Management of Late Blight of Potato by Non-Chemical Methods at Gokuleshwor, Baitadi

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Abstract- A field experiment for the management of late blight of potato by non- chemical method was conducted at Horticulture plot of Gokuleshor Agriculture and Animal Science College (GAASC) located in western hills of Baitadi district of Nepal during winter season of 2017. Field experiment was layed out in one factor RCBD which was replicated three times. Efficacy of 7 non chemical treatments was tested in Potato variety Desiree. The soil of experimental site was sandy loam with pH 5.93. The soil was medium in organic matter content and total nitrogen, high in available phosphorus and medium in available potassium. The disease severity was maximum in Panchagavya (36.00), while disease severity (22.67)was found less in timur applied plot (Xanthoxylum aromatum) during first data recording. But in second data recording was maximum disease severity (30.67) was recorded in no treatment applied plot , and minimum disease severity (22.66) was recorded in copper colloide applied plot. Similar result was also recorded in third. disease .severity i.e maximum value (44.00) in treatment applied plot and minimum value (6.66) in panchagavya applied plot. Mean AUDPC value was maximum in no treatment applied plot (175.00) while minimum value (102.67) was recorded in copper collide applied. 25 ppm a concentration of copper colloide gave best result against late blight and 1:5 (one part Panchagavya and 5 part Water) ratio gave higher economic yield as well as test weight Thus the optimum dose of copper colloide and panchagavya results low disease severity and higher yield in potato under hilly region of Baitadi district.

Index Terms- AGDP,ANOVA,AUDPC,CV

I. INTRODUCTION

Potato (*Solanum tuberosum* L.) has been regarded as one of the most important staple food and a major vegetable crops contribute to the total world food crop basket that feed more than 1 billion of the world population, with Asia and Europe as largest consumption region (FAOSTATA 2016) . About 50% of the potato grown in the world is produce and consumed in Asian region (FAOSTATA, 2016).It is the fourth leading crop of Nepal contributing nearly 5% of agriculture GDP (MoAD, 2014).Potato is grown in about 6.37% (193037 ha) of total cultivated area across diverse geographic regions ranging from the lowland-Terai (<100masl) to high hills (4000masl) with production of 2586287mt.,with the average yield of 13126 kg/ha (MoAD, 2016) whereas in Baitadi district potato is grown in 450 ha and with total production of 4500 mt and yield of 1000kg/ha (MoAD, 2015). There is a continue increasing global demand of potato which is expected to reach 341 million tons and in order to produce 80 million tons of more potato to fill this deficit, there is a need to enhance the productivity of potato from 7.62 to 17.8 tons/ha. Potato is the third most human- consumed crop (after rice and wheat). The main diseases that impaired production are Late blight, Bacterial wilt, Brown spot ,Early blight, Wart etc. However, in hilly region of Nepal despite of difficult topographical features, late blight is major problem faced by Neplease hilly farmers.

Late blight caused by *Phytophthora infestans* is an oomycetes that cause the serious potato disease known as Late blight or potato blight. It is a major fungal diseases of potato, because of its wide distribution and destructiveness under favourable condition (Shrestha and Kharel, 1996). Depending on the cultivar susceptibility, environmental condition and management system, it causes yield loss upto more than 755 at high hills (Shrestha and Kharel 1996) and in terai losses have been recorded 50 to90 % in same year. This diseases has caused significant yield losses in different potato growing countries, eg. 38 to 65% in India (Rao and Veeresh, 1989) (Bisht et al., 1997), 22.8% losses in Poland (Pietkiewicz, 1991), 6 to 40% losses in Romania (Cupsa et al., 1983), 25 to 75%losses in Cameroon (Fontem and Aighewi, 1993).The disease first recorded in Nepal was between 1983 and 1987 (Shrestha , 1998) and has been appearing in epidemic proportions since mid 1990s.In the mid hill valley like Kathmandu and Pahchkhal where potato are grown twice a year autumn ans spring season, late blight become severe. It is prevalent throughout the potato growing area in the country. In Nepal, the disease causes the 15 to 20% yield reduction in susceptible varieties, but in the severe case, it goes upto 90% (Shrestha, 2000).

The disease can managed by planting resistant cultivars, application of fungicides, and manipulation of planting time, organic fertilizers, Farmer field school and irrigations (Sharma and Dhital, 2007).Late blight is a very difficult diseases to manage organically . Non-chemical diseases management is one of the most important practices for high production system in long run, but non-chemical diseases management may show slow response to potato pathogen, pest, as well as development pattern of pathogen population due to change of environment. Non-chemical diseases management is an essential component of organic farming and IPM, which includes management of

diseases without the use of pesticides and other artificial chemicals and with use of relating to or derived from living matter. Panchagavya, an organic product has the potential to play the role of promoting growth and providing immunity in plant system. Panchagavya consists of nine products viz, cow dung, cow urine, milk, curd, jiggery, ghee, banana, tender coconut and water, when suitably mixed and use these have miraculous effects. Neem (*Azadirachta indica)* leaf extract accts as a potential source for the management of severe diseases in addition to its positive effect on growth parameter (Chaturbedi et al., 2003). Asuro (*Adhatoda vasica)* leaf extract containing vasicine acetate and other chemical showed moderate anti pathogenic activity(R.Wise, 2008). Timur (*Zanthoxylum alatum)* fresh leaf containing essential oil and linalool, 2-decanone, sabinene exhibited potent antifungal activity (J.K and Hollomon, 1998). Sisnu (*Urtica dioica)* leaf extract containing several chemicals viz, acetylcholine, histamine, moroidin, formic acid etc shows anti pathogenic activity(Micheal.I and Greenberg, 2003). Copper colloide which is toxic to fungi and bacteria because of their ability to destroy protein in plant tissue (NASA). Bakino (*Melia azedarch)* leaf extract containing tetranortriterpenoids constitute an important toxic principle to pathogen(Baza Mendonca and dos Anjos, 2005). These seven product are essential to increase yield and management of late blight of potato, but severity of late blight increasing with low and excess use of these product. Among several factors of management of late blight these seven non-chemical product plays a key role. So, optimum use of these non-chemical product should be applied in appropriate time with good agriculture practices.

