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Can drip irrigation with plastic mulch be favourable for growth and yield of potato (*Solanum tuberosum* L.) varieties under potato-based cropping system?

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Abstract
A study was conducted at the Research Farm of ICAR-CPRI-RS, Maharajpura, Gwalior (M.P.) during *kharif*, *rabi* and *summer* season of 2018 and 2019 to investigate the effect of plastic mulching and drip irrigation on growth and yield attributing characteristics of potato (*Solanum tuberosum* L.) varieties under potato-based cropping system. The study involved eight treatment replicated four times in split plot design. The treatments comprised of four mulching *viz*. DM_1: Drip irrigation with black-black plastic mulch, DM_2: Drip irrigation with silver-black plastic mulch; DM_3: Drip irrigation without mulch; FI_4: Farmer's practice (Check) and two varieties *viz*. V_1 Kufri Badshah and V_2: Kufri chipsona-3. The performance of potato in terms of almost all growth parameters and yield attributes was significantly better under drip irrigation with silver-black plastic mulching. The highest grade wise total tuber yield (42.9 t ha^{-1}) was recorded under silver-black plastic mulch being at par with black-black plastic mulch application. Among the varieties, Kufri Chipsona-3 out-performed Kufri Badshah recording significantly highest grade wise total tuber yield (38.5 t ha^{-1}) of potato. The interaction of black-black plastic mulch x Kufri Chipsona-3 and silver-black plastic x Kufri Chipsona-3 being at par with each other found significant with respect to yield parameters. The two year study clearly showed that the system productivity of potato-based cropping system with higher gross and net returns was significantly highest under silver black plastic mulch with drip irrigation, however, it was comparable to black-black plastic mulching.

Keywords: Drip irrigation, grading, potato, plastic mulch, tuber yield

1. Introduction
Potato (*Solanum tuberosum* L.) is a herbaceous annual crop that contributes substantially towards food and nutritional security in the world. The crop has always been the 'poor man's friend'. It originated in the high Andean hills of South America and introduced in India from Europe in early 17th century AD. Potato is being cultivated in the country for the last more than 300 years.

It is the third most important food crop in the world after rice and wheat in terms of human consumption. The current global production of potato is 376 million tonnes, China being the biggest producer globally. India being the second largest potato producer contributes nearly 14.36% to global production after China (FAO STAT, 2021) [1]. In country, it is cultivated on 2.20 million hectare area with production of 56.17 million tones and productivity of about 25498 kg ha^{-1} (Agricultural Statistics at a Glance, 2022) [2].

The crop has wide adaptability and is grown in sequence with diverse type of crops like cereals, millets, legumes, sugar crops, vegetables, fodder and fiber crops under different agro-climatic conditions. It can be adjusted within the growing period available due to its flexible planting and harvesting window. Thus, it has become an important part of existing and emerging cropping systems. Potato based cropping systems have been found to be usually more profitable than cereal based cropping systems. When potato is involved in a cropping system, most of the times the production potential and profitability of the whole system hinges upon the most efficient utilization of resources to potato, because of its high input demand and resource intensiveness.

Plastic mulching is the best mulching material for potato cultivation (Bharti *et al.*, 2020) [3]. Potato is reported to increase tuber yield when plants are mulched with plastics compared with plants grown in bare soil. The moisture does not escape from soil under plastic mulch. Mulching technique is widely practiced on the wide range of the vegetable crops while its

application has been limited to the potato production. As, potato is one of the major staple crops of this region its demand is always high (Bharti *et al*., 2020) [3]. Different types and colors of polyethylene mulch have optical properties that change the levels of light radiation reaching the soil, causing increase or decrease in the soil temperature (Kasirajan and Ngouajio, 2012) [4].

Particularly, both black (PE-B) and transparent (PE-T) polyethylene mulches are completely resistant to water and therefore decrease the moisture losses from soil and conserve the soil particles over the surface (Tarara, 2000) [5]. Plastic-film mulch is popular in potato cultivation in the areas where the potential crop evapo-transpiration is far greater than rainfall and water resources for irrigation are limited. The application of mulches helps the crop to harvest 7-10 days earlier with extended duration of harvesting periods. (Zhao *et al*., 2012) [6]. But there is still a research gap in finding the best and effective plastic mulch among various plastic mulches available in the market.

