Effect of different levels of fertilizer and mulching materials on growth, yield and quality of potato (Solanum tuberosum L)

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Abstract
The experiment was conducted at Horticultural Research Cum Instructional Farm, College of Agriculture, I.G.K.V. Raipur, Chhattisgarh during the 2019-2020 Rabi season to investigate the “Effect of different levels of fertilizer and mulching materials on growth, yield and quality of potato (Solanum tuberosum L).” The experiment was carried out under split plot design with four replications. There were two different fertility levels in the main plot. F₁ (75% NPK) and F₂ (100% NPK). Whereas sub plot had five different mulch treatment M₀ (no mulch), M₁ (paddy straw mulch), M₂ (black polyethylene mulch), M₃ (woven mulch) and M₄ (silver mulch). The goal of this study is to define the possible outcome of different types of mulches influencing parameters on plant growth and yield. The application of 100% N,P,K was most suitable for providing better performance to plant emergence, emergence percent, number of shoots and number tubers and grade wise tubers yield. Among the different mulches were evaluated woven mulch was recorded for maximum yield of tuber (25.9 t/ha) followed by black polyethylene mulch (24.9 t/ha). While, lowest no mulch (20.9 t/ha). Quality parameters such as specific gravity, haulm dry matter content, tuber dry matter content, dry weight of tuber and total yield of tuber were found to be higher in woven mulch. While, lowest in no mulch. The interaction effect of this two combinations recorded significant maximum tuber yield (28.10 t/ha) and maximum net income (383,703,435) were observed that the application of 100% NPK with woven mulch. The present study also found that potato crop should be planted on 100% N,P,K with woven mulch or 100% N,P,K with black polyethylene mulch for higher tuber production.

Keywords: Potato, polyethylene mulch, fertility levels, tuber yield

Introduction
The production of vegetables plays a pivotal role in Indian agriculture, it provides food and nutrition to consumer as well as economical support to farmers. It also generates foreign trades and satisfies processing industries by supplying raw material. The total area under vegetable cultivation in the world is 10.25 million hectares with a production of 184.39 million tonnes and a productivity of 18.00 tonnes per hectare (Anonymous, 2018) [1]. Potato (Solanum tuberosum L.) is a major cash crop for both the temperate and subtropical climate. It is popularly known as “Alloo,” and member of Solanaceae family, having chromosome number 2n=4x=48 originated in South America. India ranks second in production and third in area after China and Russia. It has fourth position among the most important food crops, after wheat, rice and maize (Anonymous, 2010). Potato is considered to be the king of vegetables, it is an underground tuber crop and considered as a new world food crop, produced and consumed globally. It is also an important food crop, particularly for populated countries like India and has ability to satisfy increasing food demands and food security of the of the country. Total global area under potato cultivation was 17.58 million hectares from which total 368.24 million tonnes of potato produced during 16.64 tonnes per hectare of productivity (Anon, 2018) [2]. In India 21.42 lakh hectares area under potato cultivation with 513.27 lakh MT production with average productivity of 23.68 tonnes per hectare (Anon, 2019) [1]. In Chhattisgarh is mainly known for rabi potato cultivation except Mainpat and Samripat where kharif crop have cultivated. In Chhattisgarh total 45435 hectares area under potato crop with 682342 tonnes production and 15.02 tonnes productivity per hectare (Anon, 2019) [1].
Potato produces highest dry matter and edible protein per unit area under per unit time. It is rich source of starch of carbohydrates (22.6g), edible protein (2.8g), starch (16.3g), total sugar (0.6g), crude fibre (0.5g), fat (0.14g), mineral (0.9g), calcium (7.7mg), iron (0.75mg), and vitamin C 19.7mg on 100 g fresh weight of tuber.