Hilly region of Baitadi district is quite backward in use of new technology. Many people use traditional methods in agriculture. A major fungal diseases late blight of potato emerge due to many reasons such as susceptible varieties, faulty agricultural practices and biotechnological methods and lack of use of fungicides. Mostly problem exist in these area is due to lack of fungicides, resistant varieties and occurrence of drought condition. People here are unknown about the proper information about new advanced technology, many are unknown about importance and use of non- chemical methods to control late blight of potato. People still give emphasis on local varieties which are susceptible to late blight.

Use of resistant varieties, organic fungicides and improved agricultural practices and biotechnological methods can reduce the effect of late blight which lead to more productivity. However, the use of resistant varieties and organic fungicides is most economical and environmental friendly method for the management of late blight but the resistance and organic fungicide is subject to breakdown due to appearance of new/more virulent race of the pathogen.

The productivity of potato in Baitadi district is 10000 kg/ha which is low as compared to national productivity 13125kg/ha (MoAD, 2016). Since food security and health is an important role of agricultural research in Gokuleshwor at present. People with large area also have to starve from potato, they have to depend on other cereal and vegetable such as rice, wheat, cabbage and leafy vegetables for sustenance, while people of poor economic background have to completely dependent on import market. Many people left to plant potato due to lack of planting materials, other inputs and low productivity. Late blight is major problem roaming in Baitadi district for low production. So, through this research, how non-chemical method can be capable to reduce late blight and at what proportion can imparted to local people. As a use of different proportion of non-chemical products can easily boost potato yield. If applied correctly allows better plant compensation and tolerance to injury. Panchagavya, Neem, Bakino, Sisnu, Asuro, Timur, copper collide also can help in fast germination, growth, diseases resistance and allows faster recovery of injury or stress plants. It favors vegetative growth and increases the size and weight of the tuber. While it also renders resistance to late blight of potato also. So people can understand the importance of non-chemical products and its impact on low and high proportions. By optimum use of non-chemical products in required time people can enhance the productivity of potato.

II. MATERIALS AND METHODS

It covers the description about the site, layout and design of the experiment along with the description of the test crop, land preparation, sowing, cultural practices, preparation of non-chemical pesticides, application, sampling, data recording, harvesting and methods of statistical analysis. The experiment was conducted at the pathology farm of Gokuleshwor Agriculture and Animal Science College (GAASC), Baitadi to study the management of late blight of potato by non-chemical methods in Desiree

3.1 Description of the field experiments

3.1.1 Experimental site

The experiment was carried out at the Gokuleshwor Agriculture and Animal Science college (GAASC), College field , Gokuleshwor , Baitadi. The elevation of the site i.e Gokuleshwor is at 700 masl with 24˚75'N Latitude and 90˚50'E longitude.

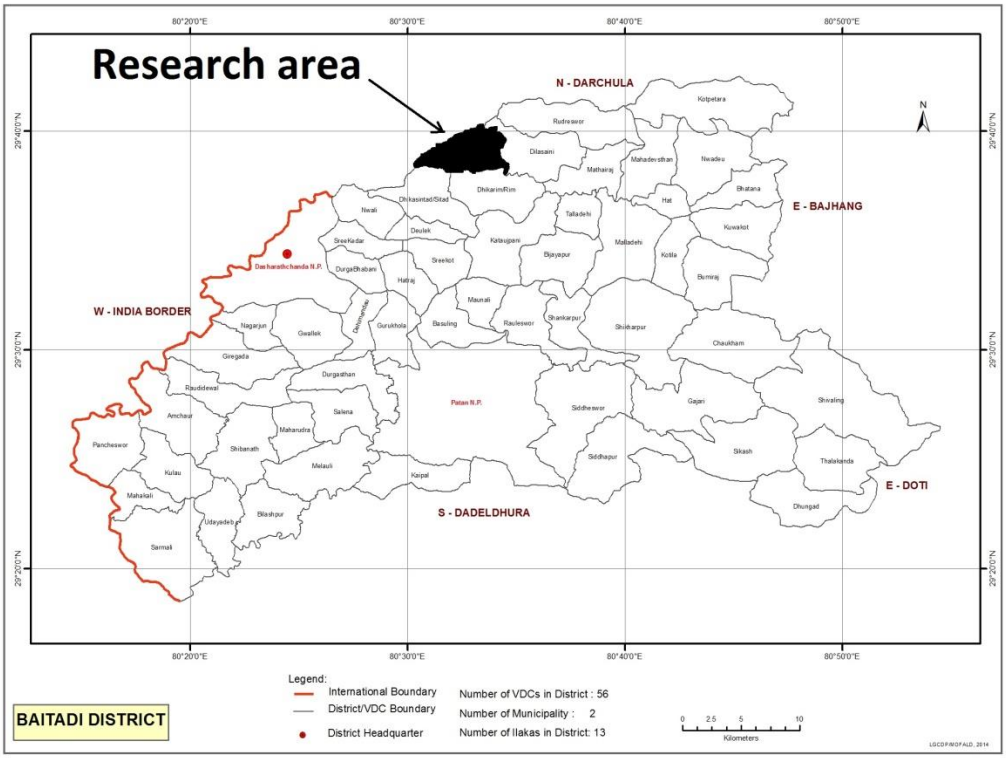

Figure 2. Map showing research station (Gokuleshwor) of the Baitadi district

Table 1. Physiochemical properties of the soil of the experimental site of GAASC, Baitadi.