Compounding the problem of reduction yields is the prediction that the world population will exceed 8 billion by 2030, requiring a doubling of the world food production on the current cultivated areas by using the available limited irrigation water resources. Drip irrigation is also highly suitable for fertigation as it can supply water and nutrients directly to the crops at the root level and provide desirable conditions for water movement in soil and for nutrient uptake by roots. An adequate water supply is required for tuber initiation till near maturity for higher yield and good quality. So, our challenge is to increase food production while reducing water consumption. This can be achieved by introducing advanced irrigation methods and improved agricultural management practices**.**

2. Materials and Methods

The experiment was conducted at the Research Farm of ICAR-Central Potato Research Institute - RS, Gwalior (M.P.) during the *Kharif, Rabi and summer* seasons of 2018-19 and 2019-20. Gwalior is located at 26º13' North latitude and 78º14' East longitude and 206 meters above mean sea level which lies in the North tract of M.P. enjoying subtropical climate, with extreme hot up to 48°C in summer and minimum temperature as low as 4.0°C during winter season. The annual rainfall ranges between 750 to 800 mm, most of which received from end of June to end of September, with few showers in winter months. The experiment was conducted in split plot design (SPD) with four replications. There were 8 treatment combinations comprising of Main plot treatments (plastic mulching under drip irrigation) *viz.* DM_1 = Drip irrigation with black-black plastic mulch, DM_2 = Drip irrigation with silver-black plastic mulch, DM_3 = Drip irrigation without mulch, FI_4 = Farmers practice (check) and Sub plot treatments (varieties) *viz.* V_1= Kufri Badshah (table purpose) V_2= Kufri Chipsona-3 (processing purpose). Under this study different growth and yield parameters namely Emergence (%) of Potato, Plant height (cm), Number of Compound Leaves Plant $^{-1}$, Number of Stem Plant^{-1}, Number of Tubers Plant^{-1},Fresh and dry weight of potato tubers plant^{-1}Grade wise diameter of potato tuber (mm), Grade wise tuber number ('000 ha^{-1}) of potato and Grade wise tuber yield (t ha^{-1}) of potato studied to evaluate the effect of plastic mulching on growth and yield attributing characteristics of potato (*Solanum tuberosum* L.) varieties under potato-based cropping system. The data were statistically analyzed by using the analysis of variance techniques in order to find the significance of different treatments. The analyzed data for two years including pooled data has been presented in tabular form as well as supported by graphical representation, wherever necessary.

3. Results and Discussion

3.1 Growth parameters

3.1.1 Emergence (%) of potato, number of compound leaves plant^{-1}, number of stem plant^{-1}

The data (Table 1) revealed that plastic mulching under drip irrigation and potato varieties under potato-based cropping system had no significant effect on emergence of potato (%) at 30 DAP during both the experimental years, however, the highest emergence % was observed under silver- black plastic mulching during the first year and without mulch during the second year. The pooled data showed that silver- black plastic mulch with drip irrigation resulted in significantly highest percentage of potato emergence (94%) while the treatments drip irrigation without mulch and drip irrigation with black-black plastic mulch remained at par with each other. The farmers practice recorded the lowest emergence (90.9, 87.7 and 89.4%, respectively) during both the experimental years and on pooled basis. Among the potato varieties, Kufri Chipsona-3 recorded the higher percentage of emergence (95, 96.1 and 95.5%, respectively) during 2018-19, 2019-20 and on pooled basis over Kufri Badshah.

Significantly, maximum number of compound leaves plant $^{-1}$ (Table 2) were recorded with black-black plastic mulch at all growth stages during both the experimental year and on pooled basis except at maturity stage in 2019-20 where it was significantly maximum under drip irrigation with silver-black plastic mulch. The pooled data revealed that application of drip irrigation with black-black plastic mulch resulted in significantly maximum number of compound leaves plant^{-1} (81.5, 110.4 and 79.2, respectively) at 30, 60 DAP and maturity stage. This treatment, however, remained at par with drip irrigation with silver-black plastic mulching. Among the cultivars Kufri Chipsona-3 had significantly maximum number of compound leaves plant^{-1} (72.1, 99 and 69.7) at 30, 60 DAP and at maturity, respectively based on pooled analysis.

With respect to interaction effect (Table 2.), Kufri Chipsona-3 grown under drip irrigation with silver-black plastic mulching recorded significantly highest number of compound leaves plant^{-1} (90.5 and 86.6 respectively) at 30 DAP and maturity stage. However, it was statistically at par with performance of Kufri Badshah under drip irrigation with silver-black plastic mulch at maturity stage. Whereas, Kufri Badshah under farmer's practice remained the least performing treatment combination at all growth stages.

