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Performance of potato with organic mulches in Meghalaya

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ABSTRACT

Organic mulching is one of the important ingredients under natural farming, which ensures salubrious soil environment with respect to *in-situ* soil moisture and soil temperature and thereby resulting higher crop productivity. This practice is followed mostly during winter season to maintain soil moisture under different terrain. Potato is one of the important winter season crops of Meghalaya that faces water scarcity and thereby reduction in optimum yield. Under this scenario, the performance of potato (*Solanum tuberosum* L.) was assessed during 2021-22. Four different organic mulches, *viz*., M_1-no mulch M_2- paddy straw mulch, M_3-maize stubble mulch and M_4 - weed mulch constituted as treatments and the experiment was replicated thrice. Irrigation was provided with different furrow irrigation system. Paddy straw mulch (M_2) showed higher values for plant height, number of branches per plant, leaf area index (LAI), number of tubers per plant, weight of tubers per plant (g), tuber yield (t ha^{-1}). Paddy straw mulch registered the highest tuber yield (17.15 t ha^{-1}) which was found at par with M_4 (16.66 t ha^{-1}), the lowest yield was reported in no-much treatment (12.24 t ha^{-1}) followed by treatment under maize stubble mulch (14.96 t ha^{-1}). Similarly, the maximum field water use efficiency (WUE) was recorded for M_2 (47.49 kg $ha^{-1}mm^{-1}$) over M_1 (33.91 kg ha^{-1} mm^{-1}) and M_3 (41.62 kg ha^{-1} mm^{-1}), but it was at par with M_4 (46.62 kg ha^{-1} mm^{-1}). Maximum gross return (Rs. 2, 57,177.78 ha^{-1}), net return (Rs.1, 54, 582.82 ha^{-1}) and BCR (2.50) were reported highest in M_2 over M_1, M_3 and it was found to be at par with M_4.

1. Introduction

Potato is an important food crop of the world (Haverkort, 1990; Scott *et al.*, 2000; Gurjar*et al.*, 2022) and is ranked fourth in production volume, after wheat, rice and corn (Fabeiro*et al.,* 2001; Bowen, 2003; Camire*et al.,* 2009; Chakraborty *et al.*, 2010; Gogoi*et al.*, 2020) with a total production of 370 M T from 17 M ha cultivated area (FAO, 2019). India is the second largest potato producer after China (Scott and Suarez, 2011; Saxena and Mathur, 2013). Indian overall production was 48.24 MT on an area of 2.15 M ha having an average yield of 22 t ha^{-1} (Anonymous-I, 2017). Potato is an herbaceous plant requires light and frequent irrigation throughout the period of crop growth. In comparison with other crops, it is very sensitive to water stress and has shallow root system (Epstein and Grant, 1973; Jabro*et al.*, 2012; Gogoi and Ray, 2019; Goyal and Ray, 2022). Being a water sensitive crop, potato gives good response when cultivated with assured condition. Almost 10% of India's total potato area is covered by the North East Hill (NEH) region. Potato productivity of this region is very low as compared to national average; one of the major constraints of low productivity may be attributed due to the lack of optimum water availability during the growing season. Hence, it is very much essential to adopt suitable water saving irrigation methods which helps the farmers for judicious water usage, which will not only save a good amount of water but also enhance water use efficiency (WUE). Resource conservation techniques like mulching will

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also help to conserve *in-situ* moisture during winter seasons (Dey and Ray, 2017a; Dey and Ray, 2017b; Mawthaoh*et al.*, 2019). Mulching can also affect the temperature and provide better edaphic environment for root growth and yield of crops.

To study the effect of mulching under furrow irrigation system, a field experiment has been laid out during 2021-22 with an objective to assess the performance of potato under different organic mulching treatments.

2. Materials and Methods

A field experiment was conducted during winter season (2021-22) at the experimental field of College of Postgraduate Studies in Agricultural Sciences (CAU-Imphal), Ri-Bhoi, Meghalaya to evaluate the performance of potato (variety: Kufri Megha) under different organic mulches. The experiment was laid out with four different organic mulches, *viz.*, No mulch (M_1), Paddy straw mulch (M_2), Maize stubble mulch (M_3) and Weed mulch (M_4); and replicated thrice. A schematic layout of the experimental site is shown in Fig.1. The variation of weekly rainfall (mm), evaporation (mm), maximum and minimum temperature (^oC) and relative humidity (%) is shown in Fig. 2. The experimental site is situated at 91˚18' E longitude and 25˚40' N latitude and at an altitude of 950 m above the mean sea level (MSL).The climate of Ri-bhoi is classified as subtropical humid type with high rainfall and cold winters. Soil sample was collected at 15 cm depth and analyzed to determine different soil physic-chemical parameters. Experimental soil texture was found to be sandy clay loam type with 1.36 g cc^{-1} bulk density. The pH of soil was acidic in nature with pH 4.8, rich in organic carbon (1.64%), low in available nitrogen (243.34 kg ha^{-1}), medium in P_2O_5 (16.52 kg ha^{-1}) and medium in K_2O (260 kg ha^{-1}).