The potato plant grown well under ample availability of all macro (N, P, K, Ca, Mg, S) and micro elements (Fe, Mn, B, Zn, Cu, Mo). Nitrogen is most important element as it is a constituent of proteins and influences the development of numerous physiological and biochemical processes, plant growth and consequently affects yield and quality. Phosphorus enhances tuber growth, increases tuber quality and increases tuber size. Potassium plays an important part in the plant’s biological cycles, enhances the efficiency of the cooking and packaging, improves tubers’ sensitivity to damage and influences dry matter concentration.

Mulching materials along with proper fertility levels increased the plant growth parameters *i.e.* plant emergence, total chlorophyll content, plant height, number of shoots and the yield of potato due to more availability of nutrients to the plant. The growth parameters were significantly higher in the mulched plants over the un mulched plants. Mulching practice affects crop growth and development in various ways, Sharma *et al.*, (2013)\[^{14}\].

Material and Methods

The present investigation entitled, “Effect of different levels of fertilizer and mulching materials on growth, yield and quality of potato (*Solanum tuberosum* L.)” was carried out during the year 2019-20 in *rabi* season located at Horticultural Research Farm, College of Agriculture, Indira Gandhi Krishi Vishwavidyalaya, Raipur (C.G). The experiment with Split Plot Design has been replicated four times with ten treatments. The field was divided into 40 experimental units of 3.0 m x 3.0 with 60 cm irrigation channel in between two units. The allotment of treatments to various plots done by random method. Treatment consist of various fertility levels F\(_1\)-75% NPK and F\(_2\) - 100% NPK, and treatment consist various different mulching materials (M\(_0\) - no mulch, M\(_1\) Paddy straw mulch, M\(_2\) - black polyethylene mulch, M\(_3\) - Woven mulch and M\(_4\) - silver polyethylene mulch). The treatments consist of ten treatment viz., F\(_1\)M\(_0\) - no mulch, F\(_1\)M\(_1\) – paddy straw mulch, F\(_1\)M\(_2\) – black polythene mulch, F\(_1\)M\(_3\) -Woven mulch, F\(_1\)M\(_4\) - silver mulch, F\(_2\)M\(_0\) – no mulch, F\(_2\)M\(_1\) – paddy straw mulch, F\(_2\)M\(_2\) – black polythene mulch, F\(_2\)M\(_3\) -Woven mulch and F\(_2\)M\(_4\) - silver mulch.

Result and Discussion

Emergence percent

The percent of emergence reported at 40 days after planting were analysed statistically which is presented in table 4.1 and depicted through figure 4.2, the percent emergence of plant at 40 days remained significantly affected with fertility levels and non significantly by mulching materials, the highest emergence percent was noted in 75% fertility level (91%) while lower under 100% fertility level (88%). As regards the mulching, data on the days for plant emergence percent ranged from (88.0 to 92.25%). Woven mulch showed highest emergence percent (92.25%). While, lowest day for plant emergence percent was recorded under no mulch (88.00%). In this investigation percent emergence was affected non-significantly by the interaction of these two factors. Among different treatment combination highest percent of plant emergence was noted in 75% N,P,K with woven mulch (93.50%). While, the lowest percent emergence was noted in 100% N,P,K and no mulch (86.50%). Similar findings were also recorded, (Ping *et al.*, 1994; Mahmoud *et al.*, 2002 and Jagmohan *et al.*, 2013)\[^{10,14}\].