The number of stems plant^{-1} were significantly highest under drip irrigation with black-black plastic mulch (8.1, 7.4 and 7.4, respectively) in 2018-19 and application of drip irrigation with silver-black plastic mulch (7.8, 7.6 and 7.6, respectively) in 2019-20 at 30, 60 DAP and at maturity. However, the pooled data showed that number of stems plant^{-1} were significantly higher with silver- black plastic mulch with drip irrigation at 60 DAP (7.5) and maturity stage (7.6) followed by drip irrigation with black-black plastic mulch. However, at 30 DAP it was recorded significantly higher with drip irrigation with black-black plastic mulching (7.8) and this

treatment remained at par with silver- black plastic mulch with drip irrigation. Among the cultivars, Kufri chipsona-3 recorded significantly maximum number of stems plant^{-1} (7.0) in 2018-19 and on pooled basis (7.0) at 30 DAP (Table 3). A significant interaction between black-black plastic mulch with drip irrigation and Kufri-chipsona-3 resulted in maximum number of stems plant^{-1} (9.3, 8.4 and 8.8) at initial growth stage during both the experimental years and on pooled basis, respectively (Table 3). However, the treatments did not differ significantly at 60 DAP and maturity during the experimental year 2019-20. It was revealed from the pooled analysis of data that number of stems (8.0 and 8.0, respectively) at 60 DAP and maturity were significantly maximum in Kufri chipsona-3 when silver-black plastic mulch was applied with drip irrigation however, it remained at par with drip irrigation with black-black plastic mulching. The treatment farmer's practice recorded the lowest value (Table 2).

The results revealed that combined with drip irrigation, plastic mulch showed a significant influence on almost all growth parameters of potato. This positive effect of plastic mulch and drip irrigation on enhancing potato growth attributes might be due to the fact that drip irrigation increased water use efficiency three times over conventional method of irrigation (Kumari, 2011) [7] and plastic film conserved moisture by reducing water loss, suppressed weeds and improved soil physico-chemical and biological conditions thus, promoting better plant growth (Romic *et al.*, 2003, Li *et al.*, 2004) [8, 9]. Our finding was in line with the results reported by Gangwar *et al.* (2017) [20] who found that application of plastic mulch improved water use efficiency (WUE) over no mulch condition. Thus, it can be concluded that mulch acts as a preventive layer covering the surface of the soil (Jafarnia and Homayi, 2006) [10]. The results are in conformity with the findings of Kasirajan and Ngouajio (2012) [4] who suggested that combining drip irrigation with plastic mulches played a major role in expanding the production of some vegetables such as tomato and potato.

Among varieties, Kufri chipsona-3 performed better over Kufri Badshah with respect to plant height, number of compound leaves plant^{-1} and potato emergence. This could be attributed to the genetic makeup of the two varieties which resulted in difference in their photosynthetic efficiency and capacity to absorb nutrients. These results corroborate with the findings of Al-Rawahi *et al.* (2011) [11] in cucumber and Andino and Motsenbocker (2004) [12] in watermelon.

With reference to the interaction effect between different plastic mulch combined with drip irrigation and potato cultivars, it was found that Kufri Chipsona-3 performed significantly better under different mulch treatments over that of Kufri Badshah during both the years. This might be due to higher soil temperature, warmer microclimate and weed free environment under plastic mulch. Besides, plastic mulches hinder the evaporation and moderate the soil temperature and moisture conditions which in turn, help in better root development and nutrient uptake by plant thus ultimately improving the plant growth. These findings are in line with those reported by Khan *et al.* (2015) [13] in sponge gourd and Bhatt *et al.* (2011) [15] in summer squash.

3.2 Yield and yield attributing characters

3.2.1 Number of tubers plant^{-1}

The data showed varying trends for number of tubers plant^{-1} (Table 4) during both the experimental year at all growth stages. On pooled basis, significantly highest number of tubers were recorded with drip irrigation with silver-black plastic mulching (9.14 and 13.68) at 30 and 60 DAP, respectively. However, at maturity it was significantly highest under drip irrigation with black-black plastic mulching (18.21). The treatments drip irrigation with black-black plastic mulch and silver-black plastic mulch remained at par with each other. The cultivar Kufri Chipsona-3 and Kufri Badshah differ significantly with respect to number of tubers plant^{-1}. The pooled data revealed that significantly highest number of tubers plant^{-1} (8.13, 12.06 and 16.83) was recorded with Kufri chipsona-3 at 30 and 60 DAP and at maturity, respectively. With respect to interaction, Kufri Chipsona-3 had significantly highest number of tubers plant^{-1} under drip irrigation with black-black plastic mulching (10.50, 15.13 and 20.23, respectively) at 30 and 60 DAP and at maturity (Table 4). The treatment combination of Kufri Badshah grown under farmer's practice recorded the lowest number of tubers plant^{-1} (4.25, 8.65 and 12.98) at 30 and 60 DAP and at maturity stage, respectively.

