Impact of organic mulches on growth, yield and quality of potato (*Solanum tuberosum* L) in Malwa region of Madhya Pradesh

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ABSTRACT

A field experiment was conducted to assess the impact of organic mulches on growth, yield and quality of potato at the research farm of College of Agriculture, Indore, Madhya Pradesh during rabi season of 2020-2021. The experiment was conducted in RBD with 3 replications. Nine treatments viz T_0 [Control (non-mulch)], T_1 (Paddy straw 2.5 cm), T_2 (Paddy straw 5.0 cm), T_3 (Wheat straw 2.5 cm), T_4 (Wheat straw 5.0 cm), T_5 (Soybean straw 2.5 cm), T_6 (Soybean straw 5.0 cm), T_7 (Vermicompost 2.5 cm) and T_8 (Sawdust 2.5 cm) were used to find out the best materials that could help the farmers to improve their crop production. The results revealed that growth parameters like plant height (30.58 and 29.71 cm), number of branches/plant (15.77 and 14.66), number of leaves/plant (51.66 and 50.21), fresh weight of leaves/plant (57.41 and 56.61 g), dry weight of leaves/plant (5.50 and 5.17 g) and diameter of tubers (5.27 and 5.00 cm) were maximum in T_1 (Paddy straw 2.5 cm) and T_2 (Paddy straw 5.0 cm) respectively, whereas, leaf area (305.04 cm^2), leaf area index (3.05), weight of tubers/plant (747.00 g), yield of tubers/ha (373.52 q) and TSS (7.50^{o}Brix) were maximum in T_1. The same treatment, T_1 also resulted in maximum net profit/ha (Rs 4,06,474) and B-C ratio (1:2.64). Among the treatments, T_8 (Sawdust 2.5 cm) was the poorest performer.

Keyword: Potato; mulching; straw; compost; growth; yield; economics

INTRODUCTION

Agriculture today has become a highly knowledge intensive enterprise. Moreover, in the modern day paradigm of sustainable development goals, it is expected of the farmers to produce more from less input and with minimum detrimental effect on the environment. The farmers on the other hand, desire to get the maximum profit using the resources available at their command without deteriorating their non-renewable resources. This calls for expertise for determining the quantity of various inputs to be used as well as scheduling of various cultural operations. Thus agriculture calls for great deal of managerial and technical skills for successful crop production and its marketing.

Potato, an important food and vegetable crop of the world, produces more weight and calories per unit area as compared to all other field crops. It provides a source of low cost energy for human diet. Potato tubers are also a rich source of starch, vitamins (specially B and C) and minerals (Arora et al 2009). During 2020-21 in India, potato occupied about 22.50 lakh hectare area and production was about 542.30 lakh MT (http://www.aau.in/sites/default/files/23_potato_pre_sowing_pf_2021_22_ eng.pdf). In India, the major rabi potato producing states are Uttar Pradesh, West Bengal, Bihar, Gujarat, Madhya Pradesh, Punjab, Assam, Chhattisgarh, Jharkhand and Haryana.

The application of organic mulches increases the crop growth such as earliness and harvesting period. It has a great role in soil moisture conservation through modification of microclimatic soil conditions. It helps to prevent weed growth and increases infiltration of rain water during growing season and also reduces

the rate of evaporation from the soil surface by avoiding direct entry of solar radiations. It also protects soil surface from erosion due to high speed wind and surface run-off of water. This technology is boon for the horticultural crops not only for increasing growth, development and yield but also as a method of soil and water conservation (Barche et al 2014). Mulch helps in retaining soil moisture and maintaining soil temperature, prevents soil compaction and has favourable effects on soil physical, chemical and biological properties such as pH, organic carbon, water holding capacity and bulk density (Singh et al 2019). Mulching is an approach to enhance efficiency of irrigation besides improving potato tuber yield (Banerjee et al 2016).The effectiveness of straw mulch in suppressing weeds in potato fields is largely dependent on the mulch application rate; thick applications of mulch reduce weed number and biomass while lower amounts of mulch gives inconsistent weed control (Dvorak and Kral 2018). The present investigations were carried out to assess the responses of different organic mulches on growth, yield and quality of potato and to work out the economics of different treatments.

