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Evaluation of micro irrigation and mulches on the growth and yield of potato

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Abstract
A field experiment was conducted during the year 2018-19 and 2019-20 at ICAR-CPRI-RS, Gwalior (M.P) to Evaluation of micro irrigation for improving productivity and water use efficiency in. The investigation comprised of sixteen treatments and each treatment was repeated thrice in split plot design. The treatments comprised of irrigation systems- S_1: drip irrigation system, S_2: sprinkler irrigation system; irrigation mulching- M_1: no mulch, M_2: paddy straw mulch @ 5 t/ha, M_3: polythene sheet mulch (25µ thickness), M_4: spray of chemical formulation at TIS & Bulking stage (40 & 65 DAP) and their combination. The results show that plant population per plot found higher with treatment S_1M_3 at 30 DAP (88.17) and at maturity (90.50); number of compound leaves/plant found higher with treatment S_1M_3 at 30 DAP (39.70), at 60 DAP (53.09) and at maturity (54.90); number of tubers/plant found maximum with treatment S_2M_3 at 30 DAP (2.90), at 60 DAP (12.41) and at maturity (13.04); higher root shoot ratio found higher in treatment S_1M_2 at 30 DAP (0.334), at 60 DAP (0.293) and at maturity (0.297) treatment S_1M_1 recorded maximum root shoot ratio; chlorophyll content found higher in treatment S_1M_3 at 30 DAP (51.78), at 60 DAP (45.67) and at maturity (39.56); Fresh haulm yield (26.047 t/ha) found higher with S_2M_2; Fresh tuber yield (38.415 t/ha) found higher with S_2M_2; starch content of potato tuber (13.8%) found higher in treatment S_1M_2; water content of potato tuber (81.84%) found higher in treatment S_1M_1; N (91.074 kg/ha), P (19.891 kg/ha), K (140.855 kg/ha) uptake by potato tuber is found higher with treatment S_2M_2; N (66.258 kg/ha), P (15.956 kg/ha), K (68.883 kg/ha) uptake by potato haulm is found higher with treatment S_2M_2; significantly higher gross return (Rs. 1,92,075/-), net return (Rs. 1,13,056/-), B:C ratio (2.43) and harvest index (60.23%). While, minimum gross return (Rs. 1, 11,045/-), net return (Rs. 33,026/-), B: C ratio (1.42) and harvest index (53.07%) recorded with treatment S_2M_1.

Keywords: Potato, drip, sprinkler, irrigation system, polythene mulch, paddy straw mulch

Introduction
Potato is the most important staple food crop with production of 381.6 million tones, China being the biggest producer globally, India ranks 2nd in area and production of potato in the world after China (FAO STAT, 2014). In India, it is grown on an area of 2 million hectares with the production of 44.3 million tones and the productivity is 21967 kg ha^{-1}. Currently, Madhya Pradesh contributes about 05.45 per cent in area and 05.24 per cent in production of potato in the India. The area under the crop during 2019-20 was 110 thousand hectares and the production was 2322 thousand tones in M.P. During 2019-20, productivity of Gujarat was (29.8 t ha^{-1}) highest in India and Madhya Pradesh was at 6th position with 22834 kg ha^{-1} yield (Agricultural Statistics at a Glance, 2019-20).
Water is prime resource in agriculture. Its share for agriculture is becoming limiting factor due to increased competition in demand for various other sectors. Thus, it has become inevitable to use the water very judiciously and efficiently. At present surface irrigation (furrow irrigation) in vogue in potato cultivation practice is less efficient compared to pressurized irrigation system. The water can be efficiently utilized by adopting the modern pressurized micro-irrigation systems. Drip irrigation is one of the efficient micro irrigation methods providing irrigation water directly into soil in the root zone of crop and permits irrigation to limit the watering close to the consumptive use of plants. Drip is found advantageous in soil with high infiltration rate and land with steep slope minimizing losses like runoff, seepage etc. In drip irrigation, as controlled amount of water is applied frequently at required time in root zone, the deep percolation losses and fertilizer losses are minimized. (Araki and Yamaguchi, 2007) [4]. Drip irrigation minimizes the conveyance losses and saves water up to 59% depending on crop situation and yield advantages upto 1 to 30%.

