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Maximizing potato yield and water use efficiency: stage-based irrigation scheduling with organic inputs in north eastern India

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ABSTRACT

Potato is one of the most important food crops grown in the north-eastern hilly terrain especially during *rabi* season. The cropping system of most of the states under north-eastern region of India is paddy-potato based. Potato also enjoys a special place in the dietary food habits of the people in the region. Potato is highly sensitive to water stress and since it is being cultivated mostly during the *rabi* season, it is of utmost importance for water management through irrigation scheduling techniques for better potato production. A field experiment was taken up to study the performance of potato (*Kufri megha* var.) under four critical stages, *viz*., sprouting (S_1); sprouting + stolonisation (S_2); sprouting + stolonisation + tuber initiation (S_3) and sprouting + stolonisation + tuber initiation + tuber bulking (S_4), based irrigation scheduling during 2018-19 at the experimental farm of College of Agriculture, Kyrdemkulai, Meghalaya. Irrigated potato during stolonisation, and tuberisation (S_2) performed better (17.52 t ha^{-1}) over others. The amount of water used was 140, 206, 345 and 575 mm for S_1, S_2, S_3 and S_4 treatment, respectively. Tuber yield was found to be significantly higher under S_2 (17.52 t ha^{-1}) followed by S_4 (16.62 t ha^{-1}) and S_1 (16.26 t ha^{-1}), whereas, S_3 (14.87 t ha^{-1}) recorded the lowest yield. Organic manure treatments yielded significant results. M_2 (17.77 t ha^{-1}) showed the highest tuber yield closely followed by M_1 (13.94 t ha^{-1}) and the lowest yield was reported by M_0 (10.22 t ha^{-1}). Considering S_2 stage as base, the comparative water saving over S_3 and S_4 treatment are 67.5 and 179.13%, respectively. Therefore, the S_2 treatment (Irrigation at sprouting and stolonization) and M_2 treatment (poultry manure) showed the best result under hilly terrain of north-eastern India where winter irrigation is a major concern to ensure a better yield. There is a huge scope of further research to discover more economical methods for management of irrigation water for the post rainy season crop in the hilly terrain.

1. INTRODUCTION

Potato (*Solanum tuberosum* L.) is one of the most important crops in the world ranking fourth in production after rice, wheat and maize. It ranks second in India in terms of production after China (Scott and Suarez, 2011). In Meghalaya, the total area under potato cultivation is 18,473 ha and total production is 1,82,285 metric tonnes (mt). One of the promising varieties of potato is *Kufri Megha*. Potato is grown mainly under irrigated conditions during the *rabi* or post rainy season (Dey *et al*., 2017b; Gogoi and Ray, 2019; Gogoi *et al*., 2020; Das, 2023). The north-eastern states of India contribute about 10% of the total area under potato in the country and 4% of the total production in India (Gupta *et al*., 2004, Mawthaoh *et al*., 2019; Gogoi *et al*., 2020). However, the productivity of potato in the north-eastern region of India is very low (8.64 t ha^{-1}) may be due to non-adherence of scientific production technology, improved varieties and inputs (both fertiliser and irrigation) (Burman *et al.,* 2007; Scott and Suarez, 2011).

Potato is highly sensitive to moisture stress and cultivated mostly during the *rabi* season, it is essential to adopt a suitable approach of irrigation scheduling to enhance the productivity of the crop. (Dey and Ray, 2017a; Dey *et al*., 2017; Gogoi and Ray, 2019; Ray *et al*., 2017; Ray *et al*., 2023). Suitable irrigation scheduling during crop's critical growth stages (stolonisation, tuber initiation and tuber bulking) can help farmers to conjunctively use water whilst also increasing the yield. Also, being an exhaustive crop, proper nutrient management needs to be addressed to ensure potential output. Manures improve crop growth by enhancing uptake of nutrients by plants to the soil and improve soil fertility by increasing available nutrients (Baishya *et al*., 2010; Ati *et al*., 2012; Begum *et al*., 2018). Organic manure application enhances soil porosity, soil moisture content and water holding capacity (Baishya *et al*., 2010; Mahmood *et al*., 2017).