The finding is in line with the results reported by Mahmood *et al.* (2002) [16] who found that mulching increases tuber yield by 25% over no mulch condition and also corroborates with results reported by Gangwar *et al.* (2017) [20]. Maximum number of tubers recorded under black mulch may be due to more congenial soil temperature which resulted in better tuberization. Higher tuberization with moderate soil temperature was also reported earlier. The results are also in close agreement with the study of Patel *et al.*, 2002 [17] on relationship of number of tubers per plant and size of tubers as affected by temperature. Similarly, Kufri Chipsona-3 had significantly highest number of tubers plant^{-1} at all growth stage. This could be due to the reason that this variety was more vigorous in terms of height and foliage which synthesized more food ultimately leading to higher number of tubers. Bharat and Kumar (2021) [3] also reported highest total tuber yield, processable tuber yield and nonprocessable tuber yield of potato in Kufri Chipsona-3. A significant interaction between mulches combined with drip irrigation and potato varieties could be attributed to the better performance of potato due to suitable soil temperature and moisture for proper vegetative and reproductive growth of the plant under black-black plastic mulching and Kufri Chipsona-3 being superior in its genetic potential over Kufri Badshah. The results are in conformity with the findings of Bharat and Kumar (2021) [3].

3.2.2 Fresh haulm, tuber and biological yield (t/ha)

The data presented (Table 5) revealed that application of black-black plastic mulch along with drip irrigation produced the highest haulm, tuber and biological yield of potato (10.9, 43.1 and 54.0 t ha^{-1}, respectively) and it was at par with the silver-black plastic mulch application (42.9 and 53 t ha^{-1}) in tuber and biological yield along with drip irrigation during 2018-19. However, during 2019-20 the yields were highest under silver-black plastic mulched plots with drip irrigation (12.9, 42.8 and 55.7 t ha^{-1}, respectively) being at par with black-black plastic mulch with drip irrigation. The pooled analysis showed highest tuber and biological yield (42.9 and 54.4 t ha^{-1}) under silver-black plastic mulch being at par with black-black plastic mulch under drip irrigation while haulm yield (11.8 t ha^{-1}) was highest under black-black plastic mulch and it was at par with silver-black plastic mulch with drip

irrigation. Farmers practice recorded the lowest values for haulm, tuber and biological yields. Among the cultivars, Kufri Chipsona-3 recorded the highest haulm, tuber and biological yield (9.6, 38.5 and 48.1 t ha^{-1}, respectively) during both the years of study and on pooled basis under all the treatment combinations of mulch and irrigation practices.

As for the interaction (Table 5), drip irrigation with black-black plastic mulch applied in K. Chipsona-3 recorded significantly highest haulm yield (12.3, 14.1 and 13.2 t ha^{-1}), tuber tuber (48.1, 46.5 and 47.3 t ha^{-1}) and biological fresh yield (60.4, 60.5 and 60.4 t ha^{-1}) during both the years and on pooled basis, respectively being at par with silver-black plastic mulch x K. Chipsona-3 (13.3 t ha^{-1}) during the second year.

3.3 Economics

The statistical analysis of data (Table 6) revealed that silver-black plastic mulch application and Kufri chipsona-3 fetched higher gross return over the other treatments. During 2018-19, 2019-20 and on pooled basis, maximum gross return (₹ 482906/-, ₹ 467084/- and ₹474995/-) and net returns (₹ 369623/-, ₹ 353668/- and ₹ 361645/-) was recorded with treatment DM_1V_2 while minimum was recorded with FI_4V_1 during year 2018, 2019 and pooled basis.

With respect to benefit cost ratio (Table), maximum B C ratio (4.26) was found with treatment DM_1V_2 followed by DM_3V_2 (4.08) and minimum with treatment FI_4V_1 (3.15) during the first year. During 2019, it was maximum (4.19) with treatment DM_3V_2 followed by DM_1V_2 (4.12), DM_3V_1 (4.06), and with treatment FI_4V_1 (3.22). Pooled analysis revealed maximum B: C ratio (4.19) under DM_1V_2 which was followed by DM_3V_2 (4.13), DM_2V_1 (4.0) and minimum B: C ratio with treatment FI_4V_1 (3.18). Li (2018) in his found similar results concluding that applying the black plastic mulch raises soil temperature In comparison to other bare soils and warmer soil temperatures can hasten seedling emergence and growth to achieve the desired population structure at an earlier growth stage, maximizing solar radiation absorption, enhancing yield, and thus fetching higher economic returns. According to Kumar (2015) [18], who thought that a more favourable water regime led to higher yields, mulching is useful both economically and in terms of protecting the soil. Our finding also corroborate with the findings of Banarjeeet *et al.* (2016) [31] who reported that crops in mulched plots had higher net returns and a better benefit: cost ratio than crops in unmulched plots.

