Impact of planting dates on incident and absorbed photosynthetically active radiation of potato crop under different irrigation frequencies

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Abstract
A farm level experiment was carried out with two (i.e. Jyoti and Ashoka) different potato cultivars (i.e. Ashoka and Jyoti) at “C” block farm of the Bidhan Chandra Krishi Viswavidyalaya during November-March (2009-2010) to assess the incident (IPAR) and absorbed (APAR) photosynthetically active radiation of potato under three different irrigation levels (I1, I2 and I3) with 3 cm irrigation depth. The experiment was conducted under two planting dates (D1: 20/11/2009 and D2: 29/11/2009) during the above period. The plot size was 4.5 m × 3.7 m. The soil was sandy-loam with medium land situation. In particular, readings were taken four times with two hours interval (9:00, 11:00, 13:00 and 15:00 h). Throughout the period, it was observed that the maximum IPAR and APAR values were at 11:00 h irrespective of the irrigation frequency, planting date and variety of potato.

Keywords: Active radiation, planting date, potato

Introduction
Agriculture is the major water utilization sector. Hence, the efficient utilization of water is utmost important to conserve it for future. For sustainable agricultural production, more judicious water use is needed, particularly in dry season (Onder et al., 2005) [9]. During dry season, irrigation water availability is not uniform throughout the world. Per capita per year surface water availability which was 1902 m³ in 2001 will be declined to 1492 and 1345 m³ by the year 2025 and 2050 respectively. Shortage of this fresh water resource makes irrigated agriculture in an alarming situation during dry season (Sharma and Dixit, 1992) [9]. Agricultural scientists should come forward to meet the challenge and plan to progress the irrigation potential (Abdelgahy, 2009; Nasare et al., 2009) [1, 7]. It is also essential to develop new technique particularly those designed to meet the needs of the water and as such, a significant amount of water could be saved. The food production target of India will be 457 million tonnes by the year 2050 to feed 1413 million populations. After wheat, rice and corn, potato is most valuable agricultural product irrespective of the irrigation frequency, planting date and variety of potato.

2. Materials and Methods
The experiment was carried out at “C” block farm (lat - 22.5° N, long - 89° E and altitude 9.75 m above msl) at Kalyani during November-March, 2009-10. The soil of the study site is sandy-loam with medium land situation.

2.1 Experimental design and treatments
The treatments were distributed in a split plot design, where the date of planting was...
considered as the main plot treatment, the irrigation levels as sub plot treatment and varieties as sub-sub plot (Biswa and Roy, 2020) [2].

The treatment combinations were as follows
Main plot treatment (Dates of planting; D)
D₁ – 20th November
D₂ – 29th November

Sub plot treatment (Irrigation level; I)
IW/CPE
I₁ = 1.40
I₂ = 1.20
I₃ = 1.00

Total plot size was 4.5 m × 3.7 m. In a particular plot, the spacing is 45 cm × 15 cm.

Sub-sub plot treatment (Potato variety; V)
V₁ – Ashoka
V₂ – Jyoti

2.2 Methods and Observation

2.2.1 Net radiation
It is the differences between upward and downward radiation fluxes. It is the measure of energy available at the ground surface. With the help of net Pyrradiometer (Pyrradiometer Sl. No. 090001), net radiation above the potato crop canopy was measured.

The equations are as follows
RN = RSWBAL + RLWBAL
RSWBAL = RSW ↓ - RSW ↑
RLWBAL = RLW ↓ - RLW ↑

Where
RN = Net radiation; RSWBAL = Short wave radiation balance; RLWBAL = Long wave radiation balance; RSW ↓ = Incoming short wave radiation; RSW ↑ = Outgoing short wave radiation; RLW ↓ = Incoming long wave radiation; RLW ↑ = Outgoing long wave radiation

2.2.2 Absorbed photosynthetic active radiation (APAR): It is measured by the following formula:
APAR = (PARO + RPA RS) – (TPAR + RPARC)

Where
PARO = the portion of the incident PAR
TPAR = Transmitted portion of the incident PAR through the canopy to the soil surface

3 Results and Discussion

3.1 Incident photosynthetically active radiation (IPAR) of potato crop: Irrespective of dates of planting, irrigation level and variety of crops, incident photosynthetically active radiation (IPAR) was increased from 9:00 h to 11:00 h when it reached at the highest value and then decreased from 11:00 h to 15:00 h in a particular day. On 14th January, the IPAR value was decreased linearly at increasing rate. On 28th January and 11th February, the value was decreased at decreasing rate at first and then it was decreased at increasing rate. Among those three days, the highest 11:00 h value took place on 28th January followed by 11th February and 14th January.

