Further analyses of the stomatal conductance readings indicated that the stomatal conductance from the SURF was generally higher than the other treatments. The stomatal conductance readings between the treatments were significantly different *(p <0.05; Table 2)*.

The interaction between the sampling period (DAS) and the treatment was also significantly different. The stomatal conductance readings of plants in the SURF and SUB treatments were higher than those in STAT, largely as a result of higher soil moisture in the former treatments. In contrast, as the soil moisture in the STAT treatment was depleted with time, the values for this treatment were low. Works by Smith et al. (1993) on tea suggested that low stomatal conductance is associated with highly negative water potential in the xylem; causing water stress.

Shoot dry matter and fresh tuber yield The shoot dry matter of the plant under different irrigation regimes are presented in *Table 2*. There were no significant differences among the treatments. Nevertheless, higher shoot dry matters were obtained from the SURF treatment with the mean at 250 g/lysimeter. The mean shoot dry matters for the STAT and the SUB treatments were 217 g/lysimeter and 225 g/lysimeter respectively. These data were closely correlated (correlation coefficient, 0.94) with the LAI readings at the end of experiment *(Table 3)*. Higher shoot dry matter indicated that the plant was

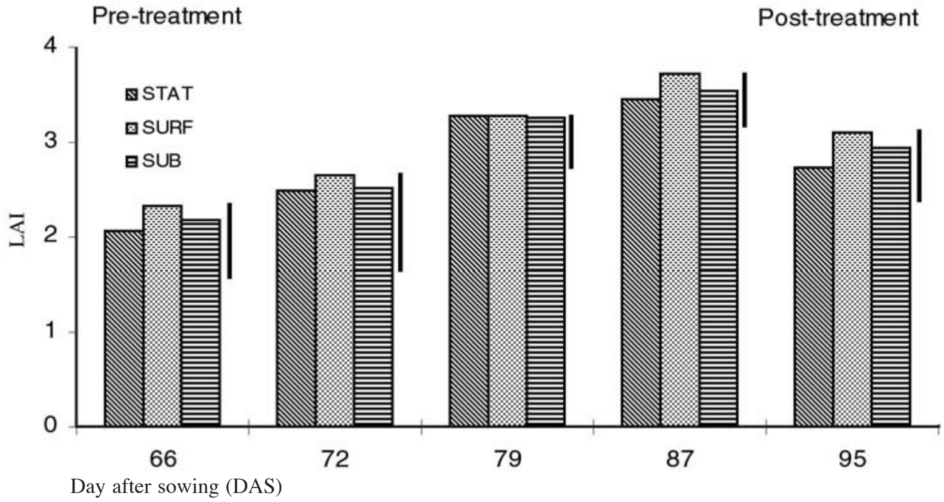

Figure 3. LAI during experimental period (values were means of three replicates, bars indicate LSD between treatment means at 5% level)

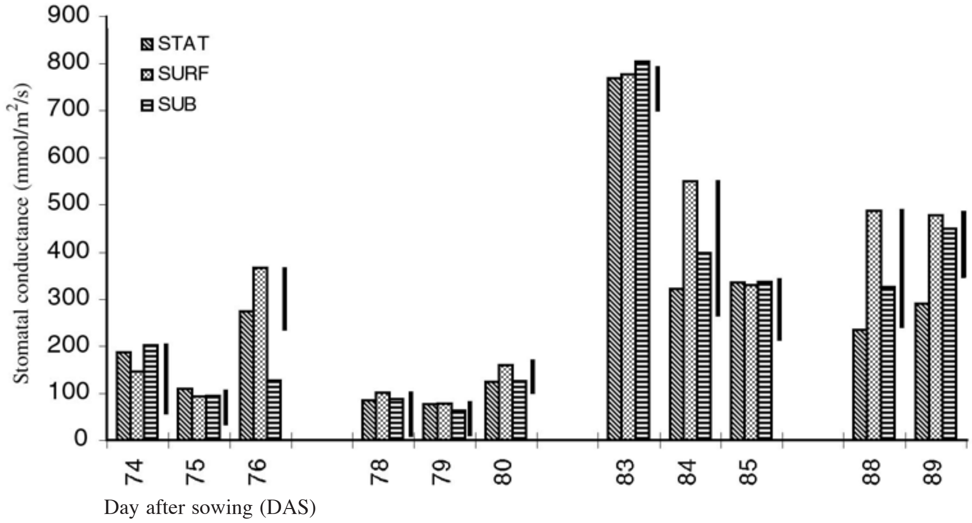

Figure 4. Stomatal conductance recorded during experimental period (values were means of 3 replicates, bars indicate LSD between treatment means at 5% level)

bigger as it had more leaves and stem, which was supported by a higher LAI value.