MATERIAL and METHODS

The experiment was laid out at the research farm of Department of Horticulture, College of Agriculture, Rajmata Vijayaraje Scindia Krishi Vishwa Vidyalaya, Indore, Madhya Pradesh. It is located at a latitude of 22°43" N and longitude of 75°66" E at an elevation of 553 m amsl. It has subtropical climate and is a semi-arid region having a temperature range of 29-45°C as maximum and 7-23°C as minimum in summer and winter seasons respectively.

The experiment was carried out in RBD with 9 treatments and 3 replications. Nine treatments viz T_0 [Control (non-mulch)], T_1 (Paddy straw 2.5 cm), T_2 (Paddy straw 5.0 cm), T_3 (Wheat straw 2.5 cm), T_4 (Wheat straw 5.0 cm), T_5 (Soybean straw 2.5 cm), T_6 (Soybean straw 5.0 cm), T_7 (Vermicompost 2.5 cm) and T_8 (Sawdust 2.5 cm) were used.

Potato cv Lady Rosetta comprised the planting material. It is a cross between Cardinal x SVP(VTN2) 62.33.3. Lady Rosetta is a specialist crisping variety with high dry matter and low reducing sugars. It has early crop maturity and is suitable for quality crisp production either fresh or from short term storage. Tubers are round, red with light yellow flesh. Pre-planting seed treatment was done with mancozeb 0.2 per cent solution for 10 minutes and seeds were spread at a cool and moist place to avoid fungal infection. Shallow furrows were opened 6 cm apart with the help of pickaxe manually and tubers were dibbled at a spacing of 45 cm row to row and 45 cm plant to plant in the morning. A week after planting, gap filling was done. Recommended package of practices was followed to raise a healthy crop.

A uniform dose of 120 kg N, 60 kg P and 60 kg K/ha was applied to all the plots. Full quantity of phosphorus and potassium along with half dose of nitrogen was applied before planting. Rest of the nitrogen was applied during earthing up 25 to 30 days after planting, before spreading of paddy straw, wheat straw, soybean straw, vermicompost and sawdust mulches. Planting distance of 45 cm was marked. After marking, tubers were planted and simultaneously organic mulches were spread treatment-wise. The data were recorded on growth, yield and quality parameters during the period of experimentation. The weeds were sampled by least count quadrate method as discussed by Misra (1968) at 30, 45 and 60 days after planting. The data based on individual plant selected for observation were statistically analysed as described by Panse and Sukhatme (1954).

Cost of cultivation is the total expenditure incurred for raising a crop in a treatment. The cost included for this purpose consisted of own or hired human labour, owned or hired machine labour, value of tubers, manures, fertilizers, herbicides, fungicides and irrigation charges.

RESULTS and DISCUSSION

Effect of treatments on growth parameters: The data given in Table 1 show that the treatments T_1 (Paddy straw mulch 2.5 cm) and T_2 (Paddy straw mulch 5.0 cm) were found significantly superior as compared to rest of the treatments with plant height of 30.58 and 29.71 cm respectively and were at par with each other. Minimum plant height (18.81 cm) was recorded in T_0 [Control (non-mulched)]. T_1 and T_2 were at par for number of branches/plant (15.77 and 14.66 respectively) and T_2 on the other hand was at par with T_3 (Wheat straw 2.5 cm) (14.00). Minimum number of branches per plant was recorded in T_0 (9.62). Maximum number of leaves per plant was recorded in T_1 and T_2 (51.66 and 50.21 respectively), the two being at par and minimum in T_0 (35.16). Maximum leaf area (305.04 cm^2) was observed in T_1 followed by T_2