In crop production water is one of the key inputs (FAO, 2008). Adequate water supply at various stages the crop growth of facilitates a satisfactory yield. Moreover, some crop water production functions were developed under limited water supply which ultimately benefit the farmer to take a judicious decision in water application (Pawar and Dingre, 2014; Etissa *et al.*, 2016; Swetha, 2022; Das, 2023). Various other crop production technologies such as high yielding varieties, fertilizer use, multiple cropping and plant protection can be most effective only when the water supply is adequate at required period (Dilip, 2000; Baishya *et al*., 2010; Ati *et al*., 2012). Judicious application of irrigation water under a suitable irrigation scheduling always ensure a remarkable yield and thereby increasing water productivity (Dey *et al*., 2017; Ray *et al*., 2017; Goyal and Ray, 2022; Singh *et al.,* 2023). Different types of irrigation schedulings have their own advantages as well as limitations, however, critical stage based irrigation scheduling is found to be effective and can easily be followed by many of the farmers, hence, most widely practiced under limited water scenarios (FAO, 1971; Sharma *et al*., 1990; Sadawarti *et al*., 2013; Kumar *et al*., 2018).

Meghalaya is a rainfed state and crop production is highly dependent on rainfall. The state receives a good amount of rainfall during monsoon period, but erratic occurrence and poor distribution of rainfall making it difficult for farmers to grow crop in the post rainy season. Potato is mainly cultivated during winter, and the availability of irrigation water under undulating hilly terrain sometimes becomes a constraint. Keeping the above consideration, a field trial has been taken up to assess the growth and yield of potato under different organic manure treatment and critical stage based irrigation scheduling as well as to assess the water productivity under hilly terrain of Meghalaya.

2. MATERIALS AND METHODS

Experimental Site and Meteorological Conditions

A field experiment was conducted during *rabi* season, (November to March) of 2018-2019 at the experimental farm of the College of Agriculture, Kyrdemkulai, Ri-bhoi district, Meghalaya. The experimental site is situated at 91° 18' to 92° 18' East longitude and 25° 40' to 26° 20' North latitude and at an altitude of 950 m above the mean sea level. The location of the experimental site is shown in Fig. 1.

The climate of Ri-bhoi is classified as subtropical humid type with high rainfall and cold winters, the annual average rainfall is more than 2,000 mm (Ray *et al*., 2012; Ray *et al*., 2019). During the entire experimentation period, maximum weekly rainfall of 20.9 mm was received during 2^{nd} standard meteorological week (SMW), and 81.73 mm total amount of rainfall was received. Mean weekly maximum temperature was the highest during the 11^{th} SMW (27°C) and lowest in 1^{st} SMW (18.20°C). Mean weekly minimum temperature was highest during 11^{th} SMW (13.20°C) and lowest in 1^{st} SMW (5.90°C). The average recorded weekly relative humidity was 90%. The weekly meteorological data are presented in Table 2.

Prior to the experiment, initial soil samples were collected to determine the basic soil physical and chemical properties. The representative soil samples were taken at a depth of 0-15 cm and 15-30 cm with the help of soil auger to find the textural class and inherent fertility status of the experimental plots. These soil samples were then thoroughly mixed and composite samples were prepared for analyzing initial soil physical and chemical properties

