Official publication of Pakistan Phytopathological Society
Pakistan Journal of Phytopathology
ISSN: 1019-763X (Print), 2305-0284 (Online)
http://www.pakps.com

MANAGEMENT OF *ALTERNARIA SOLANI* (ELL. AND MART.) BY USING PLANT EXTRACTS

[a]Mohammad S.U. Rahman, [b]Waqas Ashraf, [b]Muhammad Raheel, [b]Qaiser Shakeel, [c]Muhammad A. Zeshan [c]Awais A. Khan,

[a] Department of Plant Pathology, University of Agriculture Faisalabad. Pakistan.
[b] Department of Plant Pathology, The Islamia University Bahawalpur. Pakistan.
[c] Department of Plant Pathology, Islamia College of Agriculture, University of Sargodha. Pakistan.

A B S T R A C T

Early blight is the most destructive disease of solanaceous plants distributed in all over the world; its causal agent is *Alternaria solani* with its wide host range. Numbers of management strategies had been adopted but none of them were completely effective. That's why, an experiment was planned to find out the effective control of early blight disease. The infected samples were collected from the field and isolation, purification and multiplication of fungus was done by using PDA media.The management of early blight disease was assessed by using the extract of desert plants *viz.,* Kortuma (*Citrullus colocynthis)*, Kapok bush (*Aervaj avanica*) and Puthkanda (*Achyranthe saspera*). Application of these botanical were carried out by using poison food technique in laboratory, foliar spray in green house and field trials. Complete Randomized Block design was used for laboratory, green house and randomized complete block design (RCBD) for field trail. The data was recorded by using standard procedures on a variety of factors and statistically analyzed through suitable software.

Keywords: Solanaceous plants, *Alternaria solani,* Kortuma (*Citrullus colocynthis)*, Kapok bush (*Aervaj avanica)* and Puthkanda (*Achyranthe saspera*).

INTRODUCTION

Potato, tomato, eggplant, and chili are important members of Solanaceae family. It is a major source of vitamins like vitamin A, B, C, E, K, thiamine, niacin, pyridoxine, folacin, minerals and dietary fiber. Phytochemicals found in solanaceous vegetables like lycopene in tomato and peppers, nasunin in brinjal are strong antioxidants that detoxify cancer-causing agents (Kumari*et al*., 2017).

Potato (*Solanum tuberosum* L.) is most important, nutritious and major cash crop worldwide having production of potato in 2017 was 12.705 tons ha^{-1}inPakistan. China is one of the largest countries for the production of potato and India is on second number in potato production. Both countries produced potato one third of all over the world. The annual report FAO described that, potato production all over the world was 388000 thousand metric tons which was increase from 333600 thousand metric tons in 2010 (Abbas, 2017).

Tomato ranked second important horticultural crop all over the world but it is first one in processing crops. Worldwide tomato cultivation is on an area of 4730 thousands ha with the production of163960 thousand tones and an average yield of one hectare is 34.66 tones. In India, its cultivation is on a wide range of environmental condition on region of 0.774 millions hectare with the yield of 18732 thousand tons from an area of 774 hectares 2016 (FAO, 2016).

Eggplant (*Solanum melongena*) fruit is used extensively in Asia, India and Mediterranean countries, it contains high nutritional value (Gebhardt and Thomas, 2002). The 100g fresh weight of eggplant contains 1.0g protein, 27IU pro-vitamin A and 0.30g vitamin E, and also rich

Submitted: January 25, 2021
Revised: June07, 2021
Accepted for Publication: June 06, 2021
* Corresponding Author:
Email: waqasashraf@iub.edu.pk

source of antioxidant and minerals. The100 g of eggplant new weight can likewise gave the 5 percent of the suggested day by day sum (RDA) of phosphorus, potassium and copper just as 10 percent of phenolics (Raigón *et al.,*2008).Important antioxidants and anthocyanins were founded in abundance in pigment of peel of the fruit (Azuma *et al.* 2008). Both phenolics and anthocyanins having a free radicals scavenging properties that is important for health benefits (Kaur and Kapoor 2001).

Chili (*Capsicum* spp.) is grown in all over the world and belongs to the family Solanaceae. It has a superfluous medicinal and nutrition values (Knapp *et al*., 2004; Hunziker 2001). Pungency in chilli is due to presence of capsaicin (C18H27NO3), capsaicin is an alkaloid which an important role in reduction of many free radicals (Bhattacharya *et al.,* 2010). It also play an important role for the treatment of joint inflammation torment, herpes zoster-related torment, diabetic neuropathy, mastectomy torment, migraines and brings down glucose levels, mend intestinal issues, improves heart wellbeing and ensures against strokes and can possibly slaughter prostate disease cells (Díaz-Laviada, 2010).

Alternaria solani cause early blight disease in potato (*Solanum tuberosum)* and tomato (*Lycopersicon esculentum)* which is the most serious disease-causing heavy yield loses of field crops (Rani et al., 2017). *A. solani* also causing other diseases like collar rot, damping off, stem lesions, fruit rot of tomato and may also infect eggplant and pepper. This disease can be very harmful if left uncontrolled, often resulting incomplete defoliation of plants (Dater and Mayee, 1986).

Initial symptoms appear on older leaves of plants in the form of spots having brownish to blackish appearance surrounded with yellow halo. Later on spot size increases and whole leaf become chlorotic and defoliated. Same symptoms appear on stem but the color of spot is grayish. On fruit sunken lesions appear with pink to purple line which becomes shriveled, dry having no bad smell (Abbas, 2017).

Early blight disease is reported all over the world. Its severity requirement is high humidity, heavy rainfall, depositions of dew drops and the optimum temperature is 25-30$^{\theta}$C. (Peralta *et al*., 2005).That disease acquiring heavy yield losses infield and postharvest up to 86%(Mathur and Shekhawat, 1986). Yield losses were 1.36 %, with 1% increase in disease intensity and high disease severity may cause failure of crop (Sherf and MacNab, 1986). Saha and Das (2012) with 1 percent increase in disease causes 0.75 to 0.78 tones ha^{-1} yield losses. Infection supplemented through toxins production by *A. solani*. The toxins attack on host protoplast and also disturb the physiological processes.