Properties	Average content	Scale
Physical properties		
Sand(%)	30	
Slit(%)	40	
Clay (%)	20	
Chemical properties		
Soil pH	5.93	Slightly acidic
Soil organic matters (%)	3.2	Medium
Total nitrogen(%)	0.17	Medium
Available phosphorus (Kg/ha)	74.23	Medium
Available potassium (Kg/ha)	79.2	High
Texture /Rating	Slit loam	

3.1.2 Climatic condition during experimentation

The experimental site lies in the subtropical humid climate belt of Nepal. The area has sub-humid types of weather condition with cool winter, hot summer and distinct rainy season with annual rainfall of about 1919.5mm. It is characterized by three distinct seasons : rainy season (June to October), cool winter (November to February) and hot spring (March to May). The metrological data from cropping season was recorded from Mukteshwar kumaon weather station and presented Figure 3.

The total rainfall of 170mm was received during the entire period of experimentation. The highest rainfall was recorded during Falgun (50 mm) and lowest during Poush (20 mm) .

The minimum temperature during the experimental period ranged from 1.1˚c to 16.66˚c with average of 8.4˚c. The maximum temperature during the experimental period ranged from 11.6˚c to 21.5˚c.

3.1.3 Experimental details

3.1.3.1 Field layout

The experiment was laid out in single factor randomized complete block design with 3 replications having 8 treatments . The variety Desiree medium duration (80-90 days), generally late blight susceptible ,drought resistance and high yielding was selected. The size of individual plot was 4.8m*4m (19.2 sq.m). There was a bund of 0.5m between two experimental plot. The crop geometry of potato was maintained at 60*40cm (Row-Row and Plant-Plant spacing) with one-two potato tuber per hill with 8 rows and 10 plants per row. The all row are treated as net plot rows for harvesting and diseases scoring observations.

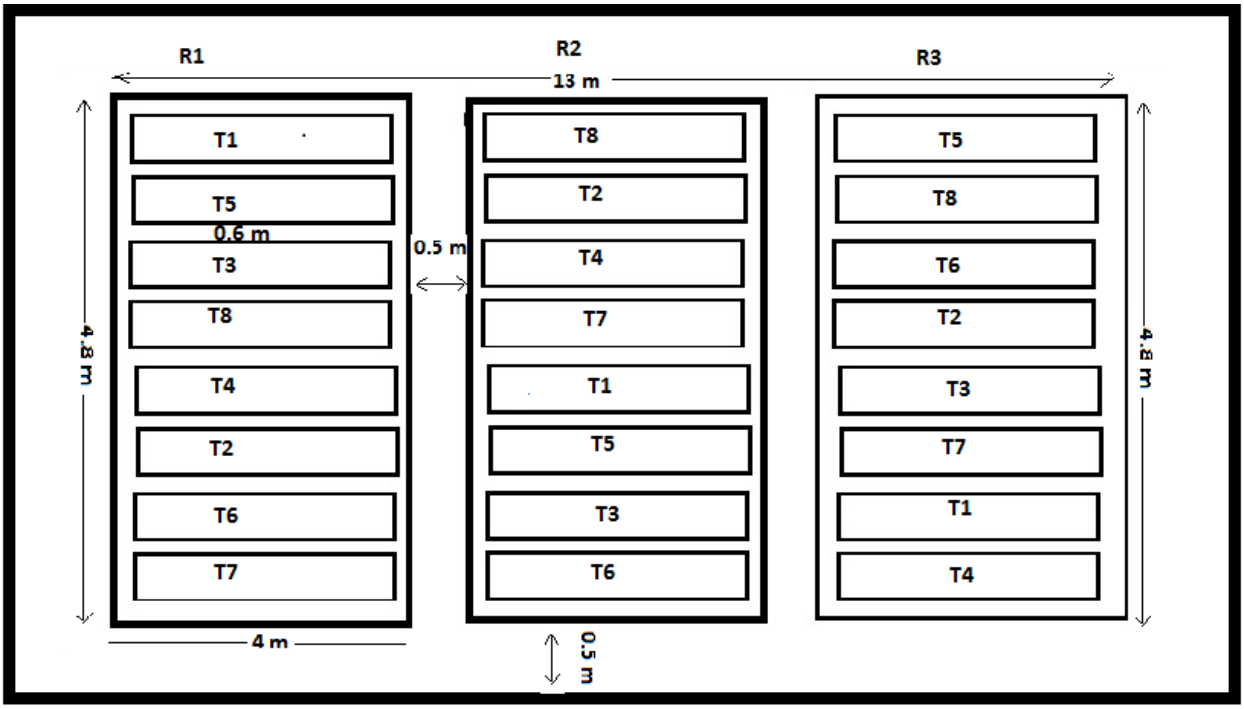

Figure-4. Layout of the experimental field at Gokulkeshwor, Baitadi , Nepal.