Now a days the sprinkler irrigation system is gaining popularity among the farmers. This system is also used to maintain the healthy microclimate in the close growing crops along with irrigation.

Mulch is commonly used to conserve soil moisture in semiarid regions, as well as sub humid and humid regions, mainly due to its positive effect on soil temperature alteration, and reduction of soil moisture evaporation by breaking the capillarity. It also improves the soil physical properties, such as bulk density, porosity, and aggregate stability (Jordán *et al.*, 2011) [17].

Potato is a good option in vegetable production but it requires frequent and ensured water supply because potato crop is considered very sensitive to soil stress (Jeffrie Meckerron 1993). Potato cultivation is possible alternate to increase the farm income, if efficient and reliable irrigation management strategy is adopted to maintain optimum moisture in the effective root zone. It can be achieved best with the use of modern irrigation system coupled with suitable irrigation scheduling under limited water resources, particularly in semi-arid region. Micro irrigation has proven its potential to increase yield and water productivity but the climatic conditions of this region seems more suitable to micro-sprinkler because micro-sprinkler protects crops from adverse climatic conditions, which helps in better growth and yield (Spieler 1994) [30]. Superiority of drip irrigation or sprinkler irrigation over traditional irrigation methods in terms of yield and economics is now well established fact (Pawar *et al.* 2002) [24]. It is, therefore, imperative to evolve efficient, economical and reliable irrigation management strategies for successful potato cultivation and to increase productivity and profitability of existing bio-production system.

Materials and Methods About the Location

A field study was conducted at the research farm of ICAR-Central Potato Research Station RS, Gwalior (M.P.) during the Rabi seasons of 2018-19 and 2019- 20.Geographically, Gwalior is located at 26o13' North latitude and 78o14' East longitude and 206 metres above mean sea level which lies in the North tract of M.P. The climate of experimental site was semi-arid with extremely hot summers and cold winters. The soil was silty clay loam with pH 7.28. Potato *cv.* 'Kufri Jyoti' was grown with sprinkler and drip irrigation systems in combination with mulches. Each irrigation system had 2 irrigation levels, Deficit and sufficient. Class-A open pan evaporimeter was located at a site adjacent to the experimental area with moderate grass cover to estimate the pan evaporation. Irrigations were scheduled at the previous day pan evaporation data. Micro-jet type sprinklers (discharge64.8 lph) and drip-in type drip irrigation systems were used to irrigate the experimental crop. The spacing between 2 sprinklers was 3 m while stake height of sprinkler was 45 cm. Drip lateral was placed between two rows of potato (40 cm apart)on each raised bed (120 cm size)and spacing between 2 drippers was 30 cm. The area of each experimental plot was 3.6 m×2.4 m. A buffer zone spacing of 1.0 m was provided between the plots. Treatments consisted of two irrigation systems as main plot treatments- S_1: Drip irrigation system and S_2: Sprinkler irrigation system; two irrigation levels as sub plot treatments- L_1: deficit irrigation and L_2: sufficient irrigation and four mulching as sub – sub plot treatments -M_1: no mulch, M_2: paddy straw mulch @ 5 t ha^{-1}, M_3: polythene sheet mulch (25 µ thickness) and M_4: spray of chemical formulation at TIS & Bulking stage (40 & 65 DAP). Treatments were replicated thrice. Recommended dose of nutrients, *i.e.* 180:80:120 kg/ha of $N:P_2O_5:K_2O$ was applied as per schedule during crop raising. In sprinkler and drip irrigation systems, one third N and full.