Table 1. Effect of organic mulches on growth parameters of potato (60 DAS)

Treatment	Plant height (cm)	Number of branches /plant	Number of leaves/plant	Leaf area (cm^2)	Leaf area index	Fresh weight of leaves/ plant (g)	Dry weight of leaves/ plant (g)
T_0: Control (non-mulched)	18.81	9.62	35.16	181.11	1.81	46.83	2.71
T_1: Paddy straw (2.5 cm)	30.58	15.77	51.66	305.04	3.05	57.41	5.50
T_2: Paddy straw (5.0 cm)	29.71	14.66	50.21	290.10	2.90	56.61	5.17
T_3: Wheat straw (2.5 cm)	27.73	14.00	44.89	260.24	2.60	54.55	4.78
T_4: Wheat straw (5.0 cm)	26.11	13.10	44.66	242.59	2.43	53.59	4.32
T_5: Soybean straw (2.5 cm)	24.43	12.22	42.00	227.39	2.27	52.63	4.04
T_6: Soybean straw (5.0 cm)	23.62	11.68	40.55	214.79	2.15	51.99	3.76
T_7: Vermicompost (2.5 cm)	25.44	13.44	42.22	232.58	2.33	53.29	4.15
T_8: Saw dust (2.5 cm)	23.36	11.33	40.08	187.76	1.88	51.18	3.33
SEm±	0.33	0.37	0.49	2.52	0.03	0.45	0.14
$CD_{0.05}$	1.00	1.12	1.47	7.56	0.08	1.35	0.41

(290.10 cm^2). Minimum leaf area of 181.11 cm^2 was recorded in T_0 which was at par with T_8 (Saw dust 2.5 cm) (187.76 cm^2). Same trend was also observed in case of leaf area index. Maximum leaf area index of 3.05 was recorded in T_1 followed by 2.90 in T_2 and minimum in T_0 (1.81 cm^2) and T_8 (1.88 cm^2), the latter two being at par. T_1 and T_2 resulted in maximum fresh weight of leaves per plant (57.41 and 56.61 g respectively), the two being at par, whereas, T_0 resulted in minimum weight (46.83 g). Dry weight of leaves per plant was highest (5.50 and 5.17 g respectively) in case of T_1 and T_2, the two being at par, whereas, T_2 was at par with T_3 (4.78 g). Minimum dry weight of leaves per plant was recorded in T_0 (2.71 g). These results are in accordance with the findings of Ahmed et al (2017) who recorded increase in plant height in paddy straw treatment as compared to other treatments and Bharati et al (2020) who observed maximum number of branches and leaves per plant in paddy straw mulch.

Effect of treatments on weeds: Results presented in Table 2 exhibit that T_8 and T_2 resulted in minimum weed density (WD) of *Parthenium* sp (2.66 and 3.02 respectively) which were at par. Maximum weed density (6.86) was recorded in T_0. Weed control efficiency (WCE) was maximum (61.22) in T_8 and minimum in T_7 (Vermicompost 2.5 cm) (21.86). In case of *Cyprus rotundus*, minimum weed density was observed in T_8 (1.54) which was at par with T_2 (1.88) and the T_2, on the other hand, was at par with T_1 (2.19). Maximum WD was recorded in T_0 (4.16). Here T_8 exhibited highest WCE (62.98) and T_7 the lowest (24.51). In case of *Chenopodium album*, lowest WD was recorded in T_8 (2.08) and highest in T_0 (7.39). Here highest WCE was observed in T_8 (71.71) and lowest in T_7 (36.12). Due to wider C:N ratio of sawdust its decomposition is slower than other organic mulches which helps to restrict the germination and growth of weed seeds.