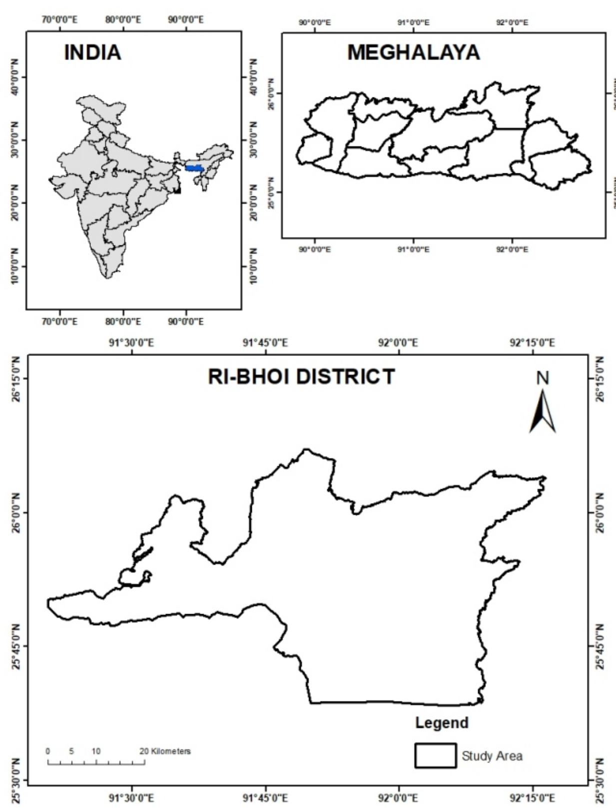


Fig.1. Location map of the study area

Table: 1
Physical and chemical properties of soil at the experimental site

Soil parameters	Value	Inference	Methods of estimation
1. Soil physical properties			
Soil texture		Sandy clay loam	Buoyoucos Hydrometer method (Chopra and Kanwar, 1976)
Sand %	49.15		
Silt %	8.40		
Clay %	42.45		
2. Soil chemical properties			
Soil pH	5.1	Acidic	pH Meter (Jackson, 1973)
Available N (kg ha^{-1})	242.8	Low	Alkaline Potassium Permanganate method (Subbiah and Asija, 1956)
Available P (kg ha^{-1})	19.25	Medium	Bray and Kurtz No. 1 method (Bray and Kurtz, 1945)
Available K (kg ha^{-1})	328.36	High	Neutral normal ammonium acetate extraction method followed by flame photometer (Jackson, 1973)
Organic Carbon (%)	1.8%	High	Walkley and Black's method (Walkley and Black, 1934)

before start of the experiment. Then the soil samples were air dried, grounded and sieved through 2 mm mesh. The processed samples were utilized for the analysis of the soil physical and chemical properties. The standard methods used for estimation, the values obtained, and the derived inferences are enlisted in Table 1.

The soil at the experimental site was found to be clay loam. The soil has initial organic carbon and pH of 1.8%, 5.10, respectively. The average values of available nitrogen (N), phosphorus (P_2O_5), and potassium (K_2O) at 0-30 cm were 242.8, 19.25, and 320 kg ha^{-1}, respectively. The soil of the experimental field is acidic in reaction.

Experimental design and treatment combinations

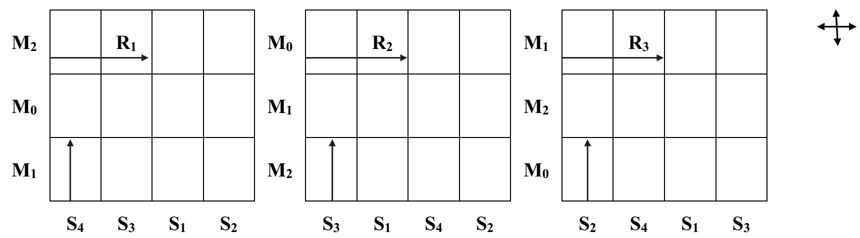
The potato variety (*Kufri Megha*) was taken as the test crop for the experiment and it was grown in acidic soil. The experiment was performed to assess the crop performance under different sources of organic input with varied stage-based irrigation scheduling. To find out the interaction between organic inputs and stage-based irrigation scheduling, strip plot experimental design was chosen for laying out the experiment. The whole experimental setup was divided into four vertical strips of equal area and then each vertical was further divided into three equal horizontal strips. The four critical growth stage-based irrigation scheduling was assigned in the vertical strips and the two sources of organic input along with a control were laid out in the horizontal strips. Hence, there are a total of 12 no. of treatment combinations. The experiment was replicated thrice. Farmyard manure (FYM) and poultry manure were applied at the rate of 24.0 and 8.0 t ha^{-1}, respectively, based on the equivalent recommended dose of nitrogen to the potato as basal dose one week before sowing. The seed rate and spacing adopted were 15 t ha^{-1} and 50 cm × 20 cm, respectively. The schematic layout of the plan of the experiment is provided in the Fig. 2. The details of the experimental combinations are presented in Table 3.