Plant height

The Plant height under different treatments was recorded at 40, 60 and 90 DAP presented in Table 4.1 and graphically figure 4.3 revealed that there was significantly difference due to application of different fertility levels and mulching materials. At 40 days after planting the tallest plant height was noted in 100% fertility level (33.30 cm) and lowest under 75% fertility level (31.61 cm). Among the mulch treatments tallest plant height was noted in black polyethylene mulch (34.55cm) found significantly superior over all treatment, followed by woven mulch (32.65cm), paddy straw (32.58cm) and silver polyethylene mulch (31.85cm) and lowest plant height was noted in no mulch (30.65cm). It was observed that between interaction effect of different fertility levels and mulching materials were differ significantly for plant height. tallest plant recorded in 100% N,P,K with black polythene mulch (36.20 cm) followed by 100% N,P,K with woven mulch (34.25 cm), 100% N,P,K with silver mulch F\(_1\)M\(_4\) (33.05 cm) and 100% N,P,K and paddy straw mulch (32.45 cm). While lowest plant height was recorded in 100% N,P,K with no mulch (30.55 cm). At 60 days after planting both the treatment and there combination were differ significantly tallest plant was noted in 100% fertility level (36.43 cm) followed by 75% fertility level (34.14 cm). Among the mulch treatment tallest plant height was recorded in black polythene mulch (37.5cm) which was significantly at par with woven mulch (35.68 cm), followed by paddy straw (35.32 cm) and silver polyethylene mulch (34.53 cm). The lowest plant height was noted in no mulch (33.41 cm). Among the treatment combinations, tallest plant height was recorded in 100% N,P,K with black polythene mulch (39.31 cm) followed by 100% N,P,K and woven mulch (37.40 cm), 100% N,P,K with silver mulch (36.10 cm) and 100% N,P,K with paddy straw mulch (35.60 cm). While, lowest plant height was recorded in 75% N,P,K and no mulch (33.40 cm). At 90 days after planting both the treatment and their combination were differ significantly tallest plant height was found in 100% fertility level (37.87 cm) followed by 75% fertility level (35.42 cm). Among the mulch treatment tallest plant height was recorded in black polythene mulch (38.2 cm) and found significantly superior over all treatment followed by woven mulch (37.12 cm), paddy straw (36.81 cm) and silver polyethylene mulch (36.25 cm). The lowest plant height was recorded in no mulch (34.74 cm). It was observed that between interaction application tallest plant height was recorded in 100% N,P,K with black polythene mulch (39.84 cm) followed by 100% N,P,K with woven mulch (39.25 cm), 100% N,P,K with silver mulch (37.60 cm) and 100% N,P,K with paddy straw mulch (37.41 cm) while, lowest plant height was recorded in 75% N,P,K with no mulch (34.60 cm). Similar results have also been reported by (Singh and Ahmed 2008 and Jagmohan 2013, Singh *et al.*, 2019)\[^{11,14}\].

Number of shoot per plant

Numbers of shoots per plant were recorded at 40, 60 and 90 DAP and presented in Table 4.1 and depicted through figure 4.4. It was observed that numbers of shoots per plant were different significantly, due to application of different fertility levels and mulching materials and their combination at all the intervals evaluates. At 40 days after planting the maximum
was recorded under no mulch (5.00 t/ha). The combinations of these two treatments were differ non-significantly. Among different treatment combination highest tuber yield t/ha (>75 g) was noted in 100% N,P,K with woven mulch (8.71 t/ha). While, the lowest tuber yield t/ha (>75g) was recorded under 75% N,P,K and no mulch (4.51 t/ha). Similar findings were also recorded (jail et al., 2004 and Singh et al., 2019)\cite{17}.

** Marketable tuber (t/ha)**

Marketable tuber yield t/ha was different treatment and there interaction effects are presented in table 4.5 and illustrated in figure 4.25. It is revealed from the data that there were significance difference for marketable tuber yield per plot t/ha under different fertility levels and mulching materials. Maximum tubers yield per plot recorded 100% fertility level (18.03 t/ha) as compared to 75% fertility level (14.77 t/ha). As regards the mulching. The maximum marketable tubers yield was recorded under woven mulch (18.4 t/ha) followed by silver mulch (16.84 t/ha), paddy mulch (16.40 t/ha) and black polythene mulch (16.02 t/ha). While, the minimum was recorded under no mulch (14.33 t/ha). The combinations of these two treatments were differ non-significantly. Among different treatment combination maximum marketable tubers yield was noted in 100% N,P,K with woven mulch (21.33 t/ha). Minimum marketable tubers yield was noted in 75% N,P,K with no mulch (13.23 t/ha). Indistinguishable results were also seen by (jail et al., 2004 and Singh et al., 2019)\cite{17}.

