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RESEARCH ARTICLE

EFFECT OF DIFFERENT PLANT EXTRACTS ON SPROUTING, STORABILITY AND POST-HARVEST LOSS OF POTATO IN BAGLUNG DISTRICT, NEPAL

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ABSTRACT

An experiment was conducted to investigate the effect of different plant extracts on sprouting, storability and post-harvest loss of potato at ambient condition in Baglung district, Nepal. The parameters observed were sprouting percentage, sprout number, sprout length, sprout mass, weight loss percentage and damage score. The experiment consists of ten different treatments namely; *Zingiber officinale* rhizome, *Azadirachta indica* leaves, *Atimisia* spp. leaves, *Utica dioica* leaves, Control, *Acorus calamus* rhizome, *Brassica campestris* oil, *Cymbopogon* spp. oil, *Azadirachta indica* oil and *Mentha* spp. oil. The experiment was conducted in a Completely Randomized Design with four replications. *Cympopogan* oil, *Mentha* oil and *Acorus* powder completely suppressed the sprouting until 60 days with *Cympopogan* oil being the most effective to suppress sprouting throughout the experiment. The highest sprout number was recorded from *Mentha* oil (1.92) and control (1.79) after 90 days. The lowest sprout number was recorded from *Cymbopogon* oil (0.38). The average sprout length of *Mentha* spp. oil (13.47 mm) and control (13.19 mm) was maximum with minimum being that of *Cymbopogon* oil (2.5 mm) and *Acorus* (5.63 mm). The sprout mass measured at the end was maximum in control (2 gm) and minimum in *Cymbopogon* oil (0.25 gm). The weight loss percentage was maximum in control (10.66 %) with minimum in *Cymbopogon* oil (6.8 %). The tubers treated with *Brassica campestris* oil were damage to least (1.46) and highest damage score was recorded from control (1.88). A strong correlation was obtained between weight loss and sprout length (r=0.85), sprout number (r=0.78) and sprout mass (r=0.70).

KEYWORDS

Cymbopogon, weight loss, sprouting, maximum, minimum.

1. INTRODUCTION

Potato is one of the most important crops in Nepal. The total area of potato production is 1,85,879 hectare and total production is 25,91,686 mt ton with the productivity of 13.94 ton/ha (ABPSD, 2017). It occupies the fifth position in area coverage, second in total production and first in productivity among the food crops grown in Nepal (ABPSD, 2017). It is used as a major vegetable in terai and mid hills and as a staple food in high hills of Nepal (NPRP, 2011). Baglung district accounts for 1.61 % of national potato producing area and 1.37 % of National production; yet it's productivity (11.86 mt/ha) is below national average (14.03 mt/ha) (ABPSD, 2017). Further farmers often face disease infestation, weight loss, shrinkage, sprouting during storage which impede their earning.

Post-harvest loss refers to any change in the commodity after harvest that hinders its normal consumption. Potato have a higher water content as compared to grains, so its long-term storage is difficult (Ishwori, 2016). Even in cold storage a loss of 8-10 % is incurred during the storage period of 7-8 months (Ishwori, 2016). A year-round supply of potatoes is made possible by storage where sprouting is suppressed and damage is minimized either by cooling, refrigeration or by using sprout suppressant (Pinhero and Yada, 2016). Post-harvest technology of potatoes helps to ensure quality of potatoes, checking its loss and fulfilling the year-round demand of processing and consumption market. The main objectives of potato storage is to save both quality and quantity of potatoes (NPRP, 2004). The main factors affecting potato storage are temperature, ventilation, relative humidity, diffused light, cultivation techniques, post-harvest handling, curing, grading, packing and insect pest during storage (Bhattarai, 2018). Losses during post-harvest storage of potato range from 15-20% (Blenkinsop et al., 2003).