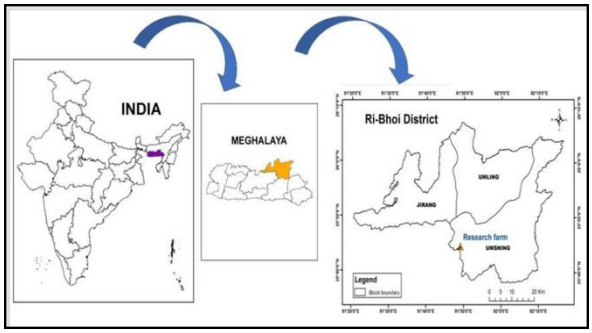

Figure 1. Location of the experimental site

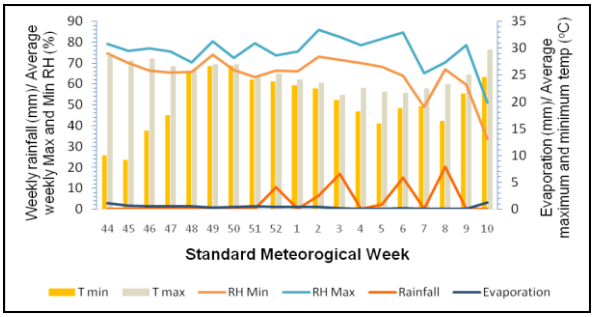

Figure 2. Weekly weather data prevailed during crop season

Medium duration (100-120 days) potato variety (KufriMegha) was used for the experiment which has good yield potential. Disease free tubers were planted on top of the ridges (50 cm × 20 cm). Farmyard manure @ 5 t ha^{-1} was applied 15 days before sowing of potato during field preparation; similarly lime was applied to neutralize the soil acidity @ 500 kg ha^{-1} in furrows. Recommended doses of N, P and K @100:80:60 kg ha^{-1} was applied. Full doses P and K were applied at time of sowing along with 50% of N and rest 50% of N at tuber initiation stage through top dressing. The details of the crop calendar are presented in Table 1. Standard agronomic practices were followed during crop growth and crop was harvested at maturity. The crop growth parameters, *viz.,* plant height, number of branches per plant, leaf area index (LAI) and dry matter accumulation per plant (g) were recorded at 15 days interval during the experiment. Similarly, the yield (t ha^{-1}) along with the number of tubers per plant and weight of tubers per plant (g) were recorded at harvest. Irrigation water was applied through furrow method based on the soil moisture depletion at 50% using a 0.5 hp electric pump set by volumetric basis and accordingly the total quantum of water applied was worked out. The water use efficiency (WUE) of the crop was determined using standard empirical formulae.

Daily evaporation was recorded in the observatory along with other weekly data as average temperature, relative humidity and total rainfall during the potato growing period from 44th standard meteorological week (SMW) November 3rd to 10th SMW March 7th. Figure 2 shows the variation of meteorological parameters during the cropping period.

The data obtained from experimental field/ observations/laboratory studies during investigation were statistically analysed by using the technique of analysis of variance. The difference between the treatment means was tested as for their statistical significance with appropriate critical difference (C.D.) value at 5% level of probability as explained by Gomez and Gomez (1984).

Table 1. Crop calendar of potato cultivation during winter season

Sl. No.	Cultural Operation	Date of Field activities/ Operation
1.	Field preparation and incorporation of lime	26th October 2021
2.	Field layout	29th October 2021
3.	Sowing and fertilizer application	03rd November 2021
4.	Application of mulch	05th November 2021
5.	Gap filling	15th December 2021
6.	Weeding in Un mulched plots	31st December 2021 (as and when required)
7.	Earthing up	06th January 2022
8.	Harvesting	07th March 2022

Leaf area index (LAI)

The leaf area index (LAI) was estimated by dividing leaf area per plant to the ground area covered by per plant. It is calculated with the following Equation (Watson, 1952) given in Eq 1.

$$LAI = \frac{\text{leaf area } (cm^2)}{\text{ground area } (cm^2)} \quad \ldots. (1)$$

Number of tubers per plant

Number of tubers per plant from three randomly selected tagged plants were counted and summed up and later the sum total was divided by the number of plants to get the average value. Their mean was expressed as number of tubers per plant.