3.1.3.2 Treatment details

The details of the treatments are given as follows:

S.N	Treatments
T1	Panchagavya
T2	Sisnu
T3	Neem
T4	Timore
T5	Bakino
T6	Copper colloid
T7	Asuro
T8	Control

3.1.3.3 Design of the experiment

The layout of the research plot was as follows:

Each plot= 19.2sq.m

Distance between each plot =0.5m

Net plot area=19.2*3=57.6sq.m

3.1.4 Cultivation practices

Date wise detail of various cultural practices recorded for potato tuber sowing to the harvesting is presented here under.

3.1.4.1 land preparation

The experimental plots were prepared after manual digging 2-3 times and weeds were removed. Ridge and furrow were constructed.

3.1.4.2 Selection of tuber

Tuber of Desiree variety of potato were selected which were medium in shape, diseases free, well budded, and injury free.

3.1.4.3 Sowing of tuber

Three plot of 4m*4.8m were prepared for raising of potato plant. Potato tuber were sown on 4th puosh, 2073 with the seed rate of 90kg/ha by ridge and furrow method. Sprouted tuber of approximately similar physiological were planted at 5-6cm depth in ridge and furrow.

3.1.4.4 Preparation of non -chemical pesticides

We prepared 7 types of non- chemical pesticides which includes ; Panchagavya, sisnu, bakino, neem, asuro, copper collide, timore. Procedure for preparation of these non-chemical pesticide were as follows-

3.1.4.4.1 Panchagavya preparation and application

It uses only organic product and can be made at home. In cities through, the ingredients may prove a little difficult to find. The five or Pancha ingredients of Panchagavya are cow urine, fresh cow dung, cow milk, cow curd and cow ghee. To eliminate foul order and improve upon the initial five ingridents, others products were added. The product with their quantities and substitutes were-

Cow milk-2 liters

Cow curd-2 liters

Cow urine- 3 liters

Cow ghee-0.5 kg

Fresh cow dung-5 kg

Sugarcane juice-3kg (Substitute 500 gm of jaggery in 3 liters of water

Tender coconut water-3 liters

Banana ripe-12 numbers

Toddy or grape juice 2 liters (Substitute 100 gm of yeast powder).

Method of preparation

Panchagavya was prepared in a wide mouth container made of mud, concrete or plastic. The first step was to mix fresh cow dung and ghee in the container. We mixed it twice a day for three days. On the fourth day, we added the remaining ingredients to the container . We Starred the mixture twice a day for the next fifteen days. On the 19th day, the Panchagavya mixture was ready for use.

Doses of Panchagavya

For spraying; 16.66% of solution in water i.e 1 litre of Panchagavya was mixed to every 5 litre of water for one application.

3.1.4.4.2 Bakino (*Melia azedarch)*

Diseases free, tender, green leaf were collected.3 kg laef were kept in the plastic bucket for fermentation along with 100 gm yeast powder, 1.5 litres coconut water, 12 number banana and 1 kg jiggery. Fermented leaf extract containing tetranortriterpenoids constitute an important toxic principle to pathogen. We Staired the mixture twice a day for the next 20 days. On the 20th day, the bakino mixture was ready for use .

Doses of bakino

For spraying; 16.66% of solution in water i.e 1 litre of bakino was mixed to every 6 litre of water for one application.

3.1.4.4.3 Sisnu (*Urtica dioica)*

Diseases free, tender, green leaf were collected.3 kg laef were kept in the plastic bucket for fermentation along with 100 gm yeast powder, 1.5 litres coconut water, 12 number banana and 1 kg jiggery. Fermented leaf extract containing , acetylcholine, histamine, moroidin, formic acid constitute an important toxic principle to pathogen. We Staired the mixture twice a day for the next 20 days. On the 20th day, the sisnu mixture was ready for use .

Doses of sisnu

For spraying; 16.66% of solution in water i.e 1 litre of sisnu was mixed to every 5 litre of water for one application.

3.1.4.4.4 Neem (*Azadirachta indica)*

Diseases free, tender, green leaf were collected.3 kg laef were kept in the plastic bucket for fermentation along with 100 gm yeast powder, 1.5 litres coconut water, 12 number banana and 1 kg jiggery. . Fermented leaf extract containing constitute azadirachtin, ninbolinin,nimbin, nimbidin, nimbidol, slannin and quercetin an important toxic principle to pathogen. We Staired the mixture twice a day for the next 20 days. On the 20th day, the neem mixture was ready for use**.**

Doses of neem

For spraying; 3%of solution in water i.e 180ml of neem was mixed to every 6 litre of water for one application.

3.1.4.4.5 Asuro (*Adhatoda vasica)*

Diseases free, tender, green leaf were collected.3 kg laef were kept in the plastic bucket for fermentation along with 100 gm yeast powder, 1.5 litres coconut water, 12 number banana and 1 kg jiggery. . Fermented leaf extract containing constitute vasicine acetate and other chemical an important toxic principle to pathogen. We Staired the mixture twice a day for the next 20 days. On the 20th day, the asuro mixture was ready for use .

Doses of asuro

For spraying; 16.66%of solution in water i.e 1 litre of asuro was mixed to every 5 litre of water for one application.