Table: 2
Weekly meteorological data prevailed during crop growing season

SMW	Total rainfall (mm)	Average maximum temperature (ºC)	Average maximum temperature (ºC)	Relative humidity (%)
48	0.00	24.30	9.50	86.00
49	0.00	22.70	10.00	84.00
50	0.00	23.60	9.20	81.00
51	0.00	19.70	7.20	84.00
52	2.60	20.30	10.00	90.00
1	0.00	18.20	5.90	84.00
2	20.90	20.00	6.30	89.00
3	0.00	23.10	8.40	81.00
4	0.00	21.40	7.90	83.00
5	0.00	22.20	4.60	83.00
6	0.00	24.50	9.60	86.00
7	0.00	24.80	10.60	84.00
8	0.00	21.60	10.00	86.00
9	13.10	18.80	5.90	81.00
10	0.00	23.00	10.40	77.00
11	0.00	27.50	13.20	69.00

Sampling, irrigation and data analysis

Three (03) plants from each treatment plots were tagged and all biometric observations, *viz*., plant height, leaf area index (LAI), dry matter accumulations per plant, tuber and haulm yield were recorded from these tagged plants. All the observations were recorded at regular 15 days interval starting from 30, 45, 60, 75, 90 and 105 days after sowing (DAS) while yield attributes were taken at the time of harvesting. The LAI was estimated by dividing leaf area per plant to the ground area covered by per plant. For estimating dry matter accumulation, three plants from each plot besides the tagged plant were selected and picked randomly. The excessive moisture was removed with the blotting paper after proper washing. The plants are separated as root, stem,



S = Critical stage-based irrigation scheduling, M = Organic manure, R = Replication

Fig.2. Schematic layout of experimental design

Table: 3
Experimental detail for the potato cultivation

Vertical strips	Horizontal strips
i. Irrigation at sprouting (10-DAS) (S_1)	a. Control (No manure) (M_0)
ii. Irrigation at sprouting (10-DAS) + stolonization (30-DAS) (S_2)	b. Farmyard manure (M_1)
iii. Irrigation at sprouting (10-DAS) + stolonization (30-DAS) + tuber initiation (50-55-DAS) (S_3)	c. Poultry manure (M_2)
iv. Irrigation at sprouting (10-DAS) + stolonization (30-DAS) + tuber initiation (50-55-DAS) + tuber bulking (65-70-DAS) (S_4)	

leaves, stolon and tubers for measuring the fresh weight. Then the samples were kept in hot air oven for abbot 48 hr at 60ºC till a constant weight was achieved. The dried weight of destructive samples was recorded for determining dry matter accumulation. Irrigation was provided to all the treatment plots as per schedule Irrigation at sprouting (10 DAS); Irrigation at sprouting (10 DAS) and stolonization (30 DAS); Irrigation at sprouting (10 DAS), stolonization (30 DAS) and tuber initiation (50-55 DAS); Irrigation at sprouting (10 DAS), stolonization (30 DAS) and tuber initiation (50-55 DAS) and tuber bulking (65-70 DAS) and the volume of water applied was measured through volumetric approach by keeping time record and the average discharge from a small (0.5 hp) electric pump set. Similarly, total amount of water applied, water productivity and percentage of irrigation water saved were also quantified.

The benefit cost analysis as per treatments was also done using standard protocols. The input costs were used based on the prevailing market price during 2018-19. The data obtained during this field investigation were analysed by using the technique of analysis of variance for strip plot design over the computer. The difference between the treatment means was tested as for their statistical significance with appropriate critical difference (CD) value at 5% level of probability as explained by Gomez and Gomez (1984). All the field data were analysed using Microsoft Excel of the MS office software.

3. RESULTS AND DISCUSSION

Plant Growth and Yield Attributes

The various plant growth parameters, *viz*., plant height, number of branches, LAI and dry matter accumulation per plants are analysed and presented in Table 4. It may be observed from the Table 4, that, significant results were obtained for all the plant growth parameter under horizontal strip plots, however, under vertical strips (irrigation scheduling) only plant height, and dry matter accumulation per plant showed significant results.

