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Assessment of performance of potato crop under modified microclimates in rice based cropping system of Upper Brahmaputra valley zone of Assam

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ABSTRACT

A field experiment was conducted during *rabi,* 2017-18 in Assam Agricultural University, Jorhat to identify appropriate adaptive strategies for combating ill effect of heat and moisture stress through modifying microclimate in rice-potato double cropping system. The potato variety – *Kufri Jyoti* was planted in split plot design with 3 dates starting from 10 November at 10 days interval (main plots) and three mulching treatments with water hyacinth, black polythene and without mulching (sub-plots) following recommended agronomic practices. The study revealed that there were 11.8 and 7.0 per cent increase in average soil moisture content under water hyacinth and black polythene, respectively as compared to non-mulched treatment. On the other hand, soil temperature was 0.5 to 1.5 °C (morning) and 1.1 to 2.3°C (evening) lower under water hyacinth, but 1.2 to 2.1°C (morning) and 1.7 to 2.6 (evening) higher under black polythene as compared to non-mulched crop. In all planting dates, crop growth parameters like LAI and biomass production were observed to be highest under water hyacinth, followed by black polythene and without mulching. Among the mulching treatment the highest and lowest tuber yield was recorded under water hyacinth (120.81 q ha^{-1}) and non-mulched treatment (85.0 q ha^{-1}), respectively in all planting dates.It was found that the tuber yield was significantly and positively correlated (at 5% level) with the average soil moisture retention (mm) in upper 30 cm layer of soil during tuber formation to physiological maturity (r =77*). Increase in tuber yield (up to 42.2%) under water hyacintheven in case of late plantings (beyond 10 November) was probably due to increase insoil moisture retention (8.1 to 15.7 %) and reduction of soil temperature (1 to 1.8°C) under water hyacinthwhich endowed with favorable hydrothermal environment as compared to that under black polythene and non mulched treatment.

Key words: Potato, *Kufri Jyoti*, microclimate, mulching, moisture and temperature stress

Though growth, development and yield of potato is greatly influenced by prevailing environmental conditions, heat and water stresses are the major limiting factors for production of the crop. During initial growth stages temperature around 25°C is most suitable while for tuber development lower temperature (< 20°C) are favorable (Western Potato Council, 2003). Generally, increase in ambient temperature reduces length of growing period, increase crop respiration rates, alter photosynthate partitioning to economic produce and ultimately reduce tuber yield. Even moderately high temperature drastically reduces tuber yield without much affecting the photosynthesis and total biomass production (Singh *et al.*, 2013). Potato is also very sensitive to water stress because of its shallow root system; approximately 85 per cent of the root length is concentrated in the upper 30.4 cm of the soil (Iwama, 2008) and 70 per cent of total water need is met by the crop from the upper 30 cm layer (Singh *et al*., 1987). Potato plants require a high degree of soil aeration; however, temporary dryness may reduce tuber yield. Therefore, to raise a successful potato crop, it is necessary to maintain soil moisture at the required regime of available moisture, so that soil moisture should be maintained above 65 per cent of the available soil water capacity throughout its crop growth period (Chandra *et al*., 2002).

One of the profitable double cropping systems identified for Assam is rice (*kharif)* plus potato (*rabi*) system which can increase the productivity of the soil to a great extent and may be a way forward to achieve the goal for doubling farmers' income (Neog *et al.*, 2018). But soil moisture depletion and increasing soil temperature particularly in the later part of *rabi* season (from mid February onwards) are two major limiting factors hindering growth and yield, if planting

of the crop is delayed beyond 15th November (Begum and Saikia, 2014). However, modification of microclimate with respect to soil temperature and moisture regime within the root zone may provide congenial microenvironment for better growth of the crop even with higher ambient temperature. Manipulation of agronomic practices like planting times, mulching, irrigation etc may substantially modify the microclimate to affect stolonization, tuber initiation and bulking and tuber enlargement at a given site, particularly where solar radiation is not a limiting factor for potato production. In Assam, the potato is grown as rainfed crop, hence, increased variability of rainfall and temperature due to climate change is bound to affect the productivity of the crop. Under such situation, modification of microclimate through mulching and planting time can be an effective adaptation strategy for combating ill effect of heat and moisture stress on potato production, especially under rainfed condition. Since, work on micro-meteorological aspect in potato has not yet been done extensively and a few research results are available in this direction. Therefore, there is the need of studies on microclimate modification in potato to address such issues.