3.1.4.4.6 Timur (*Zanthoxylum alatum)*

Diseases free, tender, green leaf were collected.3 kg laef were kept in the plastic bucket for fermentation along with 100 gm yeast powder, 1.5 litres coconut water, 12 number banana and 1 kg jiggery. . Fermented leaf extract containing constitute essential oil and linalool, 2-decanone, sabinene an important toxic principle to pathogen. We Staired the mixture twice a day for the next 20 days. On the 20th day, the timore mixture was ready for use .

Doses of timore

For spraying; 16.66%of solution in water i.e 1 litre of timore was mixed to every 5 litre of water for one application.

3.1.4.4.7 Copper colloide

Copper ion was separated from the copper rod in distill water through the passing of current from battery of 1.5 volt (6 battery were used). In 24 hours, 25ppm ion was separated ,producing slightly blue color in distill water.

Doses of copper collide

For spraying 5 litre of solution which have 25 ppm copper ion concentration relevant for one time use.

3.1.4.4.8 Control factor

Pure distill water was used for the maintaining the similar environment as other treatments and removed biasness .

3.1.4.5 Fertilizer application

Plant nutrient in the form of N,P2O5,K2O @ of 11:7:5 kg/ropani respectively (Krishi Diary), through urea, di-ammonium phosphate and muriate of potash were applied on the ridge demarcated just prior to planting. Farm yard manure @ 1.017 ton/ropani was also applied on plot before planting at the time of field preparation.

3.1.4.6 Weeding

We performed two hand weeding and earthing up as necessary to remove the weed and provide support to potato plant. 1st weeding was done at 16 Magh 2073 and 2nd weeding at 3 falgun 2073.

3.1.4.7 Irrigation

Two flood irrigation at 30 and 40 days after plantin were given. For maintaining of moisture and creating suitable environment for diseases sprinkler irrigation was also provided.

3.1.4.8 Harvesting

The tuber from the net plot area was harvested manually with the help of sickles. Harvested tuber were left in shaded area for a night.

3.1.5 Observation recorded in potato field

3.1.5.1. Diseases assessment

3.1.5.1.1 Diseases scoring

Diseases scoring was started when late blight was seen on magh 15 2073 in the field, and the data was recorded 3 times at interval of 7 days respectively by using 0-5 Scale by using Horsfall-Barratt scale formerly used at the international Potato center to estimate severity of potato late blight.

Disease scoring was assessed visually as foliage damage percent in all the observations.

0 = No disease

1 = Less than 10% leaves of the plants infected with small Lesions.

2 = 10-25% of the plants infected with large lesions

3 = 26-50% leaves of the plants infected with large lesions and slight infection on the stem (less than 10%)

4 = 51-75% leaves of the plants infected with large lesions and more infection on the stem (11-50%)

5 = More than 75% of the plants leaf infected with large lesions, stem infection more than 50% plants, plants going to die.

3.1.5.2 Diseases severity

Ten plants were randomly selected to record disease severity from each experimental unit. Percentage disease severity was then calculated using the following formula:

$$\text{Disease severity (\%)} = \frac{\text{Sum of all numerical rating}}{\text{No. of plants observed x maximum rating}} \times 100$$

3.1.5.3 Area under disease progress curve (AUDPC)

The area under disease progress curve is used to summarize the progress of disease severity. The area under the disease progress curve was estimated using the following formula (Campbell, 1990; Madden and Hughes, 1995).

$$AUDPC = \sum_{i=1}^{n-1} (Y_{i+1} + Y_i)\, 0.5\, (T_{i+1} - T_i)$$

Where

Y_i = late blight disease severity % on the i^{th} date

T_i = date on which the disease was scored

n = numbers of dates on which disease was scored

3.1.6 Yield attributing character of potato

3.1.6.1 Hundred tuber weight

Hundred tuber were counted from the randomly separated tuber yield of net plot and weighed with the help of portable weighing machine.

3.1.6.2 Economic yield

Tuber were collected from the randomly selected plant and weighted with the help of portable weighing machine.

3.1.7 Statistical analysis

Recorded data on above-stated parameters were tabulated treatment wise under 3 replications. The data recorded during the study were processed to fit into RSTAT software for analysis, Microsoft excel program was used for data tabulation, and Duncan's Multiple Range Test (DMRT) was carried out at 5 % level of significance. The data entry was done to develop ANOVA table. DMRT, a mean separation technique was applied to identify most effective treatment. Correlation and regression analysis were done for group comparison and to test the main and interaction effects (Gomez and Gomez, 1984).

3.1.8 Meteorological features

The meteorological mean data such as temperature (maximum, minimum) and total rainfall during cropping period (January to April 2017) were obtained from the regional meteorological station Dipayal. Summary of the major weather variables has been presented in Figure 4.