Data given in Table 3 show that fresh weight per plant of *Parthenium* sp was maximum in T_0 (18.73 g) whereas minimum in T_8 (7.91 g), T_2 (8.58 g), T_1 (10.20 g), T_4 (Wheat straw 5.0 cm) (10.25 g) and T_3 (10.41 g), all five being at par. Fresh weight of *C rotumdus* was maximum in T_0 (10.93 g) and minimum in T_8 (4.14 g). In case of *C album* also, fresh weight per plant was maximum in T_0 (20.02 g) and minimum in T_8 (6.26 g). Dry weight per plant of *Parthenium* sp was maximum in T_0 (7.44 g) and minimum in T_8 (2.72 g), T_2 (2.98 g) and T_1 (3.55 g), the three being at par. Maximum dry weight per plant of *C rotundus* was found in T_0 (3.86 g) and minimum in T_8 (1.18 g) and T_2 (1.42 g) where T_2 was at par with T_1 (1.76 g) and T_4 (1.86 g). In case of *C album*, maximum dry weight per plant was recorded in T_0 (6.67 g) and minimum in T_8 (1.79 g) and T_2 (2.23), where T_2 was at par with T_1 (2.64 g) and T_4 (2.76 g).

These results are in accordance with those of Ahmed et al (2017) who recorded minimum weed biomass in sawdust treatment and maximum in control. This might be due to the physical hindrance of sawdust mulching which reduced the germination and growth of weeds by reducing the light for breaking the dormancy of weed seeds and photosynthesis rate of weeds. The present results are in conformity with the results of Nkansah et al (2003) who also reported that

Table 2. Effect of organic mulches on weed density and weed control efficiency in potato crop

Treatment	*Parthenium* sp		*Cyprus rotundus*		*Chenopodium album*	
	WD	WCE (%)	WD	WCE (%)	WD	WCE (%)
T_0: Control (non-mulched)	6.86	-	4.16	-	7.39	-
T_1: Paddy straw (2.5 cm)	3.53	48.54	2.19	47.35	3.05	58.72
T_2: Paddy straw (5.0 cm)	3.02	55.97	1.88	54.80	2.56	65.35
T_3: Wheat straw (2.5 cm)	4.15	39.50	2.77	33.41	3.51	52.50
T_4: Wheat straw (5.0 cm)	3.70	46.06	2.51	39.66	2.89	60.89
T_5: Soybean straw (2.5 cm)	5.05	26.38	3.10	25.48	4.01	45.73
T_6: Soybean straw (5.0 cm)	4.71	31.34	2.75	33.89	3.18	56.96
T_7: Vermicompost (2.5 cm)	5.36	21.86	3.14	24.51	4.72	36.12
T_8: Saw dust (2.5 cm)	2.66	61.22	1.54	62.98	2.08	71.71
SEm±	0.15	-	0.16	-	0.13	-
$CD_{0.05}$	0.45	-	0.47	-	0.38	-

WD= Weed density, WCE= Weed control efficiency

Table 3. Effect of organic mulches on fresh and dry weight of weeds in potato crop

Treatment	Fresh weight/plant (g)			Dry weight/plant (g)		
	Parthenium sp	*Cyprus rotundus*	*Chenopodium album*	*Parthenium* sp	*Cyprus rotundus*	*Chenopodium album*
T_0: Control (non-mulched)	18.73	10.93	20.02	7.44	3.86	6.67
T_1: Paddy straw (2.5 cm)	10.20	7.20	8.71	3.55	1.76	2.64
T_2: Paddy straw (5.0 cm)	8.58	6.36	7.88	2.98	1.42	2.23
T_3: Wheat straw (2.5 cm)	10.41	7.83	9.62	4.70	2.29	3.25
T_4: Wheat straw (5.0 cm)	10.25	6.82	8.39	3.90	1.86	2.76
T_5: Soybean straw (2.5 cm)	11.94	8.34	10.58	4.85	2.78	3.57
T_6: Soybean straw (5.0 cm)	11.59	7.65	9.43	4.95	2.35	3.16
T_7: Vermicompost (2.5 cm)	13.31	9.39	13.35	5.57	2.85	4.43
T_8: Saw dust (2.5 cm)	7.91	4.14	6.26	2.72	1.18	1.79
SEm±	0.85	0.33	0.31	0.33	0.15	0.19
$CD_{0.05}$	2.55	1.00	0.93	0.98	0.44	0.58