Plant Height and Number of Branches

Plant height is an important parameter for determining the growth of plant. The maximum plant height was recorded as 29.98 cm. Plant heights of potato decreases with decrease of irrigation frequency (Kumar *et al*., 2007). The application of poultry manure showed the highest plant height (29.98 cm) and the shortest height was recorded under control treatment (23.73 cm) at 105 DAS as presented in Table 4. It might be due to the ability of poultry manure to decompose rapidly thereby, releasing the nutrients essential for plant growth (Boateng *et al*., 2006). Also, some studies suggested that poultry manure provides readily available form of nutrient which is easily absorbed by the plant roots and enhances morphological growth of plant (Onwu *et al*., 2014). Application of poultry manure reduce soil pH through release of CO_2 and organic acids during decomposition and the decomposition product may increases soil microbial population which solubilizes the native soil nutrients in available form for the plants (Singh *et al*., 2018). Other organic manures like FYM, has a slow nutrient release pattern (Souza *et al*., 2008). The results reported a significant difference in plant height in plants derived in poultry manure and FYM compared with that of control. These results were in agreement to the findings of Karim *et al.* (2016). Similarly, irrigation scheduling at crops' critical growth stages, showed significant results on plant height this may be attributed to timely application of irrigation water and in-situ soil moisture helps in attaining a good

Table: 4
Effect of irrigation scheduling and organic manures on potato growth performance

Treatments	Plant height (cm)	Number of branches per plant	Leaf area index	Dry matter accumulation per plant (g)
S_1	25.02	1.72	2.33	64.54
S_2	28.05	1.86	2.36	65.54
S_3	26.89	1.94	2.47	68.06
S_4	26.85	1.97	2.59	70.64
SE (m) ±	0.58	0.04	0.07	1.50
CD (P=0.05)	2.02	NS	NS	4.86
Control (M_0)	23.73	1.62	2.25	63.23
FYM (M_1)	26.40	2.02	2.55	71.93
Poultry manure (M_2)	29.98	2.06	2.61	72.27
SE (m) ±	0.38	0.07	0.08	1.74
CD (P=0.05)	1.49	0.20	0.23	2.17

*S_1- Irrigation at sprouting; S_2- Irrigation at sprouting + stolonization; S_3- Irrigation at sprouting + stolonization + tuber initiation; and S_4- Irrigation at sprouting + stolonization + tuber initiation + tuber bulking *NS = Non-significant*

growth during the cultivation period. The results were in agreement with the findings of (Boateng *et al*., 2006; Souza *et al*., 2008; Karim *et al*., 2016).

The numbers of branches per plant were not significantly influenced by irrigation scheduling, however, the results were found to be significant under organic inputs. Similar results where, organic inputs had a significant effect on branches per plant over control were given by (Ahmed *et al*., 2017; Singh *et al*., 2018; Jha *et al.,* 2017) in potato. The reason may be due to the influence of higher amount of available nutrients under organic regimes during the development.

Leaf Area Index (LAI)

LAI was found to increase very noticeably throughout the growing period but the difference was very nominal. Significant results were obtained under organic inputs over irrigation scheduling. Lahlou *et al*. (2003) reported the influence of water stress on aerial parts of potato. In contrary to these findings, Jefferies and MacKerron (1987), reported that, the reduction of leaf size is the first morphological manifestation of drought and it is associated with a lesser light interception and later leads to a reduction in dry matter accumulation in tubers. Poultry manure registered higher LAI as compared with control but it was at par with FYM. This may be due to better availability organic micro and macro nutrients which lead to better plant growth and development. Similar results were supported by Kar and Kumar (2007).

Dry Matter Accumulation

The dry matter accumulation was observed to be continuously increasing under both irrigation scheduling and organic manure treatments and the results were found to be significant. It is quantified by the total sum of above ground and underground potato parts (Mohamed *et al.,* 2017). During the early stages of growth of potato, dry matter is mostly accumulated in leaf or stem, but from tuber initiation onwards, accumulation is more on stolons. Amongst the different irrigation scheduling, the highest dry matter was accumulated under S_2 treatment (47.31 g) (Bora and Karmakar, 2012) followed by S_3 (3.66 g). Water stress at stolonisation and tuber initiation stages of potato has greater effect as compared to water stress at tuber bulking stages (Hassan *et al*., 2002). The highest accumulation was observed at under M_2 treatment (52.34 g) followed by M_1 (43.93 g) which was significantly higher than M_0 (35.28 g). It has been revealed that poultry manure has higher Nitrogen (N) content and lower C:N ratio than FYM which aids for faster decomposition (Mahmood *et al*., 2017). As a result, increase in dry matter accumulation may be due to the steady release of major nutrients required for plant metabolism (Karim *et al*., 2016). This result clarifies the contribution of poultry manure and FYM towards growth of plants.