In the current year, fungicides massive use in agriculture sector badly effect the environment and human health which is proven by both environmentalist and public health authorities. Now a day vast range of medicinal plants and bio-control agents are present to reduce inhabitants of air borne**,** seed born and soil borne pathogen. Botanical extracts having antifungal activities are used to manage pathogenic fungi under *in vivo* and *in vitro* environments to reduce losses (Abeysinghe, 2009; Jegathambigai *et al*., 2010).

Most important thing is that to decide the viability of various dosages of botanicals against early blight disease of solanaceous crop. Accordingly, keeping taking into account above realities present tests were direct on "Studies on *Alternaria solani* management through plants extract which causing early blight disease in solanaceous crops Experiments have following main objective.

To find out the efficiency of different botanicals extracts for the management of *Alternaria solani*.

MATERIALS AND METHODS

Infected sample collection: Early blight infected sample were collected from solanaceous crops such as tomato, potato, chili and egg plant growing areas during growing season.

Experimental site: All the experiments were conducted in the research area and laboratory of Department of Plant Pathology, Faculty of Agriculture, University of Agriculture Faisalabad.

Isolation and Identification of *A. solani:* *A. solani* culture was obtained by using tissue isolation technique (Nakam *et al.,*2015). Samples were thoroughly examined for confirming the occurrence of pathogen. Then infected samples were taken into laboratory and small pieces cut with size of 3-4mm. Samples surface sterilization was done with 0.1% bleach for 60 sec and three times wash with distill water. One or two sample pieces were placed on PDA media containing Petri plate of each. These Petri dishes were incubated in incubator at 25±2°C. After two to three days culture of the pathogen were obtained.

Purification of *A. solani:* Pure culture of *A. solani* was obtained by using the hyphal tip practice and single spore method (Pathak, 1972). When mycelial growth was observed in Petri dishes, newly growing hyphal tip was cut off with sterilize needle and placed to PDA media slants for pure culture and incubated at 27±2°C for 24h for further growth. In single spore method,10 days old fungal culture suspension was made and 3 drops were taken from spore suspension, placed it on plain ager media and incubated at 25±2°C for one day. When spores were produced on plates, were up lifted by sterilized inoculation needle and placed to media containing slants for further growth to get pure culture.

Collection and Preservation of desert plants sample: Fresh leaves of *Citrullus colocynthis, Aervaj avanica* and *Achyranthe saspera*were collected from desert area of Bahawalpur. These were washed and remained open for one day to reduce moisture content. Leaves were wrapped and kept in oven at 60°C temperature until they were dried. Dry leaves were grinded separately and obtained powder.

Preparation of plants extract: Hundred gram of the dry powder of plant was soaked separately in 500ml of 98% ethanol. These mixtures were agitated at 250-300 rpm for 1 hour. Mixture was pressed, then filtered by muslin cloth and extract was obtained (Nadkarni, 198).

Poisoned food technique: Extracts were added in potato dextrose agar media with different concentration such as 5, 10, 20 and 20mm poison medium was poured into 90mm of each plate. Every concentration of plant extract was repeated seven times. Each petri plate was inoculated with 5 mm pure fungal plug. During that experiment one petri plate was selected as a control. These petri dishes were incubated at 27±2°C. Growth was recorded when selected pathogen was grown completely in the control treatment. Mean radial mycelial growth of each plant extract was recorded and data was subjected to statistical analysis. Radial mycelial growths on different extract were transmuted into inhibition percentage by using the following formula:

$$\text{Inhibition \%} = \frac{\text{Mycelial growth on control} - \text{Mycelial growth on extract}}{\text{Mycelial growth on control}} \times 100$$

Each treatment was repeated three times. Treatments details are given below:

Treatment details:

P1 = *Citrullus colocynthis* (Kortuma) green fruit extract
P2 = *Citrullus colocynthis* (Kortuma) seed kernel extract
P3 = *Citrullus colocynthis* (Kortuma) dry roots extract
P4 = *Aervaj avanica*(Kapok bush) dry leaf extract
P5 = *Aervaj avanica* (Kapok bush) dry stem extract
P6 = *Aervaj avanica* (Kapok bush) dry roots extract
P7= *Achyranthe saspera* (Puthkanda) dry fruit extract
P8= *Achyranthe saspera* (Puthkanda) dry roots extract
P9= *Achyranthe saspera* (Puthkanda) dry leaves extract
P10 = Control
Concentration: 1, 2 and 3
Replication: Three
Design : CRD & RCBD

Application of botanicals for the management of *Alternaria solani* in green house: Botanical extract was applied on 40-50 days old plant with different concentrations up to 30 ml as foliar application. The foliar spray was repeated again after 15 days. After two days plants was inoculated with 20 ml suspension of A. solani containing up to 5 x 10^6 CFU/ ml. After inoculation, plants were kept at 28 $^{\theta}$C temperature with 80 % relative humidity. After 15 days inoculation the disease development was recorded. Then disease severity was also recorded (Nashwa *et al*., 2013).

Application of botanicals under field condition management of *A.solani*: The field trail was conducted in experimental area of Department of Plant Pathology, University of Agriculture Faisalabad. The plots were arranged with the size of 3 X 3.5m in rows. Botanicals were applied on 60 days old plant as such in green house. After 15 days of inoculation disease was recorded (Nashwa*et al*., 2013).

Economics and statistical analysis: Cash sparing preferred position extent of different treatments were ended up being as indicated by the movements of data applied for the disease control and wages winning all through the assessment.

STATISTICAL ANALYSIS

Data regarding three parameters (viz., concentration, pathogen and botanicals) was taken following the procedure and analyze statistically through CRD in lab, green house and RCBD in field. Inhibition of radial mycelial growth was examined by using ANOVA and means was separated by the test of LSD 0.05. Treatments significant were checked by F-test value. At 5% level of significance critical value was used for the evaluation and analysis of significant means of treatment.