Low temperature storage of potato causes undesirable sweetening in tubers due to the conversion of starch into sugar. This high level of reducing sugar causes undesirable browning during frying operation (Blenkinsop et al., 2003). This is known as maillard reaction which is the reaction between amino acids and reducing sugar during frying resulting

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browning (Pinhero and Yada, 2016). These darkened fries or chips contains high amount of acrylamide which is linked to many different cancer (Chuda et al., 2003). Similarly, chemical sprout suppressant like CIPC effectively suppress the sprouting during storage thereby reducing postharvest loss but its residue which is left in the treated tuber is harmful for human body (Aml et al., 2014). NPRP, 2074 recommend the best temperature for long term storage of seed potato is 2 - 4°C, for fresh consumption 4 - 5°C, for chips making 7 - 10°C and for frying 5 - 8°C. Due to insufficient cold store, maintaining such temperature is not feasible for Nepal (Sharma et al., 2016). Due to insufficient cold storage and harmful effect in use of chemical suppressant, there is a need of storing potatoes at ambient temperature using different plant extracts.

Commonly available methods of potato storage like cold storage and chemical treatment have their own drawbacks. With these drawbacks, researchers are interested toward other alternatives like herbs/shrubs, their essential oils (Song et al., 2008). In past times, many plant extracts and volatile oils were tested for their efficacy in potato sprout suppression and postharvest life and were effective to many extents (Song et al., 2008; Elsadr and Waterer, 2005; Tartoura et al., 2015). Potato is one of the main cash earning crop of this place. A number of people are involved in potato production. Farmers in this place are following traditional storage methods and modern storage methods are not suitable for them. So, an investigation is needed to solve their problem of storage at their level, using the products available locally/easily which raise their income and don't hamper potato quality and their health. This study aims to evaluate the efficacy of different plant extracts on suppressing undesirable sprouting and damage during the storage of potatoes.

2. Materials and Methods

The experiment entitled "Effect of different plant extract on Sprouting, Storability and post-harvest loss of Potato in Baglung district, Nepal" was conducted under rudimentary conditions which portrays the real storage condition of the farmers in Bodygad Rural Municipality, ward no 5, Khaular Bajar, Baglung, Nepal at 28°15' N latitude and 83°11' E longitude and 750 meter above sea level (masl). The variety used in the study was '*Kufri Sindhuri'*. The freshly harvested potatoes were sorted out and healthy tuber of medium sized with no external sign of disease and damage were selected for the study. Harvesting was done on Feb 22th 2019 and cured for about 10 days on the wooden floor. Six potatoes were used per treatment for study. The tubers were placed in a plastic containers and precaution was taken to facilitate the gas exchange in and out of container. The experiment was carried out in Completely Randomized Design (CRD) with ten treatments replicated four times.

Table 1: Applied treatments, their common names and abbreviation

Treatments (Scientific names)	Common name	Abbreviation
Zingiber officinale rhizome powder	Ginger	T1
Azadirachta indica leaves powder	Neem	T2
Artemisia spp. Leaves powder	Mugwort (Titepati)	T3
Utrica dioica leaves powder	Nettle (Sisnu)	T4
Control	Local/control	T5
Acoros calamus rhizome powder	Sweet flag (Bojho)	T6
Brassica campestris oil	Mustard (Tori)	T7
Cymbopogon spp. oil	Lemongrass	T8
Azadirachta indica oil	Neem	T9
Mentha spp. oil	Mint	T10

The grounded leaves and bulbs of different treatments were spread uniformly over the tubers at a dose of 1 gm/6 tubers. The essential oils were applied as wick application methods by placing a blotting paper saturated with essential oil at a dose of 1ml/6 tubers. These treatments dose were based on the previous study (Elsadr and Waterer, 2005). The application method of the essential oils were based on the previous study (Frazier et al., 2004). Precaution were taken to avoid the direct contact of oil with the tubers. These amounts were in excess of the amount theoretically sufficient to saturate the atmosphere in the container. The study lasted for 100 days starting from harvesting at 22th February to final reading at 3rd June. The parameters observed were sprouting percentage, weight loss percentage, damage score, length of sprout, number of sprout and sprout mass. The observation was taken after 60 days and then at 15 days interval with 3 observation at total. The data obtained were analyzed using MS-excel and R-studio.