Table 1: Effect of plastic mulching under drip irrigation and potato varieties on emergence (%) of potato at 30 DAP under potato-based cropping system

Treatments	Final emergence (%)		
A. Main plot	**2018-19**	**2019-20**	**Pooled**
Drip irrigation with black-black plastic mulch	93.8	93.6	93.7
Drip irrigation with silver- black plastic mulch	94.5	93.6	94.0
Drip irrigation without mulch	92.1	93.7	92.9
Farmer's practice (Check)	90.9	87.7	89.3
S.Em±	1.10	1.63	0.98
C.D. (at 5%)	NS	NS	2.93
B. Sub plot			
Kufri Badshah	90.7	88.2	89.4
Kufri Chipsona-3	95.0	96.1	95.5
S.Em±	1.11	1.27	0.84
C.D. (at 5%)	3.43	3.90	2.46
Interaction	NS	NS	NS

DM_1 = Drip irrigation with black-black plastic mulch, DM_2 = Drip irrigation with silver- black plastic mulch, DM_3 = Drip irrigation without mulch, FI_4 =Farmer's practice (Check), V_1 = Kufri Badshah, V_2 = Kufri Chipsona-3, $(M \times V)_1$ = Between two levels of variety at same level of mulch,$(M \times V)_2$= Between two levels of mulches at same level of variety

Table 2: Effect of plastic mulching under drip irrigation and potato varieties on number of compound leaves plant $^{-1}$ of potato under potato-based cropping system

Treatments	At 30 DAP			At 60 DAP			At maturity		
A. Main plot	**2018-19**	**2019-20**	**Pooled**	**2018-19**	**2019-20**	**Pooled**	**2018-19**	**2019-20**	**Pooled**
Drip irrigation with black-black plastic mulch	87.7	75.4	81.5	113.3	107.5	110.4	81.2	77.2	79.2
Drip irrigation with silver- black plastic mulch	83.0	74.3	78.7	111.3	103.2	107.3	76.9	78.9	77.9
Drip irrigation without mulch	54.9	67.0	60.9	81.8	94.6	88.2	55.3	63.8	59.5
Farmer's practice (Check)	51.2	60.9	56.1	76.5	89.1	82.8	51.4	57.8	54.6
S.Em±	1.01	2.30	1.25	3.86	2.08	2.19	2.07	2.37	1.57
C.D. (at 5%)	3.22	7.36	3.73	12.34	6.66	6.51	6.63	7.57	4.68
B. Sub plot									
Kufri Badshah	66.0	67.0	66.5	94.5	96.1	95.3	64.1	67.7	65.9
Kufri Chipsona-3	72.4	71.9	72.1	96.9	101.1	99.0	68.2	71.1	69.7
S.Em±	0.95	1.07	0.72	1.80	1.46	1.16	0.94	1.34	0.82
C.D. (at 5%)	2.93	3.31	2.09	NS	4.49	3.38	2.90	NS	2.38
Interaction	S	S	S	NS	NS	NS	S	S	S

Table 3: Interaction effect of plastic mulching under drip irrigation and potato varieties on number of compound leaves plant $^{-1}$ of potato under potato-based cropping system

At 30 DAP					At maturity				
2018-19					2018-19				
Factor	**M1**	**M2**	**M3**	**M4**	**Factor**	**M1**	**M2**	**M3**	**M4**
V1	77.6	83.4	54.0	49.2	V1	72.8	79.9	54.1	49.7
V2	97.8	82.7	55.8	53.3	V2	89.5	73.9	56.5	53.1
	(M×V)1		(M×V)2			(M×V)1		(M×V)2	
S.Em	1.90		1.68		S.Em	1.88		2.46	
CD 5%	5.85		5.24		CD 5%	5.80		7.80	
2019-20					2019-20				
Factor	M1	M2	M3	M4	Factor	M1	M2	M3	M4
V1	67.6	75.4	67.0	58.0	V1	70.7	83.6	62.8	53.7
V2	83.2	73.3	67.1	63.9	V2	83.7	74.2	64.8	61.9
	(M×V)1		(M×V)2			(M×V)1		(M×V)2	
S.Em	2.15		2.76		S.Em	2.67		3.03	
CD 5%	6.62		8.72		CD 5%	8.23		9.55	
Pooled					Pooled				
Factor	M1	M2	M3	M4	Factor	M1	M2	M3	M4
V1	72.6	79.4	60.5	53.6	V1	71.8	81.7	58.4	51.7
V2	90.5	78.0	61.4	58.6	V2	86.6	74.0	60.6	57.5
	(M×V)1		(M×V)2			(M×V)1		(M×V)2	
S.Em	1.43		1.61		S.Em	1.63		1.95	
CD 5%	4.19		4.76		CD 5%	4.77		5.76	

Table 4: Effect of plastic mulching under drip irrigation and potato varieties on number of stem plant $^{-1}$ of potato under potato-based cropping system