Similarly, the fresh tuber yield harvested at the end of the experiment did not show any significant differences among treatments *(Table 2)* although fresh tuber yield from the SURF was higher than the other treatments by 20%. MacKerron and Jefferies (1988) showed that tuber yields from water stressed crop are lower and the tubers are also smaller. The higher shoot dry matter and fresh tuber yield of crop under the SURF treatment were associated with a greater partitioning of the available dry matter to the leaves, stems and the tuber. Jefferies and MacKerron (1987) showed that low LAI which reduces light interception is the major reason for reduced yield in the potato crop shown by the reduced yields in SURF>SUB with decreased LAI. On other hand, the stomatal conductance showed a significant positive correlation with the

Table 2. Fresh tuber yield, above ground dry matter, LAI and stomatal conductance recorded at the end of experiment (96 DAS), n = 3

Treatment	Fresh tuber yield (g/lysimeter)	Above ground dry matter (g/lysimeter)	LAI	Stomatal conductance ($mmol/m^2/s$)
STAT	1,780	217	2.7	290
SURF	1,867	249	3.1	479
SUB	1,504	225	2.9	450
Level of significance[1] (p <0.05)	ns	ns	ns	*
$LSD_{0.05}$	917	41	0.7	140

[1]Level of significance at p <0.05 where, ns = not significant and * = significant

Table 3. The correlation coefficient of relationship between tuber yield, above ground dry matter, LAI and stomatal conductance (using data recorded at the end of experiment, 97 DAS)

	Tuber yield	Above ground dry matter	LAI	Stomatal conductance
Tuber yield	1	0.49	0.15	–0.15
Above ground dry matter		1	0.94	0.79
LAI			1	0.95
Stomatal conductance				1

shoot dry matter (correlation coefficient = 0.79) but had no clear relationship with fresh tuber yield *(Table 3)*. This result is similar to that of Smith et al. (1993) who found a positive correlation between high yield of tea (shoot dry matter) and stomatal conductance when the crop was sprinkler irrigated. The treatments with higher values of stomatal conductance were also noted to have greater LAI *(Table 3)*.

Root depth, distribution and density *Figure 5* shows maximum rooting depths observed in the minirhizotrons for each treatment. Results suggest that rooting depth significantly (p <0.01) increased with time through the middle and end part of the growing season. The maximum depths were reached by 96 DAS at 0.66 m, 0.63 m and 0.61 m in the STAT, SURF and SUB treatments respectively, afterwhich the rooting depth remained relatively constant.

Maximum rooting depths for potatoes recorded by Parker et al. (1989) are at 0.6 m and 0.9 m for irrigated and non-irrigated plots respectively. They also observed that potatoes in the irrigated and non-irrigated plots reached the maximum rooting depths at 100 DAS and 120 DAS respectively.

In the present experiment, the average rooting depth for all treatments were also noted to increase at 1.2–1.4 cm/day, values similar to those reported by Parker et al. (1989) and Carr et al.(1993). The STAT treatment produced the deepest root (approximately 0.66 m), but was not significantly different from the other treatments. This indicated that irrigation and water table had no significant effect on the rates of root penetration. Carr and Hamer (1988) have discussed the importance of rooting depth for water uptake in potatoes. It is clear that as the root is able to penetrate to a greater depth, the amount of available soil water to crop increased and the required amount of irrigation water reduced. When the roots reached the water table, the need for surface irrigation may be much reduced or eliminated.