RESULTS

Symptomatology: The guideline manifestations of the early scourge malady accomplished by *Alternaria solani* on tomato was showed up as water doused sores on the old leaf. More seasoned leaves got illness first and later it was advanced upward. The spots were oval or precise fit as a fiddle connected from 1 to 5 mm width. Thin chlorotic zone was besides seen around the spot. Later stage spots were made and concentric rings were limited in the middle. Beginning phase of the spots was changed from light to dull earthy colored at long last adjoining spots blended to shape bigger spots. Serious assaulted of the illness caused drying and defoliation of foliage. Right when plants were old, signs showed up on stem and petioles as abrasive concealed lessening generous tinted extended objective board type spots. These spots heightened and ensured about the whole stem and petioles inciting shriveling of the plants. Signs likewise made on calyx and bloom buds as second dirty tinted to dull healthy shaded spots which upgraded later and spread to sepals and regular things occurring in pre-absolutely develop dropping of trademark things. The responses on normal showed up first at stem end as faint or healthy toned disheartened spots both on green and more seasoned which reached out inside eight days including by a wide margin the vast majority of the natural products, at last the organic products were demolished.

Isolation and identification of the pathogen: *Alternaria solani* was isolated from the infected parts of potato and tomato plants followed by the standard tissue isolation technique. Isolation process was repeated many times for obtaining pure fungal culture. After purification the fungus description was followed as. The conidiophores were produced single and in groups, in the straight or in curve form with light to dark brown. The conidia were single in straight or in slight curve and some were in muri form with pale to dark brown colour. The length of conidium was 160-280 µm and thickness was 14-18 µm with 1-4 longitudinally and 7-9 transversely septate. The explanation of that fungal specie was agreed with the description of *Alternaria solani* by Mycological institute, Kew, England (Ellis, 1982). Thus the fungus which was the causal agent of early blight disease had been clarify as *Alternaria solani* by (Jones and Grout). The pure culture containing plate was sent to the Mycology laboratory, Department of Plant Pathology, University of Agriculture Faisalabad for identification and They confirmed that the culture was *Alternaria solani*.

Pathogenicity test: Pathogenicity test was done according the actual method which explained in Material and Methods. Inoculation was done with homogenized fungal spores suspension and mycelium at the rate of 2 x 10^4 spores / ml of *A. solani* on foliage of 25 days old plant. After 15 days of inoculation the symptoms appeared on suspension inoculated part of plant as necrotic spots light brown in color circular to oval in shape with concentric rings. Reisolation and purification of fungal culture from artificially inoculated infected parts of plant was similar to the original culture. The plants which were used as a control did not show any symptoms of the disease.

Growth inhibition of *Alternaria solani* by using botanicals extract in laboratory: At 5 % concentration of botanicals the mean values of treatments were 55, 45, 30, 50, 40, 26.667, 48.333, 33.333, 50 and 0 respectively. The given data showed that treatment P1, P4 and P9 provided maximum control, P2, P5 and P7 gave moderate and treatment P3, P6 and P8 gave less control and treatment P10 gave no control. The Standard deviation of treatments was 5, 3, 5, 5, 5, 2.887, 2.887, 7.638, 2.646 and 0 respectively. The data denoted that P8 gave maximum deviation and P1, P3, P4 and P5 deviated moderately and P6, P7 and P9 less and P10 showed no deviation. The Standard errors of treatments were 2.887, 1.732, 2.887, 2.887, 2.887, 1.667, 1.667 4.409, 1.527 and 0 respectively. The data explained that S.E of P8 was high from other treatments.

Table 4.1.1. Growth inhibition of *Alternaria solani* at 5% concentration

	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10
R1	60	45	35	55	40	30	50	35	52	0
R2	50	42	30	45	35	25	45	40	51	0
R3	55	48	25	50	45	25	50	25	47	0
Mean	55	45	30	50	40	26.667	48.333	33.333	50	0
S.D.	5	3	5	5	5	2.887	2.887	7.638	2.646	0
S.E.	2.887	1.732	2.887	2.887	2.887	1.667	1.667	4.409	1.527	0

Table 4.1.2. Growth inhibition of *Alternaria solani* at 15% concentration

	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10
R1	65	48	40	60	45	30	55	35	60	0
R2	50	42	35	55	45	35	50	45	55	0
R3	60	50	30	50	35	30	45	30	50	0
Mean	58.333	46.667	35	55	41.667	31.667	50	36.667	55	0
S.D.	7.638	4.163	5	5	5.774	2.887	5	7.6376	5	0
S.E.	4.409	2.404	2.887	2.887	3.333	1.667	2.887	4.409	2.887	0

At 15 % concentration of botanicals the mean values of treatments were 58.333, 46.667, 35, 55, 41.667, 31.667, 50, 36.667, 55 and 0 respectively. The given data showed that treatment P1, P4,P7 and P9 provided maximum control, P2 and P5 gave moderate and treatment P3, P6 and P8 gave less control and treatment P10 gave no control. The Standard deviation of treatments was 7.638, 4.163, 5, 5, 5.774, 2.887, 5, 7.6376, 5 and 0 respectively. The data denoted that P1 and P8 gave maximum deviation and P2, P3, P4, P5, P7 and P9 deviated moderately and P6 less and P10 showed no deviation. The Standard errors of treatments were 4.409, 2.404, 2.887, 2.887, 3.333, 1.667, 2.887, 4.409, 2.887 and 0 respectively. The data showed that S.E of P1 and P8 were high from other treatments.

Table 4.1.3. Growth inhibition of *Alternaria solani* at 30% concentration

	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10
R1	70	50	45	65	50	35	60	40	65	0
R2	65	45	40	60	40	30	55	35	55	0
R3	60	50	35	55	45	35	50	40	55	0
Mean	65	48.333	40	60	45	33.333	55	38.333	58.333	0
S.D.	5	2.887	5	5	5	2.887	5	2.887	5.773	0
S.E.	2.887	1.667	2.887	2.887	2.887	1.667	2.887	1.667	3.333	0

At 30 % concentration of botanicals the mean values of treatments were 65, 48.333, 40, 60, 45, 33.333, 55, 38.333, 58.333 and 0 respectively. The given data showed that treatment P1, P4,P7 and P9 provided maximum control, P2, P3 and P5 gave moderate and treatment P6 and P8 gave less control and treatment P10 gave no control. The Standard deviation of treatments was 5, 2.887, 5, 5, 5, 2.887, 5, 2.887, 5.773 and 0 respectively. The data denoted that P9 gave maximum deviation and P1, P3, P4, P5 and P7 deviated moderately and P2, P6 and P8 less and P10 showed no deviation. The Standard errors of treatments were 2.887, 1.667, 2.887, 2.887, 2.887, 1.667, 2.887, 1.667, 3.333 and 0 respectively. The data showed that S.E of P9 maximum from other treatments.