3. Result and Discussion

3.1 Weight loss percentage

The weight loss percentage recorded in different treatments over three different period is presented in Table 1. After 60 days of experiment, the highest weight loss was recorded from control (3.9%) and *Azadirachta indica* oil (3.8%). The lowest weight loss was recorded from *Acoros calamus* (3.2%) followed by *Cymbopogon* (3.3%) and *Mentha* oil (3.3%). At the end of the experiment, highest weight loss was recorded from control (8.5 %) and *Mentha* oil (8.3%) with lowest being that of *Cymbopogon* oil (5.6 %).

Tartoura, Gamily, Shall & El-Sharqawy, 2015 also recorded maximum weight loss in control followed by *Azadirachta indica* extract in potato in an experiment of using medicinal and aromatic plant extracts on potato at ambient temperature. Sprouting occurs in tubers in expense of the tuber content i.e. its weight. The varying weight losses of tuber in different treatments can be accounted for their relative efficacy in suppressing the sprout growth. Thus, tubers maximum sprout growth (numbers, mass, length) loses more weight than tubers with low sprout growth.

Table 2: Effect of different treatments on weight loss percentage of potato in Baglung district

Treatments	Weight loss percentage after		
	60 days	75 days	90 days
Gingiber officinale	3.41^{abc}	6.23^{a}	7.84^{bc}
Artimisia	3.44^{abc}	5.43^{cd}	6.38^{d}
Azadirachta indica	3.38^{bc}	5.49^{cd}	6.59^{d}
Utrica dioica	3.63^{abc}	6.13^{a}	7.92^{bc}
Acoros calamus	3.20^{c}	4.36^{e}	5.51^{e}
Brassica campestris oil	3.46^{abc}	4.96^{d}	7.61^{c}
Cymbopogon oil	3.27^{c}	4.15^{e}	5.65^{e}
Azadirachta indica oil	3.77^{ab}	6.09^{ab}	7.97^{bc}
Mentha oil	3.29^{c}	5.57^{bc}	8.28^{ab}
Control	3.88^{a}	6.35^{a}	8.47^{a}
CV, %	8.40	6.50	4.28
SEM	0.15	0.18	0.22
LSD	0.42*	0.52**	0.45**
Grand mean	3.47	5.48	7.22

Figures in the column with the same letter are not significantly different at 5% level of significance according to DMRT. CV = Coefficient of Variation, LSD = Least significant difference, and S.Em (±) = Standard error of mean difference

3.2 Sprouting percentage

The sprouting percentage recorded in different treatments over three different period is presented in Table 2. After 60 days of experiment, highest sprout percentage was recorded in control (45.75%) followed by *Utrica dioica* (41.5 %) and *Azadirachta indica* oil (41.5%). The tubers treated with *Cymbopogon*, *Mentha* and *Acoros calamus* had no sprout at all. After 75 days of experiment, *Cymbopogon* oil (8.25%) had sprouting percentage significantly lower than rest of the treatments. The highest was recorded in control (87.4%). *Cymbopogon* oil was recorded the most effective to suppress the sprouting during storage with the minimum sprouting of 13% at the end of 90 days.

Farooqi et al. also recorded the maximum sprout inhibition with lemon grass oil and minimum inhibition in control while screening volatile essential oils for sprout suppression. *Cymbopogon* essential oil consists of citral which is very effective in suppressing sprout growth [14]. Similarly,

caravon, a terpenoid is found naturally in *Mentha* essential oil which is sown to be an effective sprout suppressant in storage (Farooqi et al., 2001). *Acorus calamus* consists of monoterpene menthol is recorded to inhibit germination (Oosterhaven et al., 1995). *Mentha* essential oil cause damage to the vascular tissue causing necrosis of the emerging bud thereby inhibiting sprouting leaving black necrotic symptoms in tubers (Nawamaki and Kuroyanagi, 1996).