The various yield attributes of potato, *viz*., tuber weight per plant, tuber and haulm yield, water productivity and benefit cost ratio (BCR) of different treatment combinations are presented in Table 5.

Non-significant results were recorded in irrigation scheduling treatments on weight of tubers per plant. Even treatment with only one irrigation, *i.e.,* S_1 produced the lowest weight of tubers per plant. This indicates that water availability at the root zone of plant plays an important role on the final yield. And clearly, irrigation at stolonisation proves to be the most critical stage for better crop performance (Table 4). This is in conformity with results reported by Saikia, 2011; Bora and Karmakar, 2012. It may be attributed that, the availability of water at root zone during potato growth helps in better yield and produce (Bisht *et al.,* 2012). Among organic manure treatment M_2 (205.91 g) closely followed by M_1 (172.79 g) and M_0 (108.78 g). The findings are in accordance with Lemaga and Caesar, 1990; Amara and Mourad, 2013; Karim *et al*., 2016.

Table: 5
Effect of irrigation scheduling and organic manures on potato yield and BCR

Treatments	Weight of tuber per plant (g)	Tuber yield (t ha^{-1})	Haulm yield (t ha^{-1})	Water productivity (kg ha^{-1} mm^{-1})	Benefit Cost Ratio (BCR)
S_1	156.92	16.26	1.53	47.21	1.68
S_2	169.01	17.52	1.74	85.05	1.91
S_3	161.62	14.87	1.56	43.10	1.75
S_4	162.45	16.62	1.64	28.90	1.85
SE (m) ±	3.11	0.37	0.07	6.28	0.09
CD (P=0.05)	NS	1.27	NS	19.84	NS
Control (M_0)	108.81	10.02	1.23	-	1.18
FYM (M_1)	172.79	13.94	1.78	-	1.93
Poultry manure (M_2)	205.91	17.77	1.83	-	2.28
SE (m) ±	2.25	0.24	0.05	-	0.11
CD (P=0.05)	8.91	0.74	0.20	-	0.42

*S_1- Irrigation at sprouting; S_2- Irrigation at sprouting + stolonization; S_3- Irrigation at sprouting + stolonization + tuber initiation; and S_4- Irrigation at sprouting + stolonization + tuber initiation + tuber bulking *NS = Non-significant*

Tuber yield was found to be significantly higher under S_2 (17.52 t ha^{-1}) followed by S_4 (16.62 t ha^{-1}) and S_1 (16.26 t ha^{-1}), whereas, S_3 (14.87 t ha^{-1}) recorded the lowest yield. Organic manure treatments also yielded significant results. M_2 (17.77 t ha^{-1}) showed the highest tuber yield closely followed by M_1 (13.94 t ha^{-1}) and lowest yield was reported by M_0 (10.22 t ha^{-1}). Crop irrigated only at sprouting might have experienced water stress during the vegetative phase, reproduction phase and maturity phase causing a reduction in final tuber yield. The reduction in yield with treatment S_1 can also be attributed to the lesser number of tubers per plant and lower tuber weight per plant. High water requirement needs to be emphasized especially during critical stages of potato *viz.,* tuber initiation and tuber bulking (Hassan *et al*., 2002; Saikia, 2011; Bora and Karmakar, 2012). Among organic manure treatment M_2 (17.77 t ha^{-1}) closely followed by M_1 (13.94 t ha^{-1}) and M_0 (10.2 t ha^{-1}). Poultry manure has been reported to have a favourable effect on soil physical, chemical and biological properties (Demir *et al*., 2010, Oustani *et al*., 2015). The yield of potato is favourably higher under manure fertilisation and this may be attributed to the improvement of soil water retention and supplementation of required nutrient. Under control treatment, the yield is extremely low due to less number of tubers, small tuber size and low weight of tubers per plant. These findings are in line with those reported by Chandrakar *et al*., 2017. Similarly, the potato haulm yield did not show any significance under irrigation scheduling treatments. S_2 (1.74 t ha^{-1}) yielded the highest followed by S_4 (1.64 t ha^{-1}) and S_3 (1.56 t ha^{-1}), whereas, S_1 (1.53 t ha^{-1}) recorded the lowest yield. Organic manure treatments yielded significant results. M_2 (1.83 t ha^{-1}) showed the highest haulm yield, followed by M_1 (1.78 t ha^{-1}) and M_0 (1.23 t ha^{-1}). Sufficient soil moisture and efficient supply of required nutrients improves photosynthesis thereby increasing dry weight and eventually yield.