Table 4.1.4. Growth inhibition of *Alternaria solani* at all concentrations

Treatments	5%	15%	30%
P1	55	58.333	65
P2	45	46.667	48.333
P3	30	35	40
P4	50	55	60
P5	40	41.667	45
P6	26.667	31.667	33.333
P7	48.333	50	55
P8	33.333	36.667	38.333
P9	50	55	58.333
P10	0	0	0

In given data growth inhibition of treatments at 5% concentration were 55, 45, 30, 50, 40, 26.667, 48.333, 33.333, 50 and 0 respectively. At 5% concentration P1, P4 and P9 inhibited maximum growth from other. Growth inhibition of *A. solani* at 15% concentration was 58.333, 46.667, 35, 55, 41.667, 31.667, 50, 36.667, 55 and 0 respectively. The data showed that P1, P4, P7 and P9 inhibited maximum growth. Growth inhibited by treatments at 30% was 65, 48.333, 40, 60, 45, 33.333, 55, 38.333, 58.333 and 0 respectively. Result denoted that P1, P4, P7 and P9 maximum inhibition. In that tabulated values treatment P1 gave best result at all concentrations.

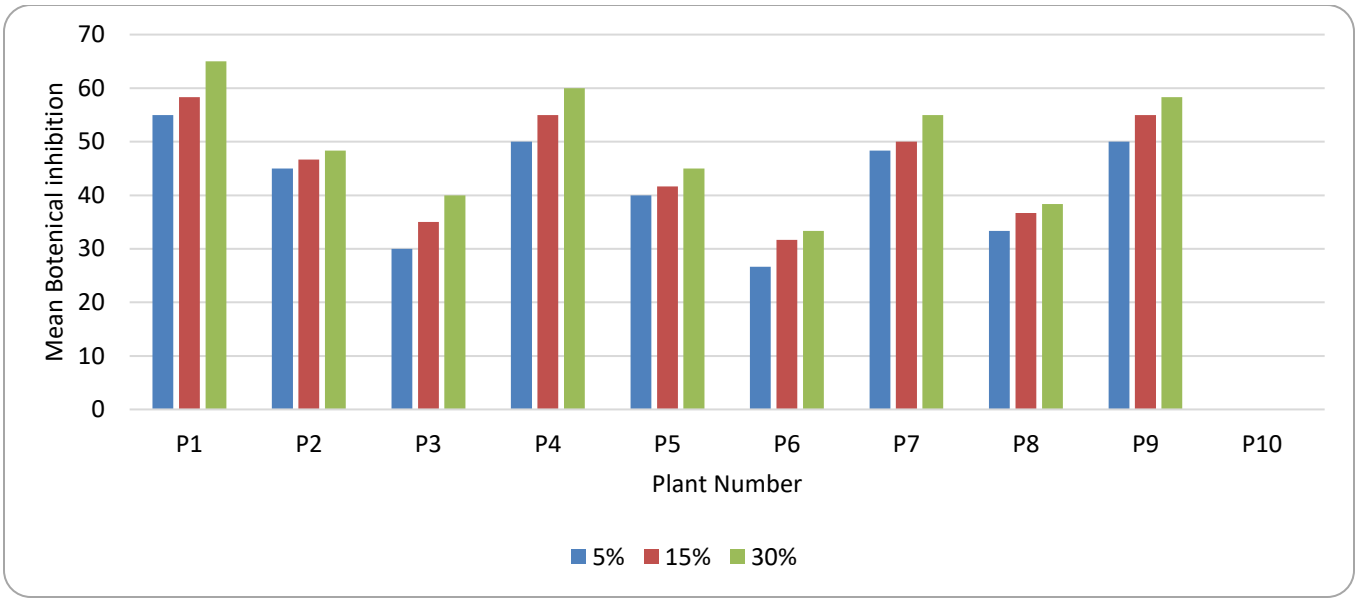

Figure 1. Growth inhibition of *Alternaria solani* by using botanicals extract at 5%, 10% and 15% concentrations of all treatments in Laboratory.

Growth inhibition of *Alternaria solani* by using botanicals extract in Green House: At 5 % concentration of botanicals the mean values of treatments were 48.333, 40, 30, 46.667, 38.333, 30, 43.333, 31.667, 48.333 and 0 respectively. The given data showed that treatment P1, P4, P7 and P9 provided maximum control, P2, P5 and P8 gave moderate and treatment P3 and P6 gave less control and treatment P10 gave no control. The Standard deviation of treatments was 2.887, 5, 5, 5.773, 2.887, 5, 2.887, 2.887, 2.887 and 0 respectively. The data denoted that P4 gave maximum deviation and P2, P3, P4 and P6 deviated moderately and P1, P5, P7, P8 and P9 less and P10 showed no deviation. The Standard errors of treatments were 1.667 2.887, 2.887, 3.333, 1.667, 2.887, 1.667, 1.667, 1.667 and 0 respectively. The data explained that S.E of P4 was high from other treatments.