Mulching is a common practice used to regulate soil microclimate, mainly soil temperature and moisture (Baten *et al*., 1995). Mulching facilitates more retention of soil moisture and helps in controlling temperature fluctuations, improves physical, chemical and biological properties of soil, as it adds nutrients to the soil and ultimately enhances the growth and yield of crops (Baten *et al*., 1995; Kar 2003; Saikia *et al.* 2014). In addition to controlling weeds, mulching reduces daily maximum soil temperature, results in faster emergence, early canopy development and higher tuber yield as compared to no mulched crop of potato (Jaiswal, 1995). Hypothesis is that in Assam situation, mulching and manipulating planting dates will create congenial microclimate for matching growing periods to fit in the required microclimatic conditions for growth, development and yield of the crop. Keeping in view the importance of the above facts, the gaps in scientific information and the necessity of generating the field data in potato, the research was planned to evaluate the effect of mulching on soil hydro-thermal regimes in potato.

MATERIALS AND METHOD

The present field study was conducted at Instructional-Cum-Research Farm of Assam Agricultural University, Jorhat, Assam (26°74'N, 94.20°46'E and 87 m amsl) during *rabi* season 2017-18. The potato variety – *Kufri Jyoti* was planted in split plot design with 3 dates starting from 10 November (P_1) at 10 days interval (main plots) and three mulching treatments with water hyacinth (M_1), black polythene (M_2) and without mulching (M_0) (sub-plots) following recommended agronomic practices. The maximum and minimum soil temperatures were recorded with soil thermometer placed at 5 cm and 10 depths of soil in 9 plots of representing different treatment combinations. Soil samples from two depths, *viz.* 0 to 15 cm and 15 to 30 cm were collected using screw auger at 10 days interval during crop growing season. They are weighed, oven dried at 105^{0}C and reweighed for estimating gravimetric soil moisture percentage and converted to the depth units by multiplying with bulk density. The observations on plant phenological stages, plant height and length of the root at harvest were taken. Plant samples for leaf area were taken periodically at 15 days interval starting from the 30 DAP. The yield samples were obtained randomly from one square meter area from each plot at two places. Tuber yield as well as number of tubers per plot was recorded. Average soil moisture retention (mm) in upper 30 cm soil profile and soil temperatures under various treatment combinations of planting dates and mulching treatments in the potato cultivar *Kufri Jyoti* were computed and correlated with crop growth parameters and tuber yield.

RESULTS AND DISCUSSION

Soil temperature variation under different microclimates

The weekly mean morning and evening soil temperature ranged from 14.0 to 19.6^{0}C and 21.0 to 28.9^{0}C, respectively under different planting dates and mulching treatments (Fig. 1). The highest average weekly morning and evening soil temperatures during crop period were recorded in P_1 with mean morning and evening soil temperature value of 16.9 and 25.6^{0}C, respectively, which was followed by P_2 and P_3. Irrespective of dates of planting, the highest soil temperatures were recorded under black polythene (with mean value of 16.8 and 26.5^{0}C in morning and evening, respectively) while the lowest was recorded under water hyacinth. The soil temperature was always 0.5 to 1.5 ^{0}C (morning) and 1.1 to 2.3^{0}C (evening) was lower under water hyacinth, while it was 1.2 to 2.1^{0}C (morning) and 1.7 to 2.6 (evening) ^{0}C higher under black polythene as compared to that under non-mulched condition during crop growth period (Fig. 1).