Weight of tuber per plant

Tuber weight per plant was determined from tagged plant expressed in g per plant.

Tuber yield

Total tuber yield was calculated by excluding the yield of the plants, from boundary but by including the yield of sample plants and converted to tonnes per hectare using suitable conversion factor.

Field water use efficiency (WUE)

Water use efficiency under different organic mulches was calculated at the time of harvest by dividing the yield with total amount of water used. It is given in Eq. 2.

$$WUE = \left[\frac{\text{Economic yield } (t\,ha^{-1})}{\text{consumptive use of water (mm)}} \right] \quad \ldots. (2)$$

Benefit cost ratio (BCR)

Cost of cultivation was calculated based on the prevailing market price of inputs, labour and land lease cost. Accordingly return obtained was estimated by multiplying tuber yield with the local market price of potato tuber. Local market price of the potato tubers was assumed Rs.15 per kg. Benefit cost ratio (BCR) value was obtained by dividing gross return with cost of cultivation as given in Eq.3.

Gross return = Tuber yield x local market price of potato tubers

Net return = Gross return – Cost of cultivation

$$\text{Benifit Cost Ratio (BCR)} = \frac{\text{Gross return}}{\text{Cost of cultivation}} \quad \ldots. (3)$$

3. Results and Discussion

The analyzed data of plant growth attributes, *viz.*, plant height, number of branches per plant, leaf area index and dry matter accumulation is presented in Table. 2. Similarly, analyzed data of the yield attributes, *viz.*, number of tubers plant^{-1}, weight of tubers (g), tuber yield (t ha^{-1}) is presented in Table.3.

Plant height

Plant height was found to have an increasing trend with the advancement of crop growth and maximum value was attained at harvest stage. The plant height was found significantly highest under paddy straw mulch over the entire crop season compared to control. Similar findings were also reported by (Sharma and Sharma, 2003; Dey and Ray, 2017b). However, the plant height under weed mulch was at par with paddy straw mulch. The reason might be due to better soil availability and better regulation of soil temperature under mulch compared to un-mulch or control.

Number of branches per plant

Significant results were also found for number of branches per plant among the organic mulch treatments. However, paddy straw mulch has shown higher number of branches per plant than weed mulch, maize stubble mulch and control. Similar results where, mulching had a significant effect on branches per plant over control were given by (Ahmed *et al.*, 2017 Gurjar *et al.*, 2022) in potato. The reason may be due to the influence of higher temperature and humidity under mulched during the early development. Similar results were supported by the research findings of (Singh *et al.*, 2019; Gogoi and Ray, 2019).

Leaf area index (LAI)

The data reveals significantly increased in LAI with the application of organic mulch treatments, where paddy straw has shown higher LAI as compared with control but it was at par with weed mulch treatments. This may be due to better soil moisture availability under mulched condition leads to better plant growth and development. Similar results were supported by Kar and Kumar (2007), Dey and Ray, (2017a, Marwein and Ray, 2021.

Dry matter accumulation per plant

Dry matter accumulation was observed to be continuous increased with the progress of the age of the plant. The highest dry matter accumulation was observed at 105 DAS under M_2 treatment (72.27 g) followed by M_4 (71.93 g) which was significantly higher than M_1 (63.23 g) and M_3 (67.81 g). Depending on the amount of photo-assimilates fixed through photosynthesis, there occurs increase in the dry mass of plants (Dey *et al*., 2017a; Gogoi *et al*., 2020).The reason might be the better plant growth and development due to better soil moisture availability under organic mulch compared to control or no mulch. Similar findings were supported by Singh and Rana (2006).