The gross return reported significant results under irrigation scheduling treatments, S_2 (₹ 2,71,511.11 ha^{-1}) recorded highest gross return over S_4 (₹ 2,57,511.11 ha^{-1}) followed by S_3 (₹ 2,30,888.89 ha^{-1}) and S_1 (₹ 1,06,777.78 ha^{-1}) being the lowest. For net return S_2 (₹ 1,76,483.25 ha^{-1}) recorded highest net return closely followed by S_4 (₹ 1,60,418.25 ha^{-1}) followed by S_3 (₹ 1,34,828.53 ha^{-1}) and S_1 (₹ 12,782.44 ha^{-1}) being the lowest. BCR also showed significant difference among the irrigation scheduling treatments, S_2 (2.83) produced the highest BCR over S_4 (2.63) and S_3 (2.39) but the lowest is S_1 (1.13). Similar findings were reported by Bisht *et al.,* 2012; Chandrakar *et al.,* 2017. For organic manure treatment, significant results were reported from gross return, net return and BCR. Gross return of M_2(₹ 2,75,708.91 ha^{-1}) showed significantly higher results compared to M_1 (₹ 2,17,945.83 ha^{-1}) and M_0 (₹ 1,56,362.50 ha^{-1}). For net return, M_2 (₹ 1,77,961.56 ha^{-1}) showed significantly higher results compared to M_1 (₹ 1,16,069.06 ha^{-1}) and M_0 (₹ 69,353.73 ha^{-1}). BCR also showed significant difference among the organic manure treatments, M_2 (2.82) produced the highest BCR over M_1 (2.13) and M_0 (1.79). This can be attributed to the significantly larger amount of yield reported from poultry manure and FYM treatments over control treatment.

Water Productivity

Based on fresh tubers harvested from the respective treatment field and amount of water applied, water productivity was expressed as the ratio of tuber yield to amount of water applied. The treatments along with their water productivity are presented in Table 6.

Table: 6
Water productivity under irrigation scheduling at different critical stages

Treatments	Tuber yield (kg ha^{-1})	Amount of irrigation water applied (mm)	Water productivity (kg $ha^{-1}mm^{-1}$)
S_1	16260	140	116.14
S_2	17520	206	85.05
S_3	14870	345	43.10
S_4	16620	575	28.20

Treatments with deficit irrigation registered higher water productivity and this is due to the use of water more efficiently (Onder *et al.,* 2005; Mokh *et al*., 2015; Dalai *et al.,* 2023; Sahoo *et al.,* 2023). The proper application of deficit irrigation practices can generate significant savings in irrigation water allocation without any significant yield reduction and therey increasing water use efficiency (Demelash, 2013).

4. CONCLUSIONS

Considering the scarcity of irrigation water during non-rainy season under hilly terrain of north-eastern region of India, critical stage based irrigation scheduling is a economical practice to be taken up by the farmers under organic input regime to reduce the quantity of the irrigation water applied and enhance soil health. Combined irrigation scheduling at sprouting and stolonization stage is the most suitable for better performance and economics of potato. Similarly based on organic inputs poultry manure may be preferred over FYM as the poultry manure enhances the availability of essential nutrient and stimulates soil microbial population and consequently increases crop yield. As a majority of household in this region have poultry farm for commercial purpose, there is no difficulties to get poultry manure. During rainy season, rainwater can be harvested for later use in the critical crop growth stages to increase the yield. Hence, it is an easier way for the farmer of the region to adopt the method of irrigation scheduling and nutrient management through organic input. The range of water used varied between 140-575 mm among four different treatments, but based on yield recorded and comparative advantages obtained due to saving of irrigation water in potato, irrigation must be provided at spouting and stolonisation stages to overcome the yield loss of potato and thereby enhancing water productivity.

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