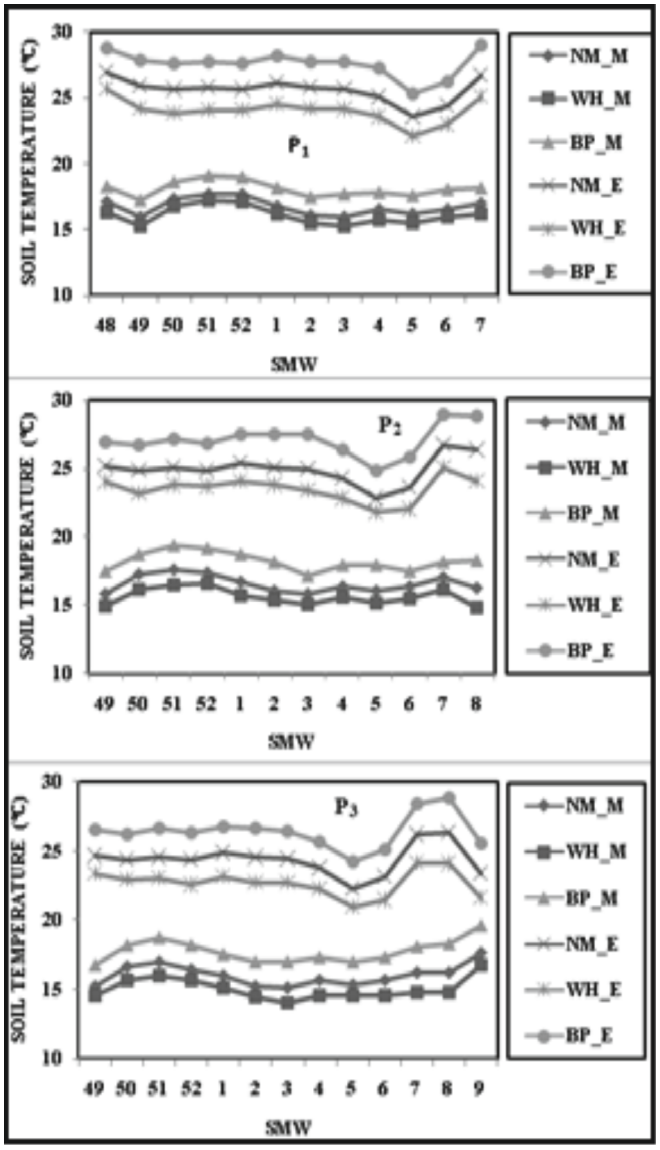

Fig.1 : Weekly mean variation of soil temperature under different dates of planting and mulching treatments in *Kufri Jyoti* during *rabi* 2017-18

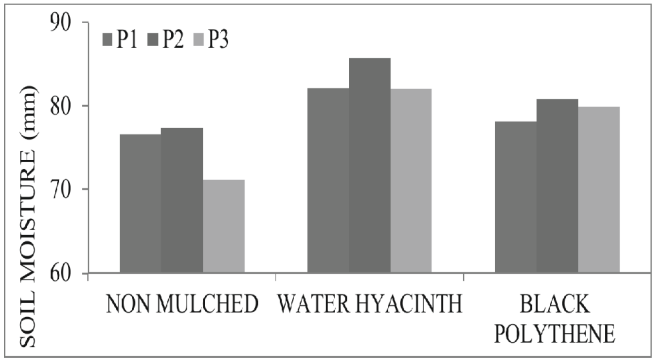

Fig. 2 : Average soil moisture retention in upper 30 cm soil profile during crop growth period of *Kufri Jyoti* under different planting dates and mulching treatment during *rabi*, 2017-18.

Soil moisture variation under different microclimate

Soil moisture data were taken from the upper 30 cm layer of soil at 10 days interval in 10 plots representing all the treatment combinations. The average soil moisture content throughout the growing season was highest in second date of planting (81.3 mm), followed by first (78.9 mm) and third (77.5 mm) dates of planting. The average soil moisture content throughout the growing season was highest in second date of planting (81.3 mm), followed by first (78.9 mm) and third (77.5 mm) dates of planting. Irrespective of dates of planting, soil moisture depth in upper 30 cm soil profile was highest under water hyacinth (83.1 mm), followed by black polythene (79.6 mm) and non-mulched condition (75.2 mm). The average soil moisture content throughout the growing season was comparatively higher under water hyacinth (11.76 %) while it was only 7.0 per cent higher under black polythene as compared controlled (Fig 2).

Effect of microclimates on growth and tuber yield of Potato

The maximum LAI, total biomass and tuber yield along with the average soil moisture retention (mm) in upper 30 cm soil profile at different phenophases are presented in the Table 1. The maximum leaf area index recorded under different dates of plantings and mulching treatment ranged from 2.21 to 3.80. Irrespective of mulching treatments, the maximum LAI under different dates of planting was recorded under P_1 (2.85), and it deceased gradually to 2.77 and 2.68 when planting was delayed to P_2 and P_3, respectively. Like dates of planting, maximum LAI of potato recoded was considerably influenced by different mulching treatments. Irrespective of dates of planting, maximum leaf area index was recorded in the crop grown under water hyacinth (3.12), followed by black polythene (2.75) and non-mulched treatment (2.42).