3.2 Absorbed photosynthetically active radiation (APAR) of potato crop: The APAR is the balance of the difference between the incident and crop reflected portion of PAR and the difference between the transmitted portion of the IPAR through the canopy to the soil surface and the reflected portion of PAR from soil. The different PAR values were measured by Quantum sensors in terms of photosynthetic photon flux density. The APAR values for various treatments were tabulated below:

| Treatment | Time of observations |
|-----------|----------------------|
| D₁        | 9:00 h 11:00 h 13:00 h 15:00 h |
| I₁        | 499.30 778.50 601.80 432.20 |
| I₂        | 543.50 750.40 624.10 454.90 |
| I₃        | 537.20 759.80 624.10 439.10 |
| V₁        | 505.60 722.30 594.40 444.40 |
| V₂        | 505.60 722.30 594.40 444.40 |

Irrespective of planting dates, irrigation level and crop variety, the APAR was increased from 9:00 h to 11:00 h and then decreased from 11:00 h to 15:00 h. In different types of treatment, it reached at the highest value at 11:00 h. Among the planting dates, on an average D₂ absorbed (593.23 μ E m⁻² S⁻¹) the highest photosynthetic radiation which was 3% higher than D₁. Among the irrigation level, I₁ absorbed the highest level of PAR (596.78 μ E m⁻² S⁻¹) which was 1.13% higher than I₁ and 5.3% higher than I₂. Therefore, the lowest irradiation level absorbed the higher PAR. Among two varieties, the highest APAR value (584.45 μ E m⁻² S⁻¹) was noted under Jyoti which was 0.26% higher than the Ashoka (Table 1).

2.2.3 Photosynthetic active radiation (PAR): It was measured by Quantum sensors in terms of photosynthetic photon flux density. The output of the instrument was given in μ E m⁻² s⁻¹ which was then converted to the unit w m⁻² by a conversion factor of 4.5 μ E m⁻²s⁻¹ per w m².

2.2.4 Intercepted photosynthetically active radiation (IPAR): It is measured by the following formula:
IPAR = PARO – TPAR

Table 1: Diurnal variation of absorbed PAR (μ E m⁻² s⁻¹) on 14/01/2010

| Treatment | Time of observations |
|-----------|----------------------|
| D₁        | 9:00 h 11:00 h 13:00 h 15:00 h |
| I₁        | 499.30 778.50 601.80 432.20 |
| I₂        | 543.50 750.40 624.10 454.90 |
| I₃        | 537.20 759.80 624.10 439.10 |
| V₁        | 505.60 722.30 594.40 444.40 |
| V₂        | 505.60 722.30 594.40 444.40 |

Table 2: Diurnal variation of absorbed PAR (μ E m⁻² s⁻¹) on 28/01/2010

| Treatment | Time of observations |
|-----------|----------------------|
| D₁        | 9:00 h 11:00 h 13:00 h 15:00 h |
| I₁        | 318 986.33 954.67 517 |
| I₂        | 394 956.33 968 540.50 |
| I₃        | 318 983 965.50 541.75 |
| V₁        | 285 985 945.50 518.50 |
| V₂        | 432 973 973 526 |

| Treatment | Time of observations |
|-----------|----------------------|
| D₁        | 284 966.33 951.33 525 |
| I₁        | 406 976.33 971.33 532.50 |
Irrespective of planting dates, irrigation level and crop variety, the APAR was increased from 9:00 h to 11:00 h and then decreased from 11:00 h to 15:00 h. In different types of treatment, it reached at the highest value at 11:00 h. Among the planting dates, on an average D1 absorbed the highest photosynthetic radiation which was 3.80% higher than D2. Among the irrigation level, I1 absorbed the highest level of PAR which was 3.4% higher than I2 and 7.3% higher than I3. Therefore, the lowest irrigation level absorbed the higher PAR. Among two varieties, the highest APAR value was noted under Jyoti which was 5.90% higher than the Ashoka (Table 2).

Table 3: Diurnal variation of absorbed PAR (APAR μ E m⁻² s⁻¹) on 11/02/2010

| APAR | Time of observations |
|------|---------------------|
| Treatment | 9:00 h | 11:00 h | 13:00 h | 15:00 h |
| D1 | 566.33 | 818.50 | 759.67 | 486.50 |
| D2 | 631.33 | 888.50 | 774.67 | 494.50 |
| I1 | 578.00 | 869.00 | 758.00 | 493.50 |
| I2 | 605.50 | 808.25 | 798.00 | 493.50 |
| I3 | 613.00 | 883.25 | 745.50 | 484.50 |
| V1 | 593.00 | 866.50 | 763.00 | 489.50 |
| V2 | 604.67 | 840.30 | 771.33 | 491.50 |

Irrespective of planting dates, irrigation level and crop variety, the APAR was increased from 9:00 h to 11:00 h and then decreased from 11:00 h to 15:00 h. In different types of treatment, it reached at the highest value at 11:00 h. Among the planting dates, on an average D2 absorbed the highest photosynthetic radiation which was 6% higher than D1. Among the irrigation level, I1 absorbed the highest level of PAR which was 1% higher than I1 and 0.77% higher than I2. Therefore, the lowest irrigation level absorbed the higher PAR. Among two varieties, the highest APAR value was noted under Ashoka which was 0.15% higher than the Jyoti (Table 3).

4. Conclusions
The cultivar selection of a crop should be such that minimum water can make maximum production, making the slogan ‘more crop per drop’ successful. The annual demand of potato in West Bengal is quite high. The potato is sensitive to water scarcity. A little water stress may cause a decrease in interception of canopy radiation and photosynthesis. Keeping these things in mind, the study concentrated on the assessment of incident and absorbed photo synthetically active radiation of two potato cultivars with three different irrigation frequencies under two different planting dates. The study concluded that the maximum IPAR and APAR values were at 11:00 h irrespective of the irrigation frequency, planting date and variety of potato. However, this result may vary from one region to another. Therefore, more research on this issue should be throughout the world.

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