Table 4.2.1: Growth inhibition of *Alternaria solani* at 5% concentration

	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10
R1	50	35	30	50	35	30	45	30	50	0
R2	50	40	25	40	40	35	40	35	50	0
R3	45	45	35	50	40	25	45	30	45	0
Mean	48.333	40	30	46.667	38.333	30	43.333	31.667	48.333	0
S.D.	2.887	5	5	5.773	2.887	5	2.887	2.887	2.887	0
S.E.	1.667	2.887	2.887	3.333	1.667	2.887	1.667	1.667	1.6667	0

Table 4.2.2. Growth inhibition of *Alternaria solani* at 15% concentration

	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10
R1	50	45	40	55	40	35	50	35	55	0
R2	55	40	30	48	45	30	42	40	45	0
R3	46	45	35	50	40	40	48	35	55	0
Mean	50.333	43.333	35	51	41.667	35	46.66	36.667	51.667	0
S.D.	4.509	2.887	5	3.606	2.887	5	4.163	2.887	5.773	0
S.E.	2.603	1.667	2.887	2.082	1.667	2.88	2.403	1.667	3.333	0

At 15 % concentration of botanicals the mean values of treatments were 50.333, 43.333, 35, 51, 41.667, 35, 46.667, 36.667, 51.667 and 0 respectively. The given data showed that treatment P1, P4 and P9 provided maximum control, P2, P5 and P7 gave moderate and treatment P3, P6 and P8 gave less control and treatment P10 gave no control. The Standard deviation of treatments was 4.509, 2.887, 5, 3.606, 2.887, 5, 4.163, 2.887, 5.773 and 0 respectively. The data denoted that P3, P6 and P9 gave maximum deviation and P1, P4 and P7 deviated moderately and P2, P5 and P8 less and P10 showed no deviation. The

Standard errors of treatments were 2.603, 1.667, 2.887, 2.082, 1.667, 2.887, 2.403, 1.667, 3.333 and 0 respectively. The data showed that S.E of P9 was maximum from other treatments.

Table 4.2.3. Growth inhibition of *Alternaria solani* at 30% concentration

	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10
R1	60	50	45	50	45	40	55	45	60	0
R2	55	50	40	55	40	45	45	40	50	0
R3	60	45	35	60	50	40	50	35	55	0
Mean	58.333	48.333	40	55	45	41.667	50	40	55	0
S.D.	2.887	2.887	5	5	5	2.887	5	5	5	0
S.E.	1.667	1.667	2.887	2.887	2.887	1.667	2.887	2.887	2.887	0

At 30 % concentration of botanicals the mean values of treatments were 58.333, 48.333, 40, 55, 45, 41.667, 50, 40, 55 and 0 respectively. The given data showed that treatment P1, P4,P7 and P9 provided maximum control, P2, P5 and P6 gave moderate and treatment P3 and P8 gave less control and treatment P10 gave no control. The Standard deviation of treatments was 2.887, 2.887, 5, 5, 5, 2.887, 5, 5, 5 and 0 respectively. The data denoted that P3, P4, P5, P7, P8 and P9 gave maximum deviation and P1, P2 and P6 deviated less and P10 showed no deviation. The Standard errors of treatments were 1.667, 1.667, 2.887, 2.887, 2.887, 1.667, 2.887, 2.887, 2.887 and 0 respectively. The data show that P1, P2 and P6 S.E value was less than from other treatments.

Table 4.2.4. Growth inhibition of *Alternaria solani* at all concentrations

Treatments	5%	15%	30%
P1	48.333	50.33333	58.333
P2	40	43.33333	48.333
P3	30	35	40
P4	46.667	51	55
P5	38.333	41.667	45
P6	30	35	41.667
P7	43.333	46.667	50
P8	31.667	36.667	40
P9	48.333	51.667	55
P10	0	0	0

In given data growth inhibition of treatments at 5% concentration were 48.333, 40, 30, 46.667, 38.333, 30, 43.333, 31.667, 48.333 and 0 respectively. At 5% concentration P1, P4, P7 and P9 inhibited maximum growth from other. Growth inhibition of *A. solani* at 15% concentration was 50.333, 43.333, 35, 51, 41.667, 35, 46.667, 36.667, 51.667 and 0 respectively. The data showed that P1, P4, P7 and P9 inhibited maximum growth. Growth inhibited by treatments at 30% was 58.333, 48.333, 40, 55, 45, 41.667, 50, 40, 55 and 0 respectively. Result denoted that P1, P4, P7 and P9 maximum inhibition. In that tabulated values treatment P1 gave best result at all concentrations.

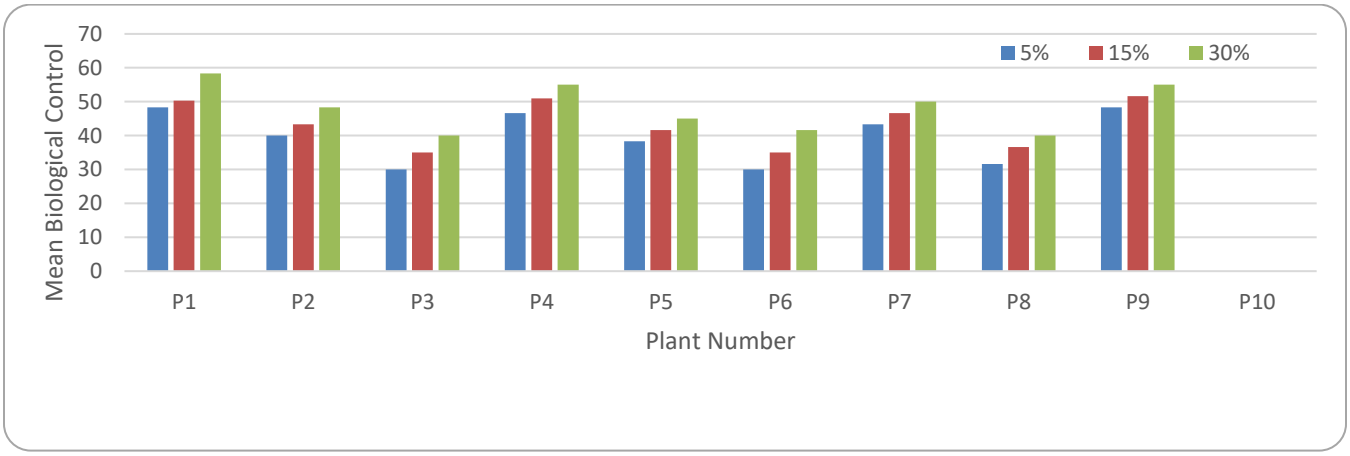

Figure 2. Growth inhibition of *Alternariasolani* by using botanicals extract at 5%, 10% and 15% concentration of all treatments in Green house.