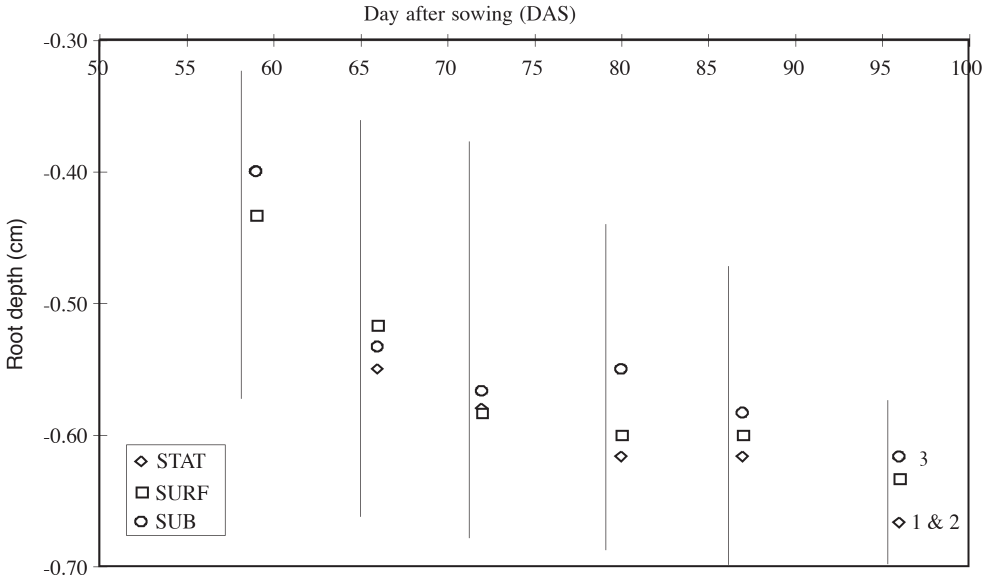

Figure 5. Rooting depth from minirhizotron observation as a function of time (bars indicate LSD between treatment means at 5% level. Number 1, 2 and 3 show the maximum rooting depth measured by core sampling method on 97 DAS for the STAT, SURF and SUB respectively)

Total root density throughout the experiment was measured using the minirhizotron method. The roots in the STAT and SUB treatments were observed to grow rapidly with time at the rate of 0.4 $cm/cm^3/d$ (*Figure 6*). In these two treatments, more roots grew after the treatments were imposed as indicated by the increased total root density at 72 DAS. Whereas the root growth in the SURF was not very obvious, with the growth rate recorded only at 0.1 $cm/cm^3/d$. The total root density at the end of experiment was significantly different ($p < 0.001$) between the treatments with the highest value recorded in the STAT treatment as the root grew longer looking for the water.

Potato root distributions measured by the core sampling method at the end of experiment are shown in *Figure 7*. The root density at each sampling depth for all the treatments ranged from 0.5 to 6.5 cm/cm^3. In the surface soil layer (0.05 m), the root density recorded from 0.5 to 1.0 cm/cm^3 in the STAT and SUB treatments, whereas in the SURF treatment, the root density ranged from 1.5 to 3.0 cm/cm^3, similar to those reported by Parker et al. (1989) in their irrigated plot. This indicated a sparse root distribution near the soil surface in the STAT treatment, which increased with depth. Only 35% of the total root was found in the top 0.30 m of soil, whereas nearly 65% was found in the lower layers. Similar rooting pattern was observed in the SUB treatment. A considerable increase in the root density occurred below 0.3 m in the SUB, although the percentage of root density in this soil layer was similar in SUB and STAT treatments. Nevertheless, crops under the SUB treatment had a slightly shallow rooting system (0.60 cm depth). This feature could have resulted from a formation of an anaerobic soil layer in the fluctuating water table zone affecting and restricting the growth of the root system.

The roots in the SURF treatment were uniformly distributed. Nearly 49% of the root mass was confined to the top 0.30 m of the soil and the remaining 51% was found below this layer. The plants in the SURF treatment had a greater total root density, but