** Unmarketable tuber **

Unmarketable tuber yield t/ha was recorded under different treatment and their interaction effects are presented in table 4.5 and illustrated in figure 4.26. 75% fertility level was recorded highest unmarketable tuber yield (7.46 t/ha) as compared to 100% fertility level (6.83 t/ha). Various levels of mulching differ non-significantly for unmarketable tuber yield. Highest unmarketable tuber yield was recorded under black polythene (8.27 t/ha) followed by woven mulch (7.59 t/ha) and silver mulch (6.64 t/ha). While, lowest unmarketable tuber yield was recorded under paddy mulch (6.59 t/ha). The combinations of these two treatments were differ non-significantly. Among different treatment combination maximum unmarketable tuber was recorded under 75% N,P,K with black polythene mulch (9.01 t/ha). While, the lowest unmarketable tuber was noted in 100% N,P,K with silver mulch (6.09 t/ha).

** Tuber yield (t/ha)**

Tuber yield per plot t/ha for different treatment and their interaction effects are presented in table 4.5 and depicted through in 4.27. It is revealed from the data that there were significance difference for tuber yield per plot t/ha under different fertility levels and mulching materials and their interactions. Highest tuber yield per plot t/ha was recorded under 100% fertility level (24.86 t/ha) and lowest was recorded under 75% fertility level (22.23 t/ha). Among the mulching treatments. Maximum total tuber yield of per plot t/ha was recorded under woven mulch (25.99 t/ha) followed by black polythene mulch (24.29 t/ha), silver mulch (23.48 t/ha) and paddy mulch (22.98 t/ha). While, the lowest tubers yield per plot t/ha was recorded under no mulch (20.98 t/ha). The interaction of these two treatments were differ non-significant differences, among different treatment combination maximum tuber yield per plot t/ha was noted in 100% N,P,K with woven mulch (28.10 t/ha). While, the minimum tuber yield per plot t/ha noted in 75% N,P,K and no
mulch (19.52 t/ha). Indistinguishable results were also seen by (Jail et al., 2004 and Jasmisa et al., 2018 and Singh et al., 2019 and Bhagat et al., 2016) [7].

**Dry matter content of tubers (%)**

Dry matter content of tuber per 100 g for fresh weight of tuber was recorded under different treatment and their interaction effects are presented in table 4.6 and illustrated in figure 4.28. Maximum dry matter content of tuber was recorded under 100% fertility level (19.57 %) and lowest dry matter content of tuber was recorded under 75% fertility level (18.74 %). As regards the mulching materials. Highest dry matter content of tuber was recorded under black polythene (19.47 %), it is at par with woven mulch (19.32%), paddy straw mulch (19.20 %) and silver mulch (19.12 %) and the lowest dry matter content of tuber was showed under no mulch (18.74%). The interaction of these two factors were differ non-significantly, among different treatment combination highest dry matter content of tuber was noted in 100% N,P,K with black polythene mulch (19.84 %). While, the lowest dry matter content of tuber was noted in 75% N,P,K with no mulch (18.31 %). Similar finding results was recorded in (Zeng et al., 2012, Jagmohan et al., 2013 and Nizam et al., 2017) [16, 14] they found that mulching was increased dry matter content as compared as no mulch.

**Harvesting Index (HI)**

Harvesting index was recorded under different treatment and their combinations are presented in table 4.7 and depicted figure 4.30. Maximum harvesting index was recorded in 100% fertility level (0.71) as compared to 75% fertility level (0.70). As regards to varying level of mulching materials. Highest harvesting index was noted in woven mulch (0.73) followed by black polythene mulch (0.72), and paddy straw mulch (0.70). While, the lowest harvesting index was recorded under no mulch (0.69). The combinations of these two treatments were differ non-significantly. Among different treatment combination highest harvesting index was noted in 100% N,P,K with woven mulch (0.74). While, the lowest harvesting index was noted in 75% N,P,K with no mulch (0.68).