Surprising effect was observed with *Mentha* oil which completely inhibit sprouting till 60 days of treatment induce massive sprouting of 70.3% at the 75 days of treatment and 92 % at the end of experiment (90 days). Frazier came up with the assertion that single application of *Mentha* oil induces enhanced sprouting after certain duration of sprout inhibition thereby signifying the importance of repeated application.

Table 3: Effect of different treatments on Sprouting percentage of potato in Baglung district

Treatments	Sprouting percentage after		
	60 days	75 days	90 days
Gingiber officinale	0.29^{b}	0.58^{cd}	1.00^{a}
Artimisia	0.29^{b}	0.46^{de}	1.00^{a}
Azadirachta indica	0.25^{b}	0.62^{bc}	1.00^{a}
Utrica dioica	0.42^{a}	0.58^{cd}	1.00^{a}
Acoros calamus	0.00^{c}	0.37^{e}	0.84^{b}
Brassica campestris oil	0.29^{b}	0.42^{e}	1.00^{a}
Cymbopogon oil	0.00^{c}	0.08^{f}	0.13^{c}
Azadirachta indica oil	0.42^{a}	0.75^{ab}	1.00^{a}
Mentha oil	0.00^{c}	0.70^{bc}	0.92^{ab}
Control	0.46^{a}	0.88^{a}	1.00^{a}
CV, %	30.9	18.3	10.6
SEM	0.03	0.04	0.04
LSD	0.11**	0.15**	0.14**
Grand mean	0.24	0.54	0.89

Figures in the column with the same letter are not significantly different at 5% level of significance according to DMRT. CV = Coefficient of Variation, LSD = Least significant difference, and S.Em (±) = Standard error of mean difference

3.3 Sprout number

The effect of different treatments on the sprout number of tubers is shown in table no 3. *Cymbopogon* oil, *Mentha* oil and Acorus powder had zero sprout till 60 days of experiment. The control had the highest sprout number (0.46). Maximum sprout number was recorded again from control (1.04) at 75 days of experiment followed by *Mentha* oil (1.0). *Mentha* oil (1.1.92) was recorded with highest sprout number at the end of experiment followed by control (1.79).

Enhanced sprout number in *Mentha* oil treated tuber must be due to the reduced inhibitory effect of *Mentha* oil with time that induces axillary bud to sprout with reduced apical dominance (Nawamaki and Kuroyanagi, 1996). Further, longer sprout suppression by *Mentha* oil requires the need of repeated application, single application of which causes enhanced sprouting (Bamnolker et al., 2010; Evenari, 1949; Pryor et al., 1940; Joshi and Bashyal, 2019). Thus, this unusual increased sprout number due to *Mentha* oil application is due to the single application of treatment which enhance sprouting with reduced apical dominance that causes axillary bud to sprout.

Table 4: Effect of different treatments on Sprout number of potato in Baglung district June 2019

Treatments	Sprout number after		
	60 days	75 days	90 days
Gingiber officinale	0.33^{bc}	0.75^{bcd}	1.42^{bcd}
Artimisia	0.29^{c}	0.63^{cd}	1.13^{d}
Azadirachta indica	0.29^{c}	0.63^{cd}	1.33^{cd}
Utrica dioica	0.42^{ab}	0.68^{cd}	1.38^{bcd}
Acoros calamus	0.00^{d}	0.54^{d}	1.08^{d}
Brassica campestris oil	0.38^{abc}	0.75^{bcd}	1.46^{bcd}
Cymbopogon oil	0.00^{d}	0.21^{e}	0.38^{e}
Azadirachta indica oil	0.42^{ab}	0.83^{abc}	1.63^{abc}
Mentha oil	0.00^{d}	1.00^{ab}	1.92^{a}
Control	0.46^{a}	1.04^{a}	1.79^{ab}
CV, %	26.3	23.6	20.1
SEM	0.03	0.04	0.08
LSD	0.10**	0.24**	0.39**
Grand mean	0.26	0.71	1.35

Figures in the column with the same letter are not significantly different at 5% level of significance according to DMRT. CV = Coefficient of Variation, LSD = Least significant difference, and S.Em (±) = Standard error of mean difference