Growth inhibition of *Alternaria solani* by using botanicals extract in Field Trail: At 5 % concentration of botanicals the mean values of treatments were 50, 38.333, 31.667, 48.333, 40, 31.667, 45, 33.333, 50 and 0 respectively. The given data showed that treatment P1, and P9 provided maximum control, P4, P5 and P7 gave moderate and treatment P2, P3, P6 and P8 gave less control and treatment P10 gave no control. The Standard deviation of treatments was 0, 2.887, 5.774, 2.887, 5, 2.887, 5, 2.887, 5 and 0 respectively. The data denoted that P3 gave maximum deviation and P5, P7 and P9 deviated moderately and P2, P4, P6 and P8 less, P1 and P10 showed no deviation. The Standard errors of treatments were 0, 1.667, 3.333, 1.667, 2.887, 1.667, 2.887, 1.667, 2.887 and 0 respectively. The data explained that S.E of P3 was high from other treatments.

Table 4.3.1. Growth inhibition of *Alternaria solani* at 5% concentration

	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10
R1	50	35	35	50	35	30	45	35	50	0
R2	50	40	25	45	45	35	40	35	55	0
R3	50	40	35	50	40	30	50	30	45	0
Mean	50	38.333	31.667	48.333	40	31.667	45	33.333	50	0
S.D.	0	2.887	5.774	2.887	5	2.887	5	2.887	5	0
S.E.	0	1.667	3.333	1.667	2.887	1.667	2.887	1.667	2.887	0

Table 4.3.2. Growth inhibition of *Alternaria solani* at 15% concentration

	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10
R1	55	45	40	55	40	35	50	40	55	0
R2	55	40	35	53	45	35	47	40	50	0
R3	50	50	35	50	45	40	48	35	55	0
Mean	53.333	45	36.667	52.667	43.333	36.667	48.333	38.333	53.333	0
S.D.	2.887	5	2.887	2.517	2.887	2.887	1.528	2.887	2.887	0
S.E.	1.667	2.887	1.667	1.453	1.667	1.667	0.882	1.667	1.667	0

At 15 % concentration of botanicals the mean values of treatments were 53.333, 45, 36.667, 52.667, 43.333, 36.667, 48.333, 38.333, 53.333 and 0 respectively. The given data showed that treatment P1, P4 and P9 provided maximum control, P2, P5 and P7 gave moderate and treatment P3, P6 and P8 gave less control and treatment P10 gave no control. The Standard deviation of treatments was 2.887, 5, 2.887, 2.517, 2.887, 2.887, 1.528, 2.887, 2.887 and 0 respectively. The data denoted that P2 gave maximum deviation and P1, P3, P4, P5, P6, P8 and P9 deviated moderately and P7 less and P10 showed no deviation. The Standard errors of treatments were 1.667, 2.887, 1.667, 1.453, 1.667, 1.667, 0.882, 1.667, 1.667 and 0 respectively. The data showed that S.E of P2 was high from other treatments.

Table 4.3.3. Growth inhibition of *Alternaria solani* at 30% concentration

	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10
R1	65	50	45	55	45	40	55	40	60	0
R2	55	55	40	55	40	45	50	40	55	0
R3	65	45	40	60	55	40	50	45	55	0
Mean	61.667	50	41.667	56.667	46.667	41.667	51.667	41.667	56.667	0
S.D.	5.774	5	2.887	2.887	7.638	2.887	2.887	2.887	2.887	0
S.E.	3.333	2.887	1.667	1.667	4.4096	1.667	1.667	1.667	1.667	0

At 30 % concentration of botanicals the mean values of treatments were 61.667, 50, 41.667, 56.667, 46.667, 41.667, 51.667, 41.667, 56.667 and 0 respectively. The given data showed that treatment P1, P4 and P9 provided maximum control, P2, P5 and P7 gave moderate and treatment P3, P6 and P8 gave less control and treatment P10 gave no control. The Standard deviation of treatments was 5.774, 5, 2.887, 2.887, 7.638, 2.887, 2.887, 2.887, 2.887 and 0 respectively. The data denoted that P1 and P5 gave maximum deviation and P2 deviated moderately and P3, P4, P6, P7, P8 and P9 less and P10 showed no deviation. The Standard errors of treatments were 3.333, 2.887, 1.667, 1.667, 4.4096, 1.667, 1.667, 1.667, 1.667 and 0 respectively. The data showed that S.E of P5 maximum from other treatments.

Table 4.3.4. Growth inhibition of *Alternaria solani* at all concentrations:

	5%	15%	30%
P1	50	53.333	61.667
P2	38.333	45	50
P3	31.667	36.667	41.667
P4	48.333	52.667	56.667
P5	40	43.333	46.667
P6	31.667	36.667	41.667
P7	45	48.333	51.667
P8	33.333	38.333	41.667
P9	50	53.333	56.667
P10	0	0	0

In given data growth inhibition of treatments at 5% concentration were 50, 38.333, 31.667, 48.333, 40, 31.667, 45, 33.333, 50 and 0 respectively. At 5% concentration P1, P4 and P9 inhibited maximum growth from other. Growth inhibition of *A. solani* at 15% concentration was 53.333, 45, 36.667, 52.667, 43.333, 36.667, 48.333, 38.333, 53.333 50 and 0 respectively. The data showed that P1, P4 and P9 inhibited maximum growth. Growth inhibited by treatments at 30% was 61.667, 50, 41.667, 56.667, 46.667, 41.667, 51.667, 41.667, 56.667 and 0 respectively. Result denoted that P1, P4, P7 and P9 maximum inhibition. In that tabulated values treatment P1 gave best result at all concentrations.