grass straw, rice straw, rice husk and saw dust mulches significantly reduced fresh weight of weeds as compared to non-mulched treatment. Weed control efficiency represents the effectiveness of treatments in controlling weed dry matter accumulation as compared with the plots where no weed control methods either manual or chemical are adopted. In the present experiment, wood dust was better than grass which could be due to the reason that wood dust is better than grass mulches in weed control due to better soil coverage and slower rate of decomposition. These results are in accordance with Olabode et al (2006) who found that wood chips/dust gave higher weed control efficiency than grassy mulches.

Effect of treatments on yield and quality parameters: Results regarding yield parameters are presented in Table 4. Number of tubers per plant was recorded highest in T_3 (8.83) and T_4 (8.26) which were at par and lowest in T_0 (5.17). Diameter of tubers was highest in T_1 (5.27 cm) and T_2 (5.00 cm) which were at par, latter being at par with T_3 (4.80 cm) and lowest in T_0 (3.75 cm). Weight of tubers per plant was highest in T_1 (747.00 g) followed by T_2 (705.54 g) and lowest in T_0 (400.00 g). Weight of tubers per plot and per hectare and TSS were maximum in T_1 (18.90 kg, 373.52 q and 7.50°Brix respectively) and minimum in T_0 (10.13 kg, 200.00 q and 5.10 °Brix respectively). Weed index was highest in T_0 (46.42%) and minimum in T_2 (5.55%). Green tubers were maximum in T_0 (11.20%) and T_5 (Soybean straw 2.5 cm)(8.78%) which were at par and minimum in T_2 (2.54%) and T_1 (5.06%), the two being at par. Ahmed et al (2017) recorded highest tuber yield in paddy straw. This could be probably due to faster decomposition of paddy straw

mulch which increased the humidity and temperature in top soil, consequently advanced the germination and emergence of seedlings as compared to plots without mulch. Acharya et al (2005) reported higher yield under paddy straw mulch which was related to favourable soil temperature and soil water content throughout the growing season.

Higher TSS in paddy straw might be due to the reason that paddy straw mulch efficiently improved the microclimate and crop growth conditions by promoting plant transpiration at the expense of evaporation from the soil. These results are in accordance with Zayton et al (2015) who reported that paddy straw mulch treatment resulted in highest TSS than other mulching materials. The minimum number of green tubers was found in paddy straw mulch 5.0 cm (2.54%) and the maximum in T_0 (11.20%) and T_5 (8.78%). Minimum number of green tubers under paddy straw could be due to the reason that its retention in the covering of soil was more due to which tubers were not much exposed to direct sunlight which prevented greening as compared to other treatments. The results are in accordance with those of Majumder et al (2016) who observed the maximum number of green tubers in no-mulch and minimum in paddy straw mulch.

Effect of treatments on economics of potato cultivation: Net profit and B-C ratio were recorded maximum in T_1 (Rs 4,06,474 and 1:2.64 respectively) followed by T_3 (Rs 3,49,959 and 1:2.35 respectively) and minimum in T_0 (Rs 1,76,194 and 1:1.42 respectively) (Table 5). This could due to the faster decomposition of paddy mulch which lead to conservation of soil moisture, reduced soil temperature, minimized evaporation loss and enhanced tuber growth ultimately leading to higher production. The findings are similar to the results obtained by Rahman et al (2006) who reported that the highest benefit-cost ratio was found in rice straw mulch and minimum in no-mulch.