$P_2O_5$and K_2O nutrients were applied as basal fertilization at potato planting and two third n was applied through fertigation in 8 equal splits after potato emergence applying twice in a week. Soluble fertilizer urea was used for applying the required nutrient to the crop in fertigation. Crop was harvested after 90 days after planting to estimate fresh tuber yield. To assess economic viability of different irrigation systems for potato production, both fixed and operating costs were taken into consideration. Economics of potato production under variable irrigation were calculated with the assumption that salvage value of the different components of irrigation systems will be zero after their useful life. Useful life of motor and sand filter, water storage tank and other irrigation system components was assumed15, 20 and 8 years respectively for economic analysis. Net returns were estimated as difference between gross income and total production cost. Gross returns were product of yield and wholesale market price of potato. The experiment was laid out in split-plot design (SPD) with irrigation systems in main plots and levels in sub-plots and mulches in sub-sub plots with 3 replications. The data were analyzed statistically by standard analysis of variance (ANOVA). Least significant difference (LSD) test was used to determine whether differences exist between certain comparisons. The probability level for determination of significance was 0.05.

Results and Discussion

Plant population per plot

The results indicated that different treatment effects of irrigation levels and mulches at 30 and 60 DAP and at maturity did not significantly affect the plant population.

Effect of irrigation system

The perusal of data presented in table 1 showed that potato plant population was at 30 days after planting (83.94) and at maturity (86.48) found higher in case of drip irrigation system.

Effect of irrigation levels

The plant population was statistically same with level of irrigation and method of irrigation, at 30 DAP and at maturity.

Plant population at 30 DAP (83.81) and at maturity (86.44) found higher in case of sufficient irrigation than deficit irrigation.

Effect of mulching

From table 1, we revealed that, in case of mulching plastic mulch reported higher no. of plant population per plot at all growth stages.

Interaction effect of irrigation system, irrigation level and mulching

A non-significant variation was found under all interactions in case of potato plant population at all growth stages are cleared by the data presented in Table 1.

Uniform plant density is an important requisite for obtaining higher precision when it is not a variable factor as the treatment. The data in Table 4.1 indicate that the plant population per plot remained statistically unchanged (non-significant) under the various treatments without giving any definite trend at 30 DAS. It may be attributed to the food materials already stored in the seed tubers, which initially boost up to emergence and size of tubers, number of eyes on seed tubers, nature of apical dominance and common irrigation, which appear to be the similar for all treatments that might have resulted similar responses for all treatments. The results are in close conformity with the findings of Shukla *et al*., 2020 [26].

Number of compound leaves/plant

Effect of irrigation system

The plant height was not affected by irrigation system at all stages of crop growth. No. of compound leaves found higher with sufficient level of irrigation at 30 DAP (35.79) at 60 DAP (46.53) and at maturity (48.84) and it was superior over deficient application of water at all growth stages.

At all growth stages drip irrigation system gave higher shoot parameters *i.e.*, fresh weight/plant and dry weight/plant compare to sprinkler irrigation system during both the years and pooled basis. This may be due to the fact that drip irrigation ensures better moisture, aeration in root zone and fluctuation in soil moisture is less. The results of present study are in conformation of the findings of Tiwari *et al*. 2003 [31] and Spehia *et al*., 2013 [29].

Effect of irrigation levels

The maximum number of compound leaves was found with sufficient level of irrigation at 30 DAP (35.79), at 60 DAP (46.53) and at maturity (48.84) during and it was superior over deficient application of water at all growth stages.

This may be due to the undesirable effect of deficit irrigation on different growth characteristics can be attributed to slower cell division, decreased photosynthetic pigment especially leaf total chlorophyll content and decreased enzymes activity consequently, reflected on the studied growth parameters. Similar results were also reported by (Abd El-Mageed *et al*., 2016; Tolessa *et al*., 2016) [1, 32]

Effect of mulching

The maximum number of compound leaves / plant at 30 DAP (36.52), at 60 DAP (48.01) and at maturity (50.74) was recorded with application of paddy straw mulch at all growth stages and it was found statically significant from rest of treatment.

The progressive increase in the parameters may be attributed to the fact that the organic mulching added organic matter and plant nutrients to the soil after decomposition, which in turn increased the vegetative yield. The findings of Banerjee *et al*. (2016) [8] and Shukla *et al*. (2020) [26] also tally with the present results uptake by the plants (Begum and Saikia, 2014) [9].

S x M: The interaction effect due to irrigation system and mulches on number of compound leaves/plant was found to be significant at all stages of growth. Among all interaction sprinkler irrigation system with plastic mulch resulted in significantly more compound leaves/plant at 30 DAP (41.80), at 60 DAP (51.87) and at maturity (54.77) as compared to the other treatments. It was because of sprinkler system maintained moisture in paddy straw mulch and increasing organic matter in soil resulted into higher shoot growth.