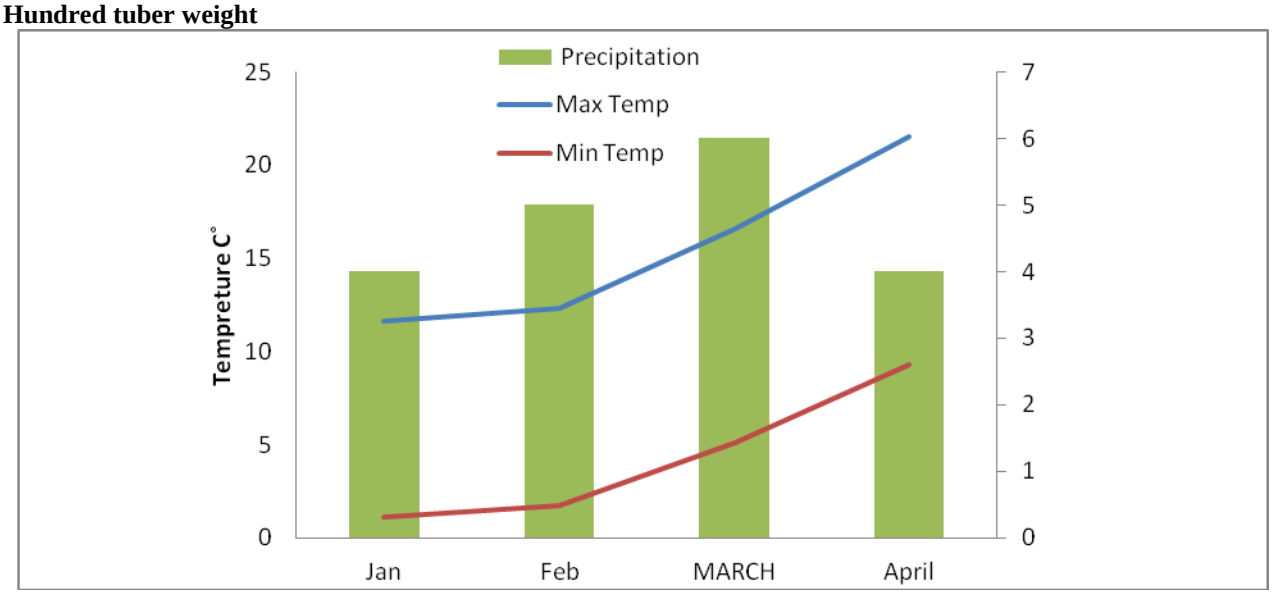

Figure 4. Weather condition of the field during research field (January to April 2017)recorded at regional meteorological station Dipayal.

III. RESULTS AND DISCUSSIONS

4.1 Diseases severity at different date of scoring

Analysis of variance (ANOVA) reveled highly significant relationship between the first diseases severity and treatments (Appendix 3). Mean value of first scoring severity was 28.16. For the management of late blight diseases different non-chemical pesticides were used for three times. Lowest first disease severity was observed in the control factor (20.00) followed by timur (22.66) and Sisnu (26.66) respectively. Highest value of diseases severity was observed in Panchagavya (36.00) followed by Neem (34.66) which is higher than the mean value (table 4).

Analysis of variance (ANOVA) reveled highly significant relationship between the second diseases severity and treatments (Appendix 3). Mean value of second scoring severity was 22.83. Lowest second diseases severity was observed in the copper colloide (22.66) followed by Bakino ,Neem , Sisnu (25.33) and timore, panchagavya (28.00)respectively. Highest

value of diseases severity was observed in control factor (30.66) followed by Asuro (29.33) which is higher than the mean value (table 4).

Analysis of variance (ANOVA) reveled highly significant relationship between the third diseases severity and treatments (Appendix 3). Mean value of third scoring severity was 19.66. Lowest third diseases severity was observed in the panchagavya (6.66) followed by copper collide (10.66) and neem (14.66)respectively. Highest value of diseases severity was observed in control factor (44.00) followed by Asuro (25.33) which is higher than the mean value (table 4).

Management of late blight of potato is greatly related with the application of non-chemical pesticides. Among several factor for management of late blight, use of Panchagavya, neem, bakino, asuro, timore, sisnu and copper collide has been found effective to a great extent (Lawless, 1995) . Diseases severity decreases with the increase in the dose of copper collide and Panchagavya and increases diseases severity with the increase in the dose of asuro and control factor Table 4 Diseases severity at different date of scoring at GAASC, Baitadi 2017

	Disease severity		
Treatments	35DAS	42DAS	49DAS
Asuro	28.00 ab	29.33 a	25.33 b
Bakaino	29.33 ab	25.33 a	20.33 bc
Control	20.00 b	30.66 a	44.00 a
Copper collide	28.00 ab	22.66 a	10.66 de
Neem	34.66 a	25.33 a	14.66 cd
Panchakabya	36.00 a	28.00 a	6.66 e
Sisnu	26.66 ab	25.33 a	17.33 cd
Timore	22.66 b	28.00 a	18.66 bc
Mean	28.16	22.83	19.66
CV	21.49	19.07	22.68
Sem	3.49	2.95	2.57
LSD	10.60	8.96	7.81

DAS: Days after sowing,CV: Coefficient of variation, LSD: Least significant difference, SEm: Standard error of mean. Treatment means are separated by Duncan's Multiple range Test (DMRT) and the columns represented by the same letter (s) are not significantly different among each other at 5%.

4.2 Effect of different treatment on AUDPC

Analysis of variance (ANOVA) revealed highly significant relationship between first date AUDPC and treatments (Appendix 4) . Mean first AUDPC was 96.25. For the management of late blight of potato we applied different non – chemical pesticides . Lowest first AUDPC was observed in timore, copper colloide and control factor (88.66) followed by Sisnu (91.00) and bakino (95.66) ,and asuro with the value of (100.33) , followed by neem (105), and Panchagavya (112) which is higher than the mean value (table 5).

Analysis of variance (ANOVA) revealed highly significant relationship between second date AUDPC and treatments (Appendix 4) . Mean second AUDPC was 162.75 . For the management of late blight of potato we applied different non –chemical pesticides . Lowest sedcond AUDPC was observed in copper colloide (116.67) followed by Panchagavya (121.33) and sisnu (149.33) ,and timore with the value of (163.33) , followed by asuro (191.33), and control factor (261.33) which is higher than the mean value (table 5).