**Table 1**: Effects of fertility levels and mulching materials on days for plant emergence, emergence percentage (%), plant height, number of shoots and number of compound leaves, dry matter content of tuber and harvesting index at 40, 60 and 90 DAP

| Treatments | Emergence percentage (%) | Plant height(cm) | Number of shoots/Plant | Dry Matter Content of tuber (%) | Harvesting Index |
|------------|--------------------------|------------------|------------------------|-------------------------------|-----------------|
| Fertility levels | | | | | |
| F1 | 75%NPK | 91.25 | 31.61 | 34.14 | 35.42 | 3.60 | 4.02 | 4.29 | 18.47 | 1.02 |
| F2 | 150%NPK | 88.00 | 33.30 | 36.43 | 37.87 | 4.17 | 4.54 | 4.86 | 19.57 | 1.04 |
| CD(P=0.05) | | 0.82 | 0.82 | 2.15 | 1.1 | NS | NS | NS | 0.72 | 0.004 |
| Mulching | | | | | |
| M0 | No mulch | 88.00 | 30.65 | 34.41 | 34.74 | 3.68 | 4.01 | 4.25 | 18.68 | 1.02 |
| M1 | Paddy straw | 89.63 | 32.58 | 35.32 | 36.81 | 3.86 | 4.18 | 4.87 | 19.20 | 1.03 |
| M2 | Black polythene | 90.25 | 34.55 | 37.59 | 38.24 | 4.01 | 4.30 | 4.90 | 19.47 | 1.04 |
| M3 | Woven mulch | 92.25 | 32.65 | 35.68 | 37.12 | 4.13 | 4.60 | 5.01 | 19.32 | 1.05 |
| M4 | Silver mulch | 88.00 | 31.85 | 34.53 | 36.25 | 3.73 | 4.10 | 4.32 | 19.12 | 1.03 |
| CD(P=0.05) | | NS | 1.16 | 1.1 | 1.1 | NS | NS | NS | NS | 0.007 |
| Fertility levels × mulching | | | | | |
| F1M0 | No mulch | 89.50 | 30.75 | 33.40 | 34.60 | 3.35 | 4.40 | 4.55 | 18.31 | 1.01 |
| F1M1 | Paddy straw | 92.75 | 32.70 | 35.01 | 36.21 | 3.60 | 3.60 | 3.75 | 18.74 | 1.02 |
| F1M2 | Black polythene | 91.00 | 32.90 | 35.70 | 36.60 | 3.88 | 4.15 | 4.39 | 19.10 | 1.03 |
| F1M3 | Woven mulch | 93.50 | 31.05 | 33.87 | 35.08 | 3.90 | 3.45 | 4.05 | 18.83 | 1.05 |
| F1M4 | Silver mulch | 89.50 | 30.65 | 33.09 | 34.85 | 3.25 | 4.50 | 4.85 | 18.74 | 1.03 |
| F1M5 | No mulch | 86.50 | 30.55 | 33.50 | 34.91 | 4.00 | 3.55 | 3.85 | 19.05 | 1.04 |
| F1M6 | Paddy straw | 86.50 | 32.45 | 35.60 | 37.41 | 4.13 | 3.71 | 4.03 | 19.66 | 1.04 |
| F1M7 | Black polythene | 89.50 | 36.20 | 39.31 | 39.84 | 4.15 | 3.61 | 4.01 | 19.84 | 1.05 |
| F1M8 | Woven mulch | 91.00 | 34.25 | 37.40 | 39.25 | 4.35 | 4.25 | 4.45 | 19.80 | 1.06 |
| F1M9 | Silver mulch | 85.50 | 33.05 | 36.10 | 37.60 | 4.20 | 3.45 | 3.85 | 19.50 | 1.04 |
| CD(P=0.05) | | NS | 2.26 | 2.05 | 1.82 | NS | NS | NS | NS |