Table 4. Effect of organic mulches on yield and quality parameters of potato

Treatment	Number of tubers /plant	Diameter of tubers (cm)	Weight of tubers (g/plant)	Weight of tubers (kg/plot)	Yield of tubers (q/ha)	Weed index (%)	TSS (%)	Green tubers (%)
T_0: Control (non-mulched)	5.17	3.75	400.00	10.13	200.00	46.42	5.10	11.20
T_1: Paddy straw (2.5 cm)	7.39	5.27	747.00	18.90	373.52	-	7.50	5.06
T_2: Paddy straw (5.0 cm)	7.20	5.00	705.54	17.85	352.77	5.55	7.07	2.54
T_3: Wheat straw (2.5 cm)	8.83	4.80	665.02	16.83	332.51	10.97	6.90	6.18
T_4: Wheat straw (5.0 cm)	8.26	4.55	630.44	15.95	315.22	18.56	6.70	6.09
T_5: Soybean straw (2.5 cm)	7.50	4.25	597.82	15.13	298.91	19.97	6.07	8.78
T_6: Soybean straw (5.0 cm)	7.33	4.14	581.02	14.70	290.51	22.22	5.90	8.27
T_7: Vermicompost (2.5 cm)	7.00	4.52	621.54	15.73	310.77	16.97	6.10	7.44
T_8: Saw dust (2.5 cm)	6.05	4.27	576.00	14.58	288.04	22.88	5.50	6.38
SEm±	0.21	0.10	3.98	0.31	6.04	-	0.06	4.27
$CD_{0.05}$	0.62	0.31	11.93	0.93	18.11	-	0.17	2.79

Table 5. Economics of various treatments used in potato crop

Treatment	Fixed cost of cultivation (Rs)	Additional cost (Rs)	Total expenditure (Rs)	Tuber yield (q/ha)	Gross income (Rs)	Net profit/ha (Rs)	B-C ratio
T_0: Control (non-mulched)	1,23,806	7,500	1,31,306	200.00	3,00,000	1,76,194	1:1.42
T_1: Paddy straw (2.5 cm)	1,23,806	30,000	1,53,806	373.52	5,60,280	4,06,474	1:2.64
T_2: Paddy straw (5.0 cm)	1,23,806	60,000	1,83,806	352.77	5,29,155	3,45,349	1:1.87
T_3: Wheat straw (2.5 cm)	1,23,806	25,000	1,48,806	332.51	4,98,765	3,49,959	1:2.35
T_4: Wheat straw (5.0 cm)	1,23,806	50,000	1,73,806	315.22	4,72,830	2,99,024	1:1.72
T_5: Soybean straw (2.5 cm)	1,23,806	30,000	1,53,806	298.91	4,48,365	2,94,559	1:1.91
T_6: Soybean straw (5.0 cm)	1,23,806	50,000	1,73,806	290.51	4,35,765	2,61,959	1:1.50
T_7: Vermicompost (2.5 cm)	1,23,806	40,000	1,63,806	310.77	4,66,155	3,02,349	1:1.84
T_8: Saw dust (2.5 cm)	1,23,806	25,000	1,48,806	288.04	4,32,060	2,83,254	1:1.90

CONCLUSION

The results of this study exhibited the significant effect of organic mulches. The mulches reduced soil water evaporation and improved soil water availability. Using organic mulches produced more vigorous plants, gave higher yield and increased soil temperature as compared to without mulch treatment. The marketable yield was also greater with the use of organic mulches as compared to without mulch. The increase in yield due to paddy straw mulch was probably associated with its faster decomposition which increased the moisture and temperature in top soil, consequently advanced the germination and emergence of seedlings as compared to plots without mulch. Mulching might have facilitated retention of soil moisture and improved physical, chemical and biological properties of soil. Mulching showed significant control over weed population by covering the surface of the soil as it acted as barrier against weeds to emerge out. It also protected the upper fertile soil from erosion and minimized the variation in soil temperature. The results of the present study may be used to develop other technological sequences for the cultivation of potatoes in Malwa region of Madhya Pradesh. It is suggested to conduct multi-location and multi-seasonal trials on this aspect to achieve more results.

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