The biomass production at maturity was the highest in first date of planting (379.7 g m^{-2}) and it decreased gradually in subsequent dates of planting. The maximum biomass was recorded under water hyacinth (412.67 g m^{-2}), followed by black polythene (355.33 g m^{-2}) and non-mulched treatment (289.64 g m^{-2}), irrespective of planting dates. It was observed that mean biomass partitioning towards root, leaf, stem and tuber were 3.1, 5.5, 9.5 and 81.6 per cent, respectively. Decreased in biomass production with delay in planting was probably be due to exposure to lesser sun shine duration along with lower LAI in case of crop planted on later dates (P_2 and P_3). Increased in plant height, LAI and crop duration might result in higher biomass production under water hyacinth as compared to other mulching treatments.

Table 1: Leaf area Index, biomass production and tuber yield of potato variety *Kufri Jyoti* along with average soil moisture retention (mm) in upper 30 cm soil profile at different phenophases of the crop during *rabi*, 2017-18.

Dates of planting	Mulching treatments	Tuber yield (q ha^{-1})	Total biomass (g m^{-2})	Maximum LAI	Soil moisture retention (mm)		
					P to TF	TF to PM	P to PM*
P_1 (Nov.10)	M_0	92.3	314.3	2.6	85.4	67.8	76.6
	M_1	135.6	445.0	3.2	88.3	75.8	82.0
	M_2	110.6	379.8	2.7	84.1	72.2	78.1
P_2 (Nov.20)	M_0	82.0	283.2	2.5	86.0	68.7	77.4
	M_1	116.1	408.2	3.1	92.5	79.0	85.7
	M_2	100.8	345.4	2.7	89.2	72.5	80.8
P_3 (Nov.30)	M_0	80.7	271.4	2.2	74.9	68.7	71.2
	M_1	110.7	384.8	3.0	88.2	79.0	82.0
	M_2	99.0	335.7	2.8	88.1	72.5	79.8

*P = Planting, TF = Tuber formation and PM = Physiological maturity

Table 2: Correlation coefficients of maximum LAI, total biomass and tuber yield, of *Kufri Jyoti* with average soil moisture retention (mm) in upper 30 cm of soil profile in different phenophases .

Variables	Planting to tuber formation	Tuber formation to physiological maturity	Planting to physiological maturity
LAI	0.79*	0.87**	0.91**
Biomass	0.64	0.83**	0.81**
Tuber yield	0.59	0.77*	0.74*

The tuber yield (qha^{-1}) in all planting dates and mulching treatments varied from 80.6 to 135.6 qha^{-1} with the overall mean of 103.0 qha^{-1}. Significant reduction of tuber yield in case of late planted crops (P_2 and P_3) as compared to first date of planting (P_1) was probably due to lower LAI, biomass production and shorter crop growth period. Significant increase of yield under water hyacinth (42.2%) and black polythene (21.6%) as compared to non-mulched treatment might be due to decrease in plant height, LAI, biomass production and comparatively shorter tuber development period under non-mulched condition.

Correlation studies between tuber yield and crop growth parameters, and the average soil moisture retention (mm) in upper 30 cm layer of soil profile showed that maximum LAI, total biomass production and tuber yield was significantly and positively correlated (at 1% level) with the average soil moisture content in most of the phenophases of the crop (Table 2). The tuber yield was significantly and positively correlated (at 5% level) with the average soil moisture retention (mm) in upper 30 cm layer of soil during tuber formation to physiological maturity (r = 77*) and planting to physiological maturity (r = 74*).

CONCLUSION

From the field experiment it was observed that increase in soil moisture retention (8.1 to 15.7 %) and reduction of soil temperature (1 to 1.8°C) under water hyacinth (M_1) endowed with favorable crop growth environment, which was reflected in increasing of LAI, biomass production, and finally tuber yield as compared to other mulching treatments. Thus it can be concluded that microclimate modification may be a successful adaptive strategy for managing weather variability with

respect to soil moisture and soil temperatures in potato crop grown in Assam.

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