**Table 2**: Effect of fertility levels and mulching materials on yield of tuber (25-50), yield of tuber (>75g), yield of marketable tuber, yield of unmarketable tuber and yield of total tuber

| Treatments | yield of tuber (25-50) t/ha | yield of tuber (50-75) t/ha | yield of tuber (>75) t/ha | marketable yield of tuber | Unmarketable yield of tuber | Total yield of tuber t/ha |
|------------|-----------------------------|----------------------------|----------------------------|---------------------------|-----------------------------|--------------------------|
| Fertility level | | | | | | |
| F1 | 75% RDF | 5.29 | 4.32 | 5.16 | 14.77 | 7.46 | 22.23 |
| F2 | 150% RDF | 5.09 | 6.44 | 6.50 | 18.03 | 6.83 | 24.86 |
| CD(P=0.05) | | 0.90 | 0.90 | 0.88 | 1.48 | 1.85 | 0.50 |
| Mulching | | | | | | |
| M0 | No Mulch | 4.60 | 4.73 | 5.00 | 14.33 | 6.64 | 20.98 |
| M1 | Paddy Straw | 5.12 | 5.69 | 5.59 | 16.40 | 6.59 | 22.98 |
| M2 | Black Polythene | 5.15 | 4.78 | 6.09 | 16.20 | 8.27 | 24.29 |
| M3 | Woven Mulch | 5.47 | 5.68 | 7.25 | 18.40 | 7.59 | 25.99 |
| M4 | Silver Mulch | 5.60 | 6.02 | 5.22 | 16.84 | 6.64 | 23.47 |
| CD(P=0.05) | | NS | NS | 1.38 | 2.30 | 2.63 | 0.96 |
| Fertility level × Mulching | | | | | | |
| F1M0 | No Mulch | 4.43 | 4.29 | 4.51 | 13.23 | 6.29 | 19.52 |
The different mulches were mulching, Applied and +.

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Conclusion

100 % RDF application is appropraiate as compare to the reduced application of RDF up to 75% the higher levels of fertilizer can enhance the growth character and yield parameters of potato.

The present investigation revealed that mulching in potato had significant response on growth, yield, quality and profitability. Among the different mulches were tested woven mulch showed overall excellent performance with respect to growth, yield and quality of potato with compared to other mulches.

100% N.P.K. with woven mulch was most suitable the fertilizer dose and mulch application solely as well as jointly influence potato yield and quality

100% N.P.K. with woven mulch accrued maximum benefit cost ratio, gross returns, net returns and net returns per rupee invested.

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| FiM1 | Paddy Straw | 5.67 | 5.01 | 5.42 | 16.10 | 6.41 | 22.51 |
| FiM2 | Black Polythene | 5.42 | 3.30 | 5.25 | 13.97 | 9.01 | 22.98 |
| FiM3 | Woven Mulch | 5.48 | 4.19 | 5.80 | 15.47 | 8.41 | 23.88 |
| FiM4 | Silver Mulch | 5.44 | 4.79 | 4.85 | 15.08 | 7.18 | 22.25 |
| FiM5 | No Mulch | 4.78 | 5.18 | 5.49 | 15.45 | 6.99 | 22.45 |
| FiM6 | Paddy Straw | 4.56 | 6.37 | 4.76 | 16.69 | 6.77 | 23.46 |
| FiM7 | Black Polythene | 4.89 | 6.25 | 6.94 | 17.63 | 7.53 | 25.60 |
| FiM8 | Woven Mulch | 5.45 | 7.17 | 8.71 | 20.79 | 6.77 | 28.10 |
| FiM9 | Silver Mulch | 5.76 | 7.25 | 5.60 | 18.61 | 6.09 | 24.69 |

CD(P=0.05) NS NS NS NS NS NS

Conclusion

- 100 % RDF application is appropraiate as compare to the reduced application of RDF up to 75% the higher levels of fertilizer can enhance the growth character and yield parameters of potato.

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