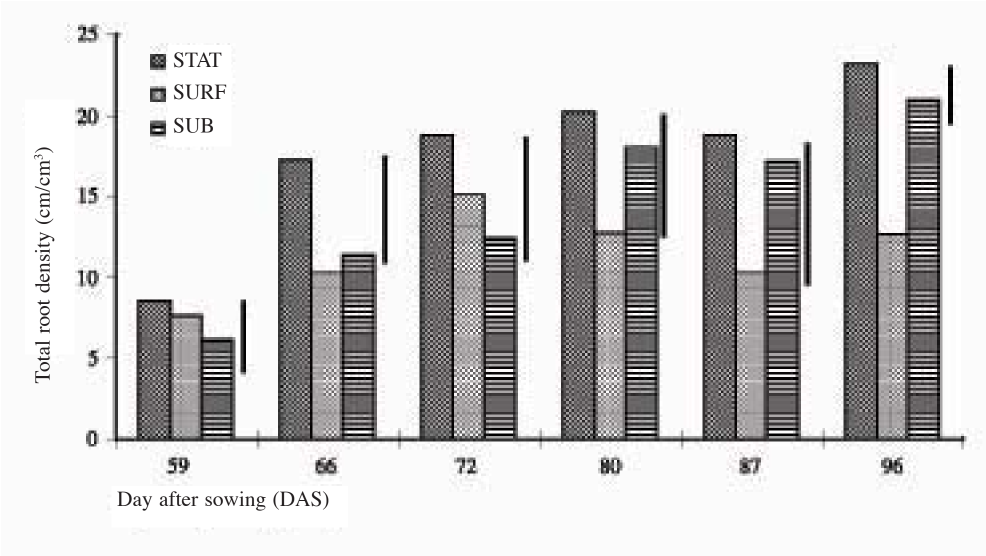

Figure 6. Root density recorded by minirhizotron method at various growth stages (bars indicate LSD between treatment means at 5% level)

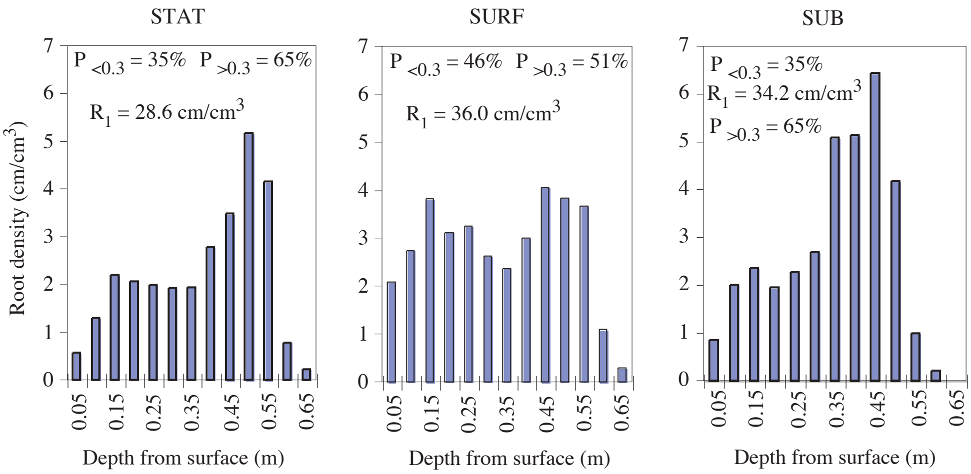

Figure 7. Root density obtained by destructive core sampling method at the end of experiment (97 DAS). ($P_{<0.3}$ and $P_{>0.3}$ are the percentages of the total root for the top 0.3 m and below 0.3 m soil layers respectively, R_T are the total root densities measured to 0.75 m depths)

they were not significantly different from the other treatments. This result is different from *Figure 6* as different measuring method was employed. The distribution and density of the roots determine the plants' ability to exploit the moisture and nutrients reserve in the soil. The dense rooting system observed on plants in the SURF treatment implied that the plants were more ready to absorb nutrients and water from its rooting zone.

The data also suggested a high correlation between the amount of water applied and the total root density. The crops which received more water (SURF treatment) tend to have a higher total root density (as shown in *Figure 7*). MacKerron and Peng (1989) found that potato plants produce much greater mass of roots in irrigated than non-irrigated plots. Crops under such treatment have more water available from the soil because of a deeper or massive rooting pattern.

The distribution of root density as a function of depth is presented in *Table 4*. The root densities in the top 0.2 m were significantly higher ($p < 0.01$) in the SURF than the other treatments. In this treatment, the soil moisture in these layers were frequently replenish by surface irrigation during the growing season, which could provide adequate water supply that subsequently enhanced the root growth. In common practices, most of the fertilisers applied to the crop was placed at these depths where preferably high proportions of the root water and nutrient uptakes occurred. The massive surface root system, such as in the SURF treatment would help to procure more nutrients. In contrast, at 0.3–0.5 m soil depth, the root density of the SUB treatment was recorded the highest although it was not significantly different between treatments. At this soil depth, the sub-surface irrigation supplied more water to the plant-root system than did the surface irrigation or the static water table treatments. This might explain why higher root densities were observed at these depths under the SUB treatment. In the 0.6–0.7 m soil depth, due to capillary rise from water table, soil water content in this part of the root zone remained near field capacity. Therefore, at this depth irrigation treatment seemed to have little effect on root density.