Treatments	**At 30 DAP**			**At 60 DAP**			**At maturity**		
A. Main plot	**2018-19**	**2019-20**	**Pooled**	**2018-19**	**2019-20**	**Pooled**	**2018-19**	**2019-20**	**Pooled**
Drip irrigation with black-black plastic mulch	8.1	7.4	7.8	7.4	7.5	7.4	7.4	7.5	7.4
Drip irrigation with silver- black plastic mulch	7.6	7.8	7.7	7.3	7.6	7.5	7.3	7.6	7.5
Drip irrigation without mulch	5.8	6.3	6.1	6.1	6.0	6.0	6.1	6.0	6.0
Farmer's practice (Check)	5.3	6.1	5.7	5.0	5.5	5.3	5.0	5.5	5.3
S.Em±	0.15	0.13	0.10	0.11	0.20	0.11	0.11	0.20	0.11
C.D. (at 5%)	0.48	0.40	0.29	0.37	0.63	0.34	0.37	0.63	0.34
B. Sub plot									
Kufri Badshah	6.4	6.8	6.6	6.4	6.5	6.4	6.4	6.5	6.4
Kufri Chipsona-3	7.0	7.0	7.0	6.6	6.8	6.7	6.6	6.8	6.7
S.Em±	0.09	0.11	0.07	0.13	0.12	0.09	0.13	0.12	0.09
C.D. (at 5%)	0.28	NS	0.21	NS	NS	NS	NS	NS	NS
Interaction	S	S	S	S	NS	S	S	NS	S

Table 5: Interaction effect of plastic mulching under drip irrigation and potato varieties on number of stem plant^{-1} of potato at 30 DAP under potato-based cropping system

Treatments	**2018-19**				**2019-20**				**Pooled**			
	DM_1	**DM_2**	**DM_3**	**FI_4**	**DM_1**	**DM_2**	**DM_3**	**FI_4**	**DM_1**	**DM_2**	**DM_3**	**FI_4**
V1	7.0	8.2	5.6	5.0	6.5	8.4	6.2	6.1	6.7	8.3	5.9	5.6
V2	9.3	7.1	6.1	5.6	8.4	7.1	6.4	6.1	8.8	7.1	6.2	5.8
	(M ×V)1				(M ×V)1				(M ×V)1			
S.Em±	0.18				0.22				0.14			
C.D. (at 5%)	0.57				0.67				0.41			
	(M×V)2				(M×V)2				(M×V)2			
S.Em±	0.20				0.20				0.14			
C.D. (at 5%)	0.62				0.62				0.41			

Table 6: Interaction effect of plastic mulching under drip irrigation and potato varieties on number of stem plant^{-1} of potato at 60 DAP and at maturity under potato-based cropping system

Treatments	**2018 - 19**				**Pooled**			
	DM_1	**DM_2**	**DM_3**	**FI_4**	**DM_1**	**DM_2**	**DM_3**	**FI_4**
V1	6.9	7.7	5.9	5.0	6.9	7.8	5.9	5.2
V2	8.0	7.0	6.3	5.1	8.0	7.2	6.2	5.3
	(M X V)1				(M X V)1			
S.Em±	0.26				0.18			
C.D. (at 5%)	0.79				0.51			
	(M×V)2				(M×V)2			
S.Em±	0.21				0.17			
C.D. (at 5%)	0.67				0.50			

Table 7: Effect of plastic mulching under drip irrigation and potato varieties on number of tubers plant^{-1} of potato under potato-based cropping system

Treatments	At 30 DAP			At 60 DAP			At maturity		
A. Main plot	**2018-19**	**2019-20**	**Pooled**	**2018-19**	**2019-20**	**Pooled**	**2018-19**	**2019-20**	**Pooled**
Drip irrigation with black-black plastic mulch	8.98	8.95	8.96	12.28	13.65	12.96	17.84	18.58	18.21
Drip irrigation with silver- black plastic mulch	8.70	9.58	9.14	12.03	15.33	13.68	18.66	17.58	18.12
Drip irrigation without mulch	6.40	7.20	6.80	10.55	9.48	10.01	14.88	14.67	14.77
Farmer's practice (Check)	5.45	4.38	4.91	10.10	7.63	8.86	13.69	12.75	13.22
S.Em±	0.212	0.228	0.156	0.216	0.352	0.207	0.224	0.291	0.184
C.D. (at 5%)	0.679	0.729	0.463	0.691	1.127	0.614	0.715	0.931	0.545
B. Sub plot									
Kufri Badshah	6.63	6.93	6.78	10.93	10.46	10.69	15.58	15.08	15.33
Kufri Chipsona-3	8.14	8.13	8.13	11.55	12.58	12.06	16.95	16.71	16.83
S.Em±	0.238	0.185	0.151	0.148	0.165	0.111	0.169	0.213	0.136
C.D. (at 5%)	0.733	0.571	0.440	0.457	0.509	0.324	0.520	0.657	0.397
Interaction	S	S	S	S	S	S	S	S	S