Number of tubers per plant

Effect of irrigation system

Number of tubers / plant was recorded periodically at an interval of 30 days starting from 30 DAP to maturity. The highest number of tubers / plant was recorded with the application of operates timely drip irrigation. Same results obtained Akram and Asif 2020 [6]; Pawar and Dingre, 2020 [24] in Potato.

Effect of irrigation levels

The higher number of tubers / plant was recorded with sufficient level of irrigation and it was superior over deficit application of water at all growth stages. Effect of irrigation levels at 30 DAP was non-significant. However, irrigation levels showed significant effect on tuber number at 60 DAP (10.00) and at maturity (10.50). It may be due to better vegetative growth. Kumar *et al*., (2007) [8] have also reported that water stress decreases plant growth of potato.

Effect of mulching

The highest number of tubers / plant was recorded with the application of mulch with polythene sheet at all growth stages and it was found statically significant from rest of the treatment. At 30 DAP (2.82 tubers/plant), At 60 DAP (11.07 tubers/plant) and at maturity (11.63 tubers/plant). It might be due to conservation of soil moisture and reduction of soil temperature. Similar findings were obtained by Begum and Saikia, (2014) [9].

S x M: Data presented in table 1 revealed that number of tuber per plant was significantly influenced by interaction effect of irrigation system and mulching. The Maximum number of tuber/plant at 60 DAP (11.79) and at maturity (12.34) found with S_1M_3 (Drip irrigation system with polythene sheet mulch) and minimum number of tuber/plant recorded with S_2M_1 (Sprinkler system without mulch) at 60 DAP (8.09) and at maturity (8.58). Data for number of tuber per plant in respect to interaction effect of irrigation system and mulching was found non-significant at 30 DAP. It was because drip irrigation system provides moisture and plastic mulch conserved the soil moisture and maintains temperature around root zone which enhance number of tubers.

Haulm yield and fresh tuber yield (q/ha)

Effect of irrigation system

Potato fresh haulm yield and fresh tuber yield was recorded at harvest. The highest fresh haulm (22.809 t/ha) and fresh tuber yield (30.769 t/ha) was recorded with application of operates timely sprinkler irrigation. It may be due to favorable moisture content in root zone and better microclimatic conditions in crop canopy (Pawar and Dingre, 2020) [24].

Effect of irrigation levels

The result revealed that the higher fresh haulm yield (23.247 t/ha) and fresh tuber yield (32.406 t/ha) was found with sufficient level of irrigation and it was superior over deficit application of water.

It might be due to water stress experienced by the crop. Patel and Patel (2001) [22] reported decrease in tuber weight with decreased irrigation water. Moreover, there had been many reports on the effects of water deficiency and irrigation regimes on potato crop in many parts of the world, which show that water deficiency caused a reduction of yield by reducing growth of crop canopy and biomass that may be due to the potato crop had low tolerance for water stress (Patel and Rajpoot, 2007; Badr *et al.*, 2012) [22, 7].

Effect of mulching

The highest fresh haulm yield (24.226 t/ha) and fresh tuber yield (35.194 t/ha during) was recorded with application of paddy straw mulch which was statistically superior over the rest of treatment.

It might be owing to better absorption and utilization of irrigation water and plant nutrients from the soil profile (Singh *et al.*, 2012). This result is disparate with the investigation of Levent *et al.* (2001), who reported that the highest fruit yield was obtained from wheat straw mulch followed by transparent and black polyethylene mulch, respectively and also confirmed by Banerjee *et al*., 2016 [8].

Effect of interaction

S x M: The highest fresh haulm yield (25.545 t/ha) and fresh tuber yield (37.749 t/ha) found with interaction S_2M_2 (Sprinkler irrigation system with paddy straw mulch). It may be due to drip system maintain moisture around root zone and paddy straw mulch increases organic matter and nutrients around root zone which enhance the growth of the plant where result in higher yield. Kar and Kumar (2007) [8] have also reported higher yield and better crop growth in straw mulch plots.