Comparing the rooting pattern of the above experiment with the findings of the irrigation trials conducted by other workers [e.g. MacKerron and Peng (1989), Parker et al. (1989), Parker et al. (1991), and Carr et al. (1993) on potatoes; Furr and Magness (1930) on apples trees], quite a different rooting pattern was found. The above workers reported that the greatest concentration of the roots (nearly 90%) are in the surface 0.3 m of the soil, becoming more sparse at greater depths. In this experiment, it was demonstrated that with the presence of water table, a greater proliferation of roots occurred below 0.3 m soil depths.

Conclusion

The crop from the treatment with the high LAI usually has the highest stomatal conductance (gs), highest top dry matter and highest yield. Plants with a higher LAI were produced when they experienced less water stress such as in the SURF and the SUB treatments. In general, it is highly correlated between the crop growth performance (LAI and top dry matter) and the tuber yield.

In comparison with the static water table treatment (STAT), the plants irrigated from SURF and SUB treatments produced 7–14% more leaves (bigger plant), 5–24% higher tuber yield and 6–25% more root

Table 4. The root density distribution recorded by core sampling method at the end of experiment (97 DAS) (n = 3)

	Root density (cm/cm^3)				
Depth (m)	STAT	SURF	SUB	Level of significance	$LSD_{0.05}$
0.0–0.1	1.86	4.83	2.87	**	2.65
0.1–0.2	4.28	6.95	4.32	**	2.24
0.2–0.3	3.92	5.88	4.96	n.s	2.69
0.3–0.4	4.74	5.37	10.24	n.s	6.78
0.4–0.5	8.65	5.27	10.63	n.s	6.85
0.5–0.6	4.94	3.18	1.07	n.s	4.75
0.6–0.7	0.07	0.10	0.00	n.s	0.25

**Significant difference at $p = 0.01$
n.s = no significant difference at $p = 0.05$

mass. In the static-deep water table situation (STAT), at certain stage of growth, the plant experienced water stress which resulted in poor crop performance.

This experiment demonstrated that in this moderately light soil, even though the soil surface reached saturation during irrigation and the water table rose close to the surface (either due to heavy rainfall or rapid irrigation), surface applications (SURF) did not experience oxygen stress. Without oxygen stress, the root development and uptake capacity for water and nutrients of plants were increased.

The higher the amount of irrigation water used, as in the case of surface irrigation (SURF treatment), the higher yield was achieved. However, for areas with limited water resources, sub-surface irrigation (SUB) and a deep-static water table (STAT) were preferable as they were able to produce moderate yields with slightly lesser water.

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Abstrak
Senario pengurusan aras air bawah tanah yang sesuai untuk tanah berpasir telah dikaji menggunakan pendekatan penyelidikan. Lisimeter saliran yang berada di dalam persekitaran rumah kaca telah digunakan untuk mengkaji kesan aras air bawah tanah dan rejim pengairan terhadap penggunaan air, perkembangan akar, pertumbuhan dan hasil ubi kentang. Rawatan yang diuji ialah pengairan permukaan, pengairan bawah tanah dan aras air bawah tanah statik. Pengairan permukaan dibuat dengan menyiram air di permukaan tanah sehingga aras air bawah tanah naik ke aras 0.45 m dari permukaan manakala pengairan bawah tanah, air bawah tanah dinaikkan ke aras 0.45 m secara mendadak.

Pengairan permukaan telah menghasilkan pokok dengan indeks keluasan daun (LAI) 7–14% lebih tinggi, bahan kering atas tanah 10–15% lebih tinggi, 6–25% lebih banyak akar dan 5–24% lebih banyak hasil ubi berbanding dengan pengairan bawah tanah, sama ada dari aras air bawah tanah yang berubah-ubah atau statik. Walau bagaimanapun, penggunaan air oleh tanaman adalah tertinggi apabila menerima rawatan pengairan permukaan.

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