Table 8: Interaction effect of plastic mulching under drip irrigation and potato varieties on number of tubers plant^{-1} of potato under potato-based cropping system

At 30 DAP					At 60 DAP					At maturity				
2018-19					2018-19					2018-19				
Factor	**M1**	**M2**	**M3**	**M4**	**Factor**	**M1**	**M2**	**M3**	**M4**	**Factor**	**M1**	**M2**	**M3**	**M4**
V1	7.25	8.30	5.90	5.05	V1	10.85	12.35	10.40	10.10	V1	16.06	18.88	13.94	13.45
V2	10.70	9.10	6.90	5.85	V2	13.70	11.70	10.70	10.10	V2	19.63	18.44	15.81	13.93
	(M×V)1		(M×V)2			(M×V)1		(M×V)2			(M×V)1		(M×V)2	
S.Em	0.476		0.398		S.Em	0.297		0.301		S.Em	0.337		0.327	
CD 5%	1.465		1.239		CD 5%	0.914		0.946		CD 5%	1.039		1.025	
2019-20					2019-20					2019-20				
Factor	M1	M2	M3	M4	Factor	M1	M2	M3	M4	Factor	M1	M2	M3	M4
V1	7.60	9.80	6.85	3.45	V1	10.75	15.40	8.50	7.20	V1	16.33	17.75	13.75	12.50
V2	10.30	9.35	7.55	5.30	V2	16.55	15.25	10.45	8.05	V2	20.83	17.42	15.58	13.00
	(M×V)1		(M×V)2			(M×V)1		(M×V)2			(M×V)1		(M×V)2	
S.Em	0.371		0.347		S.Em	0.331		0.423		S.Em	0.426		0.419	
CD 5%	1.142		1.088		CD 5%	1.019		1.338		CD 5%	1.314		1.315	
Pooled					Pooled					Pooled				
Factor	M1	M2	M3	M4	Factor	M1	M2	M3	M4	Factor	M1	M2	M3	M4
V1	7.43	9.05	6.38	4.25	V1	10.80	13.88	9.45	8.65	V1	16.20	18.31	13.84	12.98
V2	10.50	9.23	7.23	5.58	V2	15.13	13.48	10.58	9.08	V2	20.23	17.93	15.70	13.46
	(M×V)1		(M×V)2			(M×V)1		(M×V)2			(M×V)1		(M×V)2	
S.Em	0.301		0.264		S.Em	0.222		0.260		S.Em	0.272		0.266	
CD 5%	0.880		0.775		CD 5%	0.648		0.766		CD 5%	0.793		0.782	

Table 9: Effect of plastic mulching under drip irrigation and potato varieties on fresh yield of potato under potato based cropping system

Treatments	Symbol	Haulm			Tuber			Biological		
A. Main plot		**2018-19**	**2019-20**	**Pooled**	**2018-19**	**2019-20**	**Pooled**	**2018-19**	**2019-20**	**Pooled**
Drip irrigation with black-black plastic mulch	DM_1	10.9	12.8	11.8	43.1	41.8	42.4	54.0	54.5	54.3
Drip irrigation with silver- black plastic mulch	DM_2	10.1	12.9	11.5	42.9	42.8	42.9	53.0	55.7	54.4
Drip irrigation without mulch	DM_3	8.5	6.7	7.6	33.2	35.0	34.1	41.7	41.8	41.7
Farmer's practice (Check)	FI_4	7.1	5.3	6.2	28.7	29.7	29.2	35.8	35.1	35.4
S.Em±		0.18	0.21	0.14	0.36	0.22	0.21	0.41	0.28	0.25
C.D. (at 5%)		0.56	0.68	0.41	1.16	0.72	0.63	1.33	0.89	0.74
B. Sub plot										
Kufri Badshah	V_1	8.7	9.2	9.0	35.4	36.2	35.8	44.2	45.4	44.8
Kufri Chipsona -3	V_2	9.6	9.6	9.6	38.5	38.5	38.5	48.1	48.1	48.1
S.Em±		0.11	0.13	0.08	0.36	0.22	0.21	0.32	0.24	0.20
C.D. (at 5%)		0.34	NS	0.25	1.09	0.69	0.61	0.98	0.73	0.58
Interaction		S	S	S	S	S	S	S	S	S

Table 10: Interaction effect of plastic mulching under drip irrigation and potato varieties on fresh yield (t ha^{-1}) of potato under potato-based cropping system