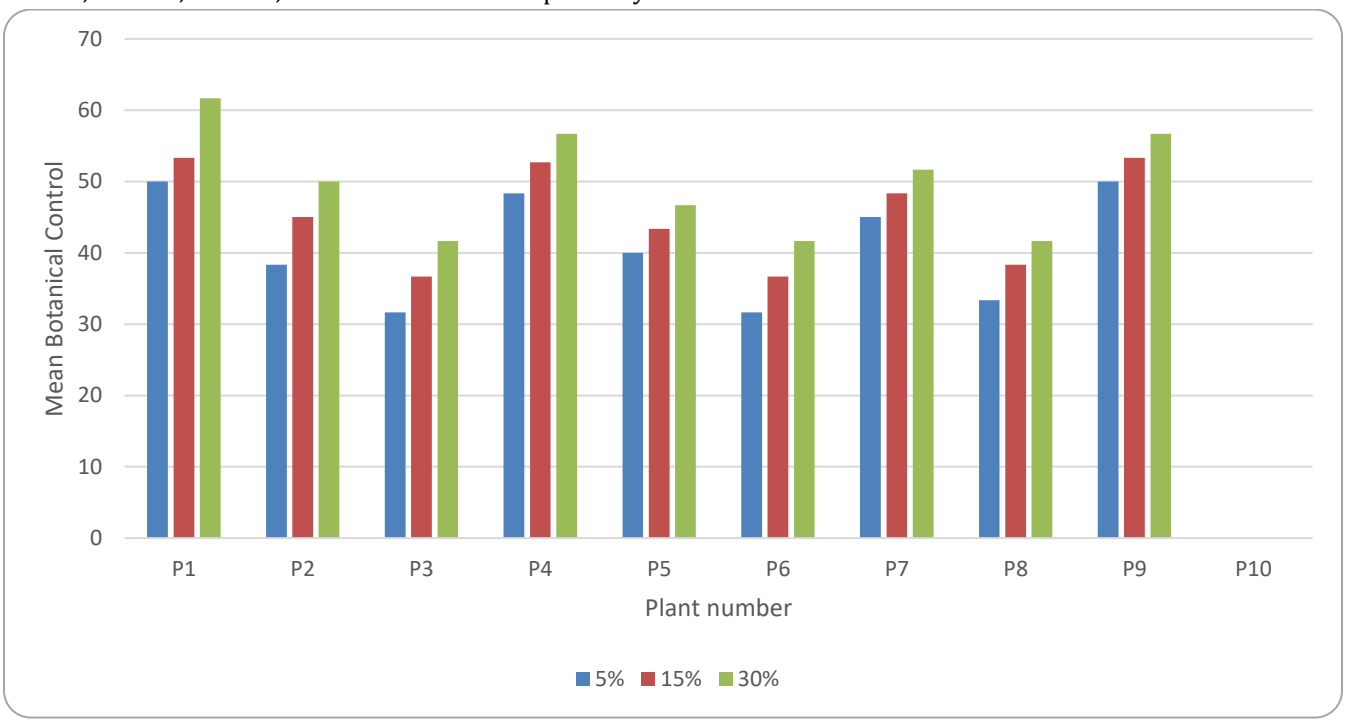

Figure 3. Growth inhibition of *Alternaria solani* by using botanicals extract at 5%, 10% and 15% concentrations of all the treatments in Field Trail.

DISCUSSION

Early blight disease was reported by Ellis and Martin (1882) in U.S.A and the causal agent was recognized as *Macrosporium solani*. Later on fungi were shifted to the *Alternaria* genus due to formation of spores on media (Jones and Grout1897). Butler (2003) first time reported *Alternaria solani* on potato from Uttar Pradesh in India. *Alternaria solani* cause infection on aboveground plant parts at every stage (Peralta *et al*., 2005; Verma and Verma, 2010). During fruiting period plants susceptibility increase to the disease (Momel and Pemezny, 2006). Fruit decaying was occurred at all stages from green to ripe (Blancard*et al.,* 2012). Sherf and MacNab (1986) described initial symptoms are small lesions appear on the lower to upper leaves of plant. Spots are oval in shape with the size of 0.2 to 0.5

cm containing small chlorotic area around. Due to disease severity defoliation of plant and fruit injury occur due to direct sun light. The maximum incidence of fruit rotten was observed in well drained and low positioning soils (Mathur and Shekhawat, 1986).

The morphological features of fungi bear non-casemated spores (Simmons, 2000). The mycelium is septate, branched; hyphal color is brown later on turn dark brown. The conidiophores are short with the size of 50-90 µm and darker in color. Conidial size is 120-296 ×12-20 µm, beaked, muri form, darker in color. Conidia contain 5-10 askew septa. The conidia contained 5-10 cross over septa and 1-5 longitudinal septa. The mycelium was septate, extended, light earthy colored hyphae which turned more obscure with age (Singh, 1987).

Pathogen survives for a long time on the plant debris and on soil (Moore and Thomas, 1942). Rotem (1998) described that it can survive on stubbles, seeds and in soil above ten years under favorable condition and also survived on other hosts *viz.,* capsicum and brinjal. Yield losses due to early blight were documented up to 79 percent worldwide. Meitei *et al.* (2012) described the 2.15 percent yield losses were recorded in resistant and 42.75 % in susceptible variety. Under favorable condition disease attack causes drying off of twigs, premature fruit drop and up to 35–78 percent yield losses (Grigolli *et al*., 2011).

The antimicrobial activity of nine medicinal plants diffusates were used against *Alternaria solani*. Antifungal activity of these plant extract was varies, Out of these Ashwagandha, Neem and Datura extract gives significant activities. The leaf extract of *W. somnifera* the mycelial growth inhibition was 62.56%, *D. stramonium* extract was inhibiting the mycelial growth up to 34.65% and *A. indica* up to 25.27% (Sahu *et al*., 2014). Efficiency of ten botanicals extract for the management of *A.solani*. Among them Jatropha leaf extract with 10 % concentration was most effective in inhibiting the mycelial growth 62.78 percent (Roopa *et al*., 2014). Rahman *et al,* (2015) evaluated some botanicals diffusate *Adhatoda vasica* with 5 percent exhibited up to 91.11% inhibition as compared to *Azadirachta indica* extract inhibit the mycelial growth up to 60 % and *Ocimum sanctum* extract gives up to 55.33% growth inhibition.

Citrullus colocynthis (L.) Schrad, commonly known as Colocynth contains various phytochemical constituents such as alkaloids, carbohydrates, flavonoids, tannins, triterpenoids, proteins, saponins and steroids along many pharmacological properties viz. diuretic, hypolipidemic, anti-cancerous, antioxidant, anti-microbial. *Aerva javanica* having nephron protective development. The current review fuses ethnomedicinal, pharmacognostical, phytochemical and unmistakable pharmacological activity of the plant *Aervaja vanica*. Achyranthes aspera plant is astringent, stomach related, diuretic, purgative and stomachic. The juice of the plant is used in the treatment of air pockets, the runs, free entrails, hemorrhoids, rheumatic tortures, shivers and skin launches (Londonkar *et al.*, 2011).