5. Dry haulm yield and dry tuber yield (t/ha)

Effect of irrigation system

Potato dry haulm yield and dry tuber yield was recorded at harvest. The highest dry haulm (3.318 t/ha) was recorded with application of sprinkler irrigation system and dry tuber yield (5.898 t/ha) was recorded with application of drip irrigation system. It may be due to favorable moisture content in root zone and better microclimatic conditions in crop canopy (Pawar and Dingre, 2020) [24].

Table 1: Effect of irrigation system and mulches on plant population/plot, number of compound leaves/plant and number of tubers/plant at 30, 60 DAP and at maturity on potato.

Treatment	Plant population (per plot)		No. of compound leaves/plant			No. of tubers/plant		
Irrigation System	At 30 DAP	At Maturity	At 30 DAP	At 60 Dap	At Maturity	At 30 DAP	At 60 DAP	At Maturity
S1	83.41	86.48	35.6	45.4	48.17	2.50	9.95	10.44
S2	82.03	84.92	32.4	44.9	47.10	2.43	9.32	9.83
S.E.(m)±	0.66	0.45	0.04	0.60	0.66	0.09	0.14	0.13
CD (at 5%)	NS	NS	0.15	NS	NS	NS	NS	0.52
Mulching								
M1	80.33	83.17	29.3	40.3	43.12	1.84	8.34	8.82
M2	83.81	86.33	36.01	47.3	49.77	2.76	9.75	10.22
M3	86.20	89.04	36.24	48.1	50.74	2.82	11.7	11.63
M4	81.47	84.25	34.53	44.0	46.93	2.42	9.36	9.86
S.E.(m)±	0.56	0.57	0.04	0.06	0.15	0.16	0.06	0.03
CD (at 5%)	NS	NS	0.11	0.16	0.42	0.45	0.18	0.09
Interaction								
CD (at 5%)	2.38	1.33	0.13	0.09	0.41	0.37	0.21	0.07
S*M	NS	NS	S	S	S	NS	S	S
S.E.(m)±	0.79	0.81	0.05	0.08	0.21	0.22	0.09	0.04
CD (at 5%)	2.26	2.31	0.15	0.23	0.60	0.64	0.25	0.12
S.E.(m)±	0.79	0.81	0.05	0.08	0.21	0.22	0.09	0.04
CD (at 5%)	2.26	2.31	0.15	0.23	0.60	0.64	0.25	0.12

Table 2: Effect of irrigation system and mulches on fresh haulm and tuber yield (t/ha) and dry haulm and tuber yield (t/ha) and soil pH and soil EC (dSm^{-1}), starch (%) and water (%) of potato.

Treatment Irrigation System	Fresh haulm yield (t/ha)	Fresh tuber yield (t/ha)	Dry haulm yield (t/ha)	Dry tuber yield (t/ha)	pH	EC (dSm^{-1})	Starch (%)	Water (%)
S1	220.54	309.72	3.211	5.898	6.60	0.44	13.44	80.56
S2	228.09	307.69	3.318	5.859	6.63	0.43	13.38	80.56
S.E.(m)±	0.36	1.04	0.31	0.20	0.04	0.02	0.03	0.14
CD (at 5%)	1.39	4.10	1.20	0.78	NS	NS	NS	NS
Irrigation Level								
Mulching								
M1	192.82	242.11	2.870	4.611	6.64	0.41	13.48	81.43
M2	241.76	351.84	3.491	6.700	6.61	0.45	13.43	80.33
M3	235.85	344.41	3.378	6.559	6.61	0.44	13.30	79.94
M4	226.83	296.46	3.317	5.646	6.60	0.44	13.41	80.55
S.E.(m)±	0.31	0.73	0.42	0.13	0.03	0.01	0.10	0.55
CD (at 5%)	0.87	2.07	1.21	0.38	NS	NS	NS	NS
Interaction								
S*M	0.43	1.03	**NS**	**NS**	0.05	0.01	0.15	0.77
S.E.(m)±	1.23	2.93	0.60	0.19	0.13	0.04	0.41	2.20
CD (at 5%)	S	S	1.71	0.54	NS	NS	NS	NS
L*M	0.43	1.03	S	S	0.05	0.01	0.15	0.77