Haulm					Tuber					Biological				
2018-19					2018-19					2018-19				
Factor	**M1**	**M2**	**M3**	**M4**	**Factor**	**M1**	**M2**	**M3**	**M4**	**Factor**	**M1**	**M2**	**M3**	**M4**
V1	9.6	10.2	8.4	6.8	V1	38.1	44.0	31.4	28.3	V1	47.7	54.2	39.8	35.0
V2	12.3	10.0	8.6	7.4	V2	48.1	41.9	34.9	29.2	V2	60.4	51.9	43.5	36.6
	(M×V)1		(M×V)2			(M×V)1		(M×V)2			(M×V)1		(M×V)2	
S,Em	0.22		0.24		S,Em	0.71		0.62		S,Em	0.64		0.61	
CD 5%	0.68		0.74		CD 5%	2.19		1.93		CD 5%	1.96		1.92	
2019-20					2019-20					2019-20				
Factor	M1	M2	M3	M4	Factor	M1	M2	M3	M4	Factor	M1	M2	M3	M4
V1	11.5	13.3	7.0	5.2	V1	37.1	44.7	34.0	28.9	V1	48.6	58.0	41.0	34.0
V2	14.1	12.5	6.5	5.5	V2	46.5	41.0	36.0	30.6	V2	60.5	53.5	42.5	36.1
	(M×V)1		(M×V)2			(M×V)1		(M×V)2			(M×V)1		(M×V)2	
S,Em	0.26		0.28		S,Em	0.44		0.39		S,Em	0.48		0.44	
CD 5%	0.80		0.88		CD 5%	1.37		1.21		CD 5%	1.47		1.37	
Pooled					Pooled					Pooled				
Factor	M1	M2	M3	M4	Factor	M1	M2	M3	M4	Factor	M1	M2	M3	M4
V1	10.5	11.7	7.7	6.0	V1	37.6	44.3	32.7	28.6	V1	48.1	56.1	40.4	34.5
V2	13.2	11.3	7.5	6.4	V2	47.3	41.4	35.5	29.9	V2	60.4	52.7	43.0	36.3
	(M×V)1		(M×V)2			(M×V)1		(M×V)2			(M×V)1		(M×V)2	
S,Em	0.17		0.18		S,Em	0.42		0.37		S,Em	0.40		0.38	
CD 5%	0.50		0.54		CD 5%	1.22		1.07		CD 5%	1.16		1.11	

Table 11: Effect of plastic mulching under drip irrigation and potato varieties on economics of potato under potato based cropping system

Treatments	Total Cost of cultivation(`/ha)			Gross return(`/ha)			Net return(`/ha)			B: C		
	2018-19	**2019-20**	**Pooled**	**2018-19**	**2019-20**	**Pooled**	**2018-19**	**2019-20**	**Pooled**	**2018-19**	**2019-20**	**Pooled**
DM1V1	111289	111383	111336	383160	373130	378145	271871	261747	266809	3.44	3.35	3.40
DM1V2	113283	113416	113350	482906	467084	474995	369623	353668	361645	4.26	4.12	4.19
DM2V1	111289	111383	111336	441668	449390	445529	330379	338007	334193	3.97	4.03	4.00
DM2V2	113283	113416	113350	420339	411901	416120	307056	298485	302770	3.71	3.63	3.67
DM3V1	84089	84183	84136	315745	342139	328942	231656	257956	244806	3.75	4.06	3.91
DM3V2	86083	86216	86150	351130	361161	356145	265047	274945	269996	4.08	4.19	4.13
FI4V1	90214	90174	90194	284376	290056	287216	194162	199882	197022	3.15	3.22	3.18
FI4V2	92199	92207	92203	293522	307292	300407	201323	215085	208204	3.18	3.33	3.26

4. Conclusion

Performance of Kufri Chipsona-3 variety of potato in terms of almost all growth parameters was significantly better under drip irrigation with silver-black plastic mulching. Application of black-black plastic mulch along with drip irrigation being at par with silver-black plastic mulching recorded significantly highest tuber number under all the grade (<25 g, 25-50 g, 50-75 g, >75 g tuber). The lowest tuber number per hectare was found under farmer`s practice. Kufri chipsona-3 being superior over Kufri Badshah performed better under all the treatment combinations of mulch and irrigation practices recording significantly higher total number of tubers. The interaction of silver-black with Kufri Badshah and black-black plastic mulching with Kufri chipsona-3 under drip irrigation was found significant in all the different grades of potato, however, interaction of farmers practice x K. Badshah recorded lowest number of tubers during both the years and on pooled basis. Under all grades of potato, the treatments showed different trend with respect to tuber yield. However, application of silver-black and black-black plastic mulching under drip irrigation in Kufri Chipsona-3 remained at par with each other and superior to other treatment combinations. The two year study clearly showed that the system productivity of potato-based cropping system was significantly highest under silver black plastic mulch with drip irrigation fetching higher returns, however, it was comparable to black-black plastic mulching. Since the results of present investigation belong to two years of experimentation for reaching to any definite conclusion and recommendation, it need further conduction of the same experiment for at least three successive years in different environments.

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