Analysis of variance (ANOVA) revealed highly significant relationship between total AUDPC and treatments (Appendix 4) . Mean of total AUDPC was 259 . For the management of late blight of potato we applied different non – chemical pesticides . Lowest total AUDPC was observed in neem (205.33) followed by Panchagavya (233.33) and sisnu (140.33) ,and asuro with the value of (291.66) and control factor (350.00) which is higher than the mean value (table 5).

Higher the application of asuro (291.66) resulted to higher diseases pressure which shows the ineffectiveness of asuro in management of diseases (Chopra, R. N., S. L. Nayr, and I. C. Chopra., 1995). Higher diseases was seen during third times application of asuro. Lower diseases severity noticed in higher use of copper colloide (205.33) which reported that severity of late blight decreases with increasing use of copper colloide. The findings also agreed with the results of project IR-4 which shows the higher use of copper colloide resulted in decreases attack of late blight decreased in total AUDPC (The Ohio State University 2016).

Table 5. 1st AUDPC, 2nd AUDPC and total AUDPC of different treatments at GAASC, Baitadi 2017.

Treatments	AUDPCI	AUDPCII	Total AUDPC
Asuro	100.33 a	191.33 b	291.66 ab
Bakino	95.66 a	158.66 bcd	254.33 bc
Control	88.66 a	261.33 a	350.00 a
Copper colloide	88.66 a	116.66 e	205.33 c
Neem	105 a	140.00 cde	245.00 bc
Panchakabya	112 a	121.33 de	233.33 bc
Sisnu	91 a	149.33 cde	240.33 bc
Timore	88.66 a	163.33 bc	252.00 bc
Mean	96.25	162.75	259
CV	18.47	14.47	14.98
Sem(±)	10.26	13.60	22.40
LSD	31.13	41.26	67.96

DAS: Days after sowing,CV: Coefficient of variation, LSD: Least significant difference, SEm: Standard error of mean. Treatment means are separated by Duncan's Multiple range Test (DMRT) and the columns represented by the same letter (s) are not significantly different among each other at 5%.

4.3 Effect of different treatments on test weight and economical yield

Analysis of variance (ANOVA) revealed highly significance relationship between test weight (kg) and treatments (Appendix 5). Mean value of test weight was 2.87. For the management of late blight of potato we applied different non –chemical pesticides . Lowest test weight was observed in no application of non- chemical pesticides (1.41) followed by asuro (2.38) and timore(2.66) resp[ectively. Higher value of test weight was observed in Sisnu (2.88), bakino (3.01), neem (3.28), copper colloide (3.46) and Panchagavya (3.86) which is higher than the mean value (table6). This results coincided with (Agricultural University, Udhagamandalan-643 001), which reported that test weight of potato tuber increased with the increase of use of panchagavya that provides all the macro and micro nutrient, other growth promoting factors .

Analysis of variance (ANOVA) revealed highly significance relationship between economical yeild (ton/ha) and treatments (Appendix 5). Mean value of economical yield was 10.88. For the management of late blight of potato we applied different non –chemical pesticides . Lowest value of economical yeild was observed in no application of non- chemical pesticides (6.00) followed by asuro (9.13) and timore(10.15) resp[ectively. Higher value of economical yield was observed in Sisnu (11.03), bakino (11.42), neem (12.26), copper colloide (12.78) and Panchagavya (14.23) which is higher than the mean value (table6). This results coincided with (Selvaraj, N., B. Anitha, B. Anusha and M. Guru Saraswathi. 2007) which reported that per unit production of potato was increased with the use of panchagavya because panchagavya acts as ramban (growth factor, diseases management , diseases tolerance power etc) without any side effect.

Table 6. Test weight and economical yield of different treatments at GAASC, Baitadi, 2017.

Treatments	Test weight(kg)	Economical yield(t/ha)
Panchakabya	3.86 a	14.23 a
Copper colloide	3.46 ab	12.78 ab
Neem	3.28 bc	12.26 b
Bakaino	3.01 bcd	11.42 bc
Sisnu	2.88 cde	11.03 bcd
Timore	2.66 de	10.18 cd
Asuro	2.38 e	9.13 d
Control	1.41 f	6.00 e
Mean	2.87	10.88
CV	10.60	10.26

Sem(±)	0.17	0.64
LSD	0.53	1.95

DAS: Days after sowing,CV: Coefficient of variation, LSD: Least significant difference, SEm: Standard error of mean. Treatment means are separated by Duncan's Multiple range Test (DMRT) and the columns represented by the same letter (s) are not significantly different among each other at 5%.

4.4 Regression study

The correlation between test weight (dependent variable) with mean AUDPC (independent variable) was studied. There was highly significant negative correlation between mean AUDPC and test weight. Contribution of mean AUDPC for reduction in test weight was 65% (Figure 5).

Table 5. Correlation between disease severity, mean AUDPC, Economic yield (t/ha) and 100 tuber weight.