S.E.(m)±	1.23	2.93	0.60	0.19	0.13	0.04	0.41	2.20
CD (at 5%)	S	S	1.71	0.54	NS	NS	NS	NS

The result revealed that the higher dry haulm yield (3.38 t/ha) and dry tuber yield (6.171 t/ha) was found with sufficient level of irrigation and it was superior over deficient application of water. It might be water stress experienced by the crop. Patel and Patel (2001) [22] reported decrease in tuber weight with decreased irrigation water.

Effect of mulching

The highest dry haulm yield (3.491 t/ha) and dry tuber yield (6.700 t/ha) was recorded with the application of paddy straw mulch, which was statistically superior over rest of the treatments. It might be owing to better absorption and utilization of irrigation water and plant nutrients from the soil profile (Singh *et al.,* 2012). This result is disparate with the investigation of Levent *et al.* (2001), who reported that the highest fruit yield was obtained from wheat straw mulch followed by transparent and black polyethylene mulch, respectively and also confirmed by Banerjee *et al*., 2016 [8].

Effect of interaction

S x M: Interaction effect of irrigation system and mulching found non-significant with dry haulm yield and dry tuber yield. It may be due to drip system maintain moisture around root zone and paddy straw mulch increases organic matter and nutrients around root zone which enhance the growth of the plant and resulting higher yield. Kar and Kumar (2007) [8] have also reported higher yield and better crop growth in straw mulch plots.

L x M: Table 2 revealed that the treatment L_2M_2 (sufficient irrigation with paddy straw mulch) recorded maximum dry haulm yield (3.578 t/ha) and dry tuber yield (6.905 t/ha) and it is significantly higher than other treatments. Minimum haulm and tuber yield observed with interaction L_1M_1 (Deficit irrigation of without mulch) during both the years of investigation. It was because of increasing soil carbon, soil moisture and adjusting soil temperature (Singh *et al*., 2015; Banerjee *et al*., 2016) [8] and the results of present study confirm this.

pH and EC (dSm^{-1})

Effect of irrigation system

The perusal of data presented in table 2 revealed that two irrigation systems (Drip irrigation and sprinkler irrigation) found non-significant effect on pH and EC (dSm^{-1}) content of soil. pH and EC (dSm^{-1}) found higher with sprinkler irrigation system.

Effect of irrigation levels

The data in table 2 showed that irrigation levels (deficit irrigation and sufficient irrigation) registered non-significant affect on pH and EC (dSm^{-1}) during both the years. pH and EC (dSm^{-1}) found higher with application of deficit irrigation.

Effect of mulching

The data with respect to pH and EC (dSm^{-1}) content of soil was not affected significantly due to mulching during both the years of investigation. pH and EC found higher with M_1 (Without mulch).

Effect of interaction

S x L: Data recorded by the interaction of irrigation systems and irrigation levels did not show significant effect on pH and EC (dSm^{-1}) contents of soil.

S x M: Statistically analyzed data recorded in interaction effect of irrigation systems and mulches pH and EC (dSm^{-1}) content of soil were found non-significant during both the years.

Starch and water content (%) of potato

Effect of irrigation system

Starch content and water content (%) of potato data are shown in table 2. The starch content and water content (%) of potato recorded were found non - significant due to irrigation system.

Effect of irrigation levels

The water content (%) of potato was found higher with sufficient level of irrigation but, it did not show significantly higher compare to deficient application of water. It might be due to adequate supply of water under higher regime, increase in water content of tuber (Arora *et al*., 1980) [5].

While, higher starch content (%) registered with deficit application of water. It is because adequate supply of water under higher regime, increase in water content resulted in decrease in dry matter content and starch content in tuber. Similar findings were reported by Carli *et al*. (2014) [10]; Wegener *et al.* (2017) [33].

Effect of mulching

It can be seen from the data that, starch content (%) found higher with no mulch application. It may be due to low moisture due to high evaporation loss, which increases dry matter content in tuber.