Table 2. Plant growth parameters during the experimental period

Parameters	Plant height (cm)						Number of branches per plant					
	30 DAS	45 DAS	60 DAS	75 DAS	90 DAS	105 DAS	30 DAS	45 DAS	60 DAS	75 DAS	90 DAS	105 DAS
M_1-No mulch	12.85	18.73	21.69	24.31	25.85	27.50	1.11	1.25	1.32	1.51	1.62	1.62
M_2- Paddy straw mulch	17.57	26.66	30.91	32.24	33.62	34.70	1.44	1.56	1.70	1.92	2.06	2.06
M_3- Maize stubble mulch	14.31	23.24	28.73	30.35	31.13	32.90	1.18	1.34	1.46	1.65	1.82	1.82
M_4 - Weed mulch	15.71	25.83	30.10	31.60	32.50	34.13	1.41	1.47	1.68	1.89	2.02	2.02
S.E.(m) ±	0.68	1.10	1.26	1.30	1.19	1.14	0.06	0.06	0.07	0.07	0.07	0.07
C.D(P=0.05)	2.03	3.26	3.73	3.85	3.54	3.39	0.17	0.17	0.19	0.21	0.20	0.20
	Leaf area index (LAI)						Dry matter accumulation per plant					
	30 DAS	45 DAS	60 DAS	75 DAS	90 DAS	105 DAS	30 DAS	45 DAS	60 DAS	75 DAS	90 DAS	105 DAS
M_1-No mulch	0.11	0.48	1.08	1.85	2.20	2.25	2.40	4.84	7.18	18.54	35.17	63.23
M_2- Paddy straw mulch	0.17	0.62	1.38	2.08	2.57	2.61	3.16	5.39	8.33	24.67	48.06	72.27
M_3- Maize stubble mulch	0.13	0.53	1.12	1.94	2.38	2.43	2.44	5.05	7.93	21.94	44.09	67.81
M_4 - Weed mulch	0.16	0.60	1.33	2.05	2.50	2.55	2.86	5.29	8.00	23.37	47.44	71.93
S.E.(m) ±	0.01	0.02	0.05	0.05	0.08	0.08	0.11	0.16	0.27	1.02	1.74	1.74
C.D(P=0.05)	0.02	0.06	0.16	0.14	0.23	0.23	0.34	NS	0.80	3.03	5.18	5.17

Table 3. Yield attributes parameters of potato

Parameters	Number of tubers per plant	Weight of tubers per plant	Tuber yield (t ha^{-1})	Water use efficiency (kg $ha^{-1}mm^{-1}$)
M_1-No mulch	6.66	247.69	12.24	33.91
M_2- Paddy straw mulch	8.59	317.89	17.15	47.49
M_3- Maize stubble mulch	7.46	273.59	14.96	41.62
M_4 - Weed mulch	8.22	294.22	16.66	46.42
S.E.(m) ±	0.32	13.92	0.48	1.40
C.D(P=0.05)	0.95	41.35	1.42	4.15

Number of tubers per plant

Paddy straw mulch recorded highest number of tuber per plant and the lowest was reported by control treatments. The main reason may be due better soil moisture availability under mulched conditions lead to better plant growth and development. These results are supported by (Dash *et al.*, 2018; Kahlon and Khera, 2015). Monneveux *et al.* (2006) also reported that, water stress at reproductive stages of the plant reduces the yield and yield parameters.

Weight of tubers per plant

Significant results were reported for organic mulch treatments, where paddy straw mulch (317.89 g) reported significantly highest weight of tuber per plant over control (247.69 g) which is at par with weed mulch (294.22 g). The similar findings were in close harmony with Farrag *et al.* (2016).

Tuber yield

Among different organic mulch treatments, M_2 (17.15 t ha^{-1}) recorded significant highest tuber yield over M_1 (12.24 t ha^{-1}) and M_3 (14.96 t ha^{-1}) which was closely at par with M_4 (16.66 t ha^{-1}). (Lindi *et al.*, 2018) reported the similar findings that application of straw mulch improved tuber yield of potato and this might be due to enhancement in infiltration rate and soil temperature adjustment due to straw mulch than the control treatments that leads to high soil temperature. These results were also agreed by findings of Bhatt *et al.*, 2011; Pandey *et al.*, 2011; Gogoi*et al.*, 2020.

Water use efficiency

Potato under paddy straw mulch (M_2) registered significantly higher WUE (47.49 kg ha^{-1} mm^{-1}) over M_1 (33.91kg ha^{-1} mm^{-1}) and M_3 (41.62 kg ha^{-1} mm^{-1}) but was at par with M_4 (46.42 kg ha^{-1} mm^{-1}).This may be the result of increased water use for the crop growth than that of for the evapotranspiration (Shylla*et al.*, 2016; Dey and Ray, 2017b; Mawthaoh*et al.*, 2019).

4. Conclusions

Organic mulching provides better soil environment for potato growth and development. This study also reflects the importance of organic mulch as a source for *in-situ* moisture conservation in the NEH region under furrow irrigation system. There was 41% yield enhancement over control with respect to paddy mulching, similarly by adhering to weed mulch and maize stover mulch there was a yield increment of 36.11 and 22.22%, respectively. Maximum value of BCR was estimated under paddy straw mulch was 2.50, with Rs. 1, 02, 595 cost of cultivation per hectare. Soil moisture deficit is one of the most important constraints for crop production during winter season in NEH region, hence, inclusion of paddy straw mulch along with furrow irrigation method is found to perform better in enhancing the crop yield and water use efficiency. By adhering to mulching techniques the farmers of NEH region can go for winter potato cultivation which improves the cropping intensity and add additional inputs to the food basket of NEH region. Most of the cultivated lands were kept fallow after rain-fed paddy, so using the paddy straw as mulch material, farmers can easily grow potato which increases yield and water use efficiency.

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