	DS10-22	DS10-29	DS11-07	MeanAUDPC	EY t/ha	TKW
DS10-22	1	.213	-.476*	-.027	.429*	.430*
DS10-29		1	.323	.783**	-.373	-.408*
DS11-07			1	.814**	-.934**	-.929**
MeanAUDPC				1	-.799**	-.812**
EY /tha					1	.995**
TKW						1

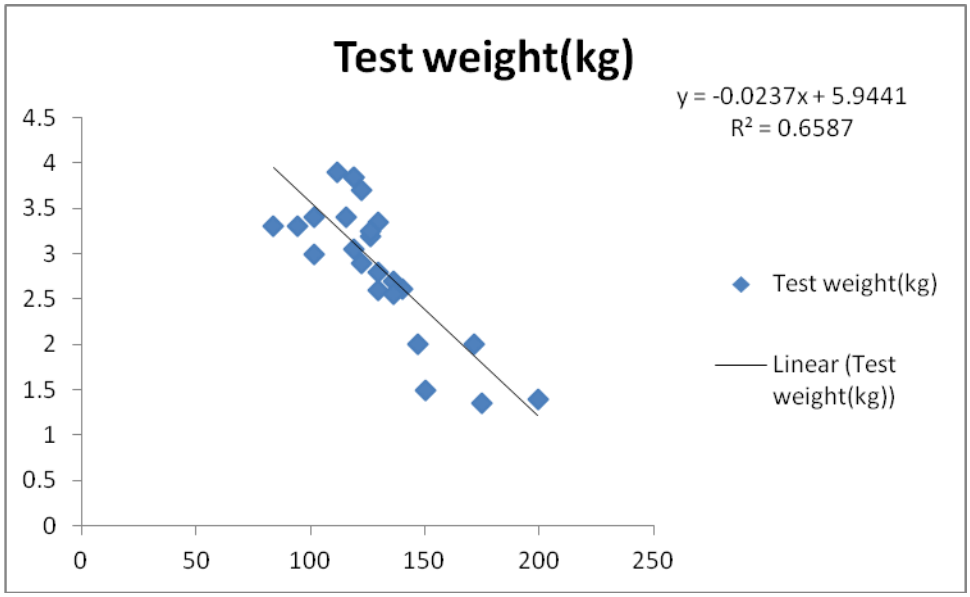

Figure 5. Correlation between mean AUDPC and test weight.

The correlation between economical yield (dependent variable) with mean AUDPC (independent variable) was studied. There was highly significant negative correlation between mean AUDPC and economical yield. Contribution of mean AUDPC for reduction in economical yield was 63% (Figure 6).

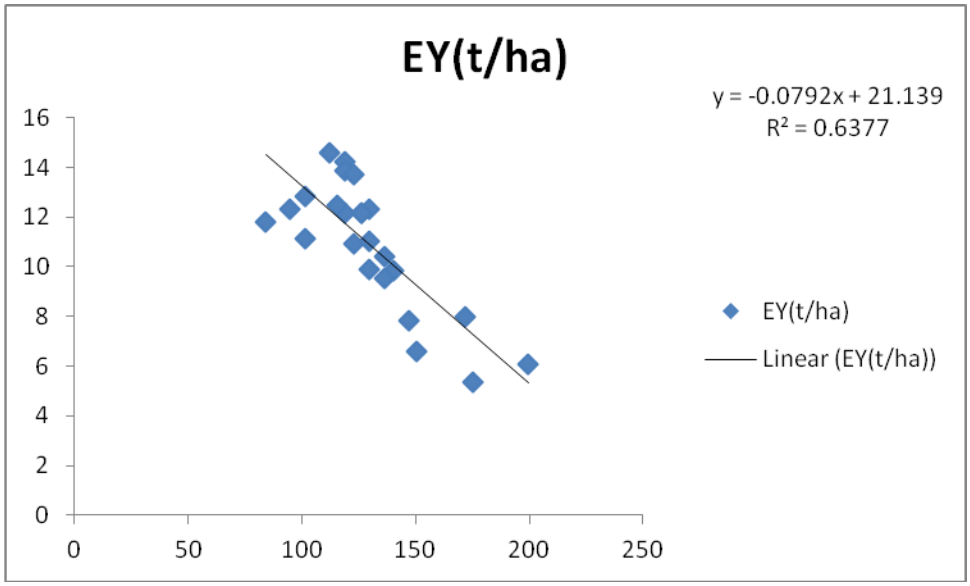

Figure 6. Correlation between mean AUDPC and economical yield.

Table 5 show the correlation between the different date of disease severity, mean AUDPC, EY t/ha and TKW, First date of disease severity and second disease severity relation was positive but non significant. Relation between first disease severity and third disease severity negative but significant, relation between first disease severity and mean AUDPC was negative but non significant. Table also show the relation between first disease severity and EY that was positive and significant, similarly, relation was seen in TKW. Disease severity second show the relation to the third disease severity that was positive and non significant, relation between second disease severity and mean AUDPC was positive and highly significant. Relation between second disease severity and economic yield was negative and non significant. Relation between second disease severity and 100 test weight was negative and highly significant.

Correlation between third disease severity and mean AUDPC was positive and highly significant. Relation between third disease severity and economic yield was negative and highly significant, similar result was found with TKW. Correlation between mean AUDPC and economic yield was negative and highly significant, similar result was found with TKW. Correlation between economic yield and TKW was positive and highly significant.

IV. SUGGESTIONS

Hence, from our research result, we can suggest the farmers of Gokuleshwor for :-

- Panchagavya can be made in easy way with low cost technology by every potato growing which is safe and sustainable for late blight management.
- The optimum dose of Panchagavya and Copper colloide can be alternate option for the management of late blight for nearby farmers of Gokuleshwor

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