While, water content (%) of potato tuber observed maximum with paddy straw mulch which was non-significant with rest of the treatments. It is because of high moisture around root zone due to high water retention capacity of paddy straw which enhances water absorption by tubers.

Effect of interaction

S x L: Interaction effect of irrigation system and irrigation level was found non-significant on starch and water content (%) of potato tuber.

S x M: Table 2 revealed that interaction of irrigation system and mulches doesn't show any significant effect on starch and water content (%) of potato tuber at both years of investigation.

L x M: Non-significant effect of interaction of irrigation levels and mulches was found on starch and water content (%) of potato tuber, (data presented in table 2).

S x L x M: Starch and water content (%) of potato tuber showed not significant effect due to interaction of irrigation system, irrigation levels and mulches during both the years as well as pooled data basis.

Economics of treatments

Cost of cultivation

Data related to different treatments in potato crop, presented in table 3 showed that cost of cultivation were ₹ 78,019/-, ₹

79,019/-, ₹ 83,619/-, ₹ 79,219/- with control, paddy straw mulch, polythene mulch and chemical spray respectively

Total cost of cultivation varied from treatment to treatment. Application of polythene mulch exhibits higher cost of cultivation during both the years. It is due to higher market cost of polythene mulch. Whereas, minimum total cost of cultivation was recorded with control treatment during both the years. The findings are in close conformity with the findings of Rahman *et al*. (2005) [25]; Shukla *et al*. (2020) [26].

Gross return (₹/ha)

Data embodied in table 3 and its statistical analysis revealed that mulch application gave more gross return over without mulch. Maximum gross return ₹ 1,92,075/- found with treatment $S_2L_2M_2$ and minimum gross return ₹ 1,11,045/- observed with treatment $S_2L_1M_1$. This is due to higher economical yield (Tuber yield) under the treatments. The findings are in close conformity with the findings of Rahman *et al*. (2004) [25]; Kumar *et al*. (2020) [20].

Net return (₹/ha)

From table 3 data revealed that the net return recorded maximum (₹ 1,13,056/-) in pooled basis and minimum net return ₹ 33,026/- registered with treatment $S_2L_1M_1$ on pooled basis. This is due to comparatively higher gross return as compare to total cost of cultivation. Similar results previously reported by Sadawarti *et al*. (2013); Asif *et al*. (2016) [6]; Akram and Asif (2020) [6].

Table 3: Effect of irrigation system, irrigation levels and mulches on economics of potato production and harvest index

B-C ratio

Data for Benefit-Cost ratio presented in table 3 revealed that the maximum B:C of 2.43 registered with treatment $S_2L_2M_2$ on pooled basis and minimum B:C ratio reported in treatment $S_2L_1M_1$ (1.42). This is due to higher gross income under treatment $S_2L_2M_2$. Earlier were reported by Banerjee *et al*. (2016) [8]; Brar *et al*. (2019) similar results.

Harvest index (%)

Data from table 3 revealed that maximum harvest index (60.23 %) on pooled basis was recorded with $S_2L_2M_3$. However, $S_2L_1M_1$ registered minimum harvest index (53.07 %) on pooled basis data. This was due to proportion of economical yield in comparison to biological yield in these treatments.

Fig 1: General view of experimental field –ICAR*CPRA Gwalior

Conclusion

Experimental results showed that drip irrigation system was better system for number of compound leaves/plant, yield and yield attributes. However, quality parameter *i.e.*, starch (%) in potato tuber recorded better with sprinkler irrigation system. Soil pH and soil EC were not affected by irrigation system. Irrigation levels affect the quality and yield of potato. In this study sufficient irrigation is better for growth and yield of potato tuber than deficit irrigation.

Paddy straw mulch was found most suitable mulching material compared to non mulch treatment. It gave higher yield compared to polythene mulch and non mulch treatments. But polythene mulch gave better quality potato tuber than paddy straw mulch and non mulch treatments. Soil pH and EC reported higher without mulch treatment than mulching treatments.

Treatment $S_2L_2M_2$ (sprinkler system, sufficient irrigation with paddy straw mulch) registered higher gross return, net return, B:C ratio and H.I. (%).

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