3.4 Average Sprout length

The average sprout length recorded in different treatments over three different period is presented in Table 4. After 60 days of treatment, the longest sprout length was recorded in the *Azadirachta indica* oil while the tubers treated with *Cymbopogon*, *Mentha* and *Acoros calamus* had zero sprout i.e. zero length. After 75 days of treatment, *Azadirachta indica* oil had the longest sprout length (7.864) which was significantly at par with control (7.824). The lowest sprout length was recorded from *Cymbopogon* (1.536) and *Acoros calamus* (3.008). At the end of the experiment (90 days after treatments) the longest sprout length was recorded from *Mentha* oil (13.47), control (13.19) and *Azadirachta indica* oil (13.29). The lowest sprout length was recorded from *Cymbopogon* (2.5) followed by *Acoros calamus* (5.63).

The abrupt rise in sprout length of tuber treated with *Mentha* oil can be due to decrease in its effect with concentration over time. Complete inhibition of sprout by *Mentha* oil is followed by stimulation of germination with reduced concentration. Inhibition of germination is followed by stimulation of germination; sometimes they appear in different concentration and sometimes inhibition is followed by stimulus with decrease in concentration over time. The enhanced length of sprout due to *Mentha* oil can be explained from this implication.

Table 5: Effect of different treatments on average sprout length of potato in Baglung district

Treatments	Average sprout length after		
	60 days	75 days	90 days
Gingiber officinale	1.46^{b}	6.71^{ab}	10.60^{b}
Artimisia	1.59^{ab}	6.05^{b}	10.50^{b}
Azadirachta indica	1.76^{ab}	6.75^{ab}	10.29^{b}
Utrica dioica	1.63^{ab}	6.20^{ab}	11.58^{ab}
Acoros calamus	0.00^{c}	3.01^{c}	5.63^{c}
Brassica campestris oil	1.46^{b}	6.78^{ab}	12.39^{ab}
Cymbopogon oil	0.00^{c}	1.54^{c}	2.50^{d}
Azadirachta indica oil	2.04^{a}	7.86^{a}	13.29^{a}
Mentha oil	0.00^{c}	7.52^{ab}	13.47^{a}
Control	1.75^{ab}	7.82^{ab}	13.19^{a}
CV, %	21.5	18.1	16.0
SEM	0.13	0.353	0.59
LSD	0.36**	1.58**	2.38**
Grand mean	1.17	6.02	10.3

Figures in the column with the same letter are not significantly different at 5% level of significance according to DMRT. CV = Coefficient of Variation, LSD = Least significant difference, and S.Em (±) = Standard error of mean difference

3.5 Sprout mass

The Sprout mass recorded at the end of the experiment is presented in Table 5. The lower sprout mass was recorded from tubers treated with *Cymbopogon* oil (0.25 gm). The highest being that of control (2 gm). Higher the growth of sprout higher will be its mass; the lower sprout mass from *Cymbopogon* oil is due to lower sprouting (13%) and lower sprout number (0.38).

Table 6: Effect of different treatments on sprout mass of potato in Baglung district

Treatments	Sprout mass at the end
Gingiber officinale	1.50^{ab}
Artimisia	1.25^{ab}
Azadirachta indica	1.25^{ab}
Utrica dioica	1.50^{ab}
Acoros calamus	1.00^{b}
Brassica campestris oil	1.50^{ab}
Cymbopogon oil	0.25^{c}
Azadirachta indica oil	1.75^{ab}
Mentha oil	1.75^{ab}
Control	2.00^{a}
CV, %	34.5
SEM	0.10
LSD	0.69**
Grand mean	1.38

Figures in the column with the same letter are not significantly different at 5% level of significance according to DMRT. CV = Coefficient of Variation, LSD = Least significant difference, and S.Em (±) = Standard error of mean difference

3.6 Damage score

The damage score recorded in different treatments over three different period is presented in Table 6. The damage score of tubers for different treatment was found not significant at 60 days of treatments; It ranged from 1.42 – 1.13. After 75 days of treatments, the damage score was higher in control (1.58). The lowest damage score was obtained from *Brassica campestris* oil (1.29) and *Acorus calamus* (1.29). At the end of the experiment, the damage was higher in the control (1.88) with lowest being that of *Brassica campestris* oil (1.46). This might be due to the peculiar constituent of *Brassica campestris* oil that keeps pests and other damaging agent away from it. The *Brassica campestris* oil and its vapor are highly toxic to different fungi in lower concentration of 10 ppm. Further, *Acorus calamus* is well known for having antibacterial property. The essential oil from dry powder of *Acorus calamus* is showed to have a good potentiality for acting as an antibacterial agent. The least damage score due to *Brassica campestris* oil and *Acorus calamus* can be understood by the points above.

Table 7: Effect of different treatments damage score of potato in Baglung district June 2019.

Treatments	Damage score after		
	60 days	75 days	90 days
Gingiber officinale	1.21	1.42^{bc}	1.75^{ab}
Artimisia	1.21	1.38^{bc}	1.67^{abc}
Azadirachta indica	1.21	1.38^{bc}	1.58^{bc}
Utrica dioica	1.33	1.46^{ab}	1.75^{ab}
Acoros calamus	1.21	1.29^{c}	1.58^{bc}
Brassica campestris oil	1.13	1.29^{c}	1.46^{c}
Cymbopogon oil	1.17	1.38^{bc}	1.58^{bc}
Azadirachta indica oil	1.21	1.38^{bc}	1.75^{ab}
Mentha oil	1.167	1.38^{bc}	1.71^{ab}
Control	1.42	1.58^{a}	1.88^{a}
CV, %	10.4	6 .92	8.59
SEM	0.02	0.02	0.03
LSD	0.18^{NS}	0.14*	0.21*
Grand mean	1.23	1.39	1.67

Figures in the column with the same letter are not significantly different at 5% level of significance according to DMRT. CV = Coefficient of Variation, LSD = Least significant difference, and S.Em (±) = Standard error of mean

3.7 Correlation between weight loss and sprout growth

The correlation between weight loss and sprout growth parameters viz; sprout number, sprout length and sprout mass are shown in table 7. A significant correlation (P<0.01) is found between weight loss and all parameters of sprout growth. Strong correlation was found between weight loss and sprout length (r = 0.85**) which signifies tuber with longer sprout length lose weight faster than that of small length tuber. Similarly, strong correlation was found between weight loss and sprout number (r = 0.78**) which signifies, tuber with higher sprout number lose weight faster than that of tubers with lower sprout number. And, a strong correlation of weight loss and mass of sprout (r = 70**) signifies, sprout grows in expense of tuber mass.

Table 8: Correlation matrix between weight loss, sprout length, sprout number and sprout mass.

	Weight loss	Sprout length	Sprout number	Sprout mass
Weight loss	1			
Sprout length	0.85**	1		
Sprout number	0.78**	0.90**	1	
Sprout mass	0.70**	0.75**	0.73**	1

*** correlation coefficient is significant at 0.01 probability level*

4. Conclusion

It can be concluded that wick application of *Cymbopogon* oil significantly decreases the sprouting percentage, sprout number, length of sprout and weight loss during storage. The use of *Brassica campestris* oil can decrease the damage of tubers during storage. *Acorus calamus* can be used successfully for short term preservation that check sprouting and hence weight loss and damage to tubers. *Mentha* oil can be used as a good sprout suppressant but it needs repeated application for its efficacy. Locally found natural compounds like *Acorus calamus*, *Artimisia spp.*, *Symbopogon spp.*, *Azadirachta indica* etc. can be used as additives during potato storage to check undesirable sprouting and loses. Use of such natural herbs during storage can significantly decrease the post-harvest loss during storage.

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Authors Contributions

Ananta Prakash Subedi supervised the experiment. Kushal Giri conducted the experiment and recorded data, analyzed and created the final manuscript. Suraj Gurung, Sujan Pokharel and Rupak Karn helped during data observation and manuscript preparation.

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