Number of management strategies had been adopted but none of them completely effective. That's why, an experiment was planned to find out the effective control of early blight disease. For this purpose, infected samples were collected from the field and isolation, purification and multiplication of fungus was done by using PDA media. The management of early blight disease was assessed by using the extract of desert plants *viz.,* Kortuma (*Citrullus colocynthis)*, Kapok bush (*Aerva javanica)* and Puthkanda (*Achyranthes aspera*).

In Laboratory growth inhibition of treatments at 5% concentration were 55, 45, 30, 50, 40, 26.667, 48.333, 33.333, 50 and 0 respectively. At 5% concentration P1, P4 and P9 inhibited maximum growth from other. Growth inhibition of *A. solani* at 15% concentration was 58.333, 46.667, 35, 55, 41.667, 31.667, 50, 36.667, 55 and 0 respectively. The data showed that P1, P4, P7 and P9 inhibited maximum growth. Growth inhibited by treatments at 30% was 65, 48.333, 40, 60, 45, 33.333, 55, 38.333, 58.333 and 0 respectively. Result denoted that P1, P4, P7 and P9 maximum inhibition. In that tabulated values treatment P1 gave best result at all concentrations.

In Green house growth inhibition of treatments at 5% concentration were 48.333, 40, 30, 46.667, 38.333, 30, 43.333, 31.667, 48.333 and 0 respectively. At 5% concentration P1, P4, P7 and P9 inhibited maximum growth from other. Growth inhibition of *A. solani* at 15% concentration was 50.333, 43.333, 35, 51, 41.667, 35, 46.667, 36.667, 51.667 and 0 respectively. The data showed that P1, P4, P7 and P9 inhibited maximum growth. Growth inhibited by treatments at 30% was 58.333, 48.333, 40, 55, 45, 41.667, 50, 40, 55 and 0 respectively. Result denoted that P1, P4, P7 and P9

maximum inhibition. In that tabulated values treatment P1 gave best result at all concentrations.

In Field trails growth inhibition of treatments at 5% concentration were 50, 38.333, 31.667, 48.333, 40, 31.667, 45, 33.333, 50 and 0 respectively. At 5% concentration P1, P4 and P9 inhibited maximum growth from other. Growth inhibition of *A. solani* at 15% concentration was 53.333, 45, 36.667, 52.667, 43.333, 36.667, 48.333, 38.333, 53.333 50 and 0 respectively. The data showed that P1, P4 and P9 inhibited maximum growth. Growth inhibited by treatments at 30% was 61.667, 50, 41.667, 56.667, 46.667, 41.667, 51.667, 41.667, 56.667 and 0 respectively. Result denoted that P1, P4, P7 and P9 maximum inhibition. In that tabulated values treatment P1 gave best result at all concentrations.

REFERENCES

Abbas, A. 2017. First Report of Alternaria Blight of Potatoes in Nomal Valley, Gilgit-Baltistan Pakistan. Department of Plant Pathology, University of Agriculture, Peshawar Pakistan. Applied Microbiology, 3:3.

Abeysinghe, S. 2009. Effect of combined use of *Bacillus subtilis* CA32 and *Trichoderma harzianum* RU01 on biological control of *Rhizoctonia solani* on *Solanum melongena* and *Capsicum annum*. Journal of Phytopathology, 8: 9-16

Azuma, K., A. Ohyama, K. Ippoushi, T. Ichiyanagi, A. Takeuchi, T. Saito and H. Fukuoka. 2008. Structures and antioxidant activity of anthocyanins in many accessions of eggplant and its related species. Journal of Agricultural and Food Chemistry, 56: 10154–10159.

Bhattacharya, A., A. Chattopadhyay, D. Mazumdar, A. Chakravarty and S. Pal. 2010. Antioxidant constituents and enzyme activities in chili peppers. International Journal of Vegetable Science, 16: 201-211.

Blancard, D., H. Laterrot, G. Marchoux and T. Candresse. 2012. A colour Handbook -Tomato Diseases: identification, biology and control. Manson Publishing Manson Publishing Limited, London UK: pp. 688

Butler, E. J. 2003. Potato disease in India. Agriculture Ledger, Crop Disease and Pest Series, 7: 87.

Datar, V.V. and C.D. Mayee. 1986. Chemical management of early blight of tomato. Journal of Maharashtra Agriculture University, 10: 278-280.

Díaz-Laviada, I. 2010. Effect of capsaicin on prostate cancer cells, Future Oncology, 6: 1545-1550.

Ellis, J. B. and G.B. Martin. 1882. *Macrosporium solani* Ellis and Martin American Naturalist, 16: 1003.

FAO. 2016. Food and Agricultural Organization, Production Year Book, FAO, Rome, Italy.

Gebhardt, S.E. and R. G. Thomas. 2002. Nutritive value of foods. Home Garden Bulletin (USDA), 72: 80–81.

Grigolli, J.F.J., M.M. Kubota, D.P. Alves, G.B. Rodrigues, C.R. Cardoso, D.J. Henriquesda Silva and E.S.G. Mizubuti. 2011. Characterization of tomato accessions for resistance to early blight. Crop Breed Applied Biotechnology, 11:174–180.

Hunziker, A. T. 2001. Genera Solanacearum: The Genera of Solanaceae Illustrated, Arranged According to a New System GantnerVerlag, Ruggell, Liechtenstein, p: 516.

Jegathambigai, V., R.S.W. Wijeratnam and R.L.C. Wijesundera. 2010. Effect of Trichoderma sp. on *Sclerotium rolfsii*, the causative agent of collar rot on *Zamioculcas zamiifolia* and an on farm method to mass produce Trichoderma species. Indian Journal of Plant Pathology, 9: 47-55.

Jones, L.R. and A.J. Grout. 1897. Notes on two species of *Alternaria*. Bulletin of the Torrey Botanical Society, 24: 254–258.

Kaur, C. and H. C. Kapoor. 2001. Antioxidants in fruits and vegetables—the millennium's health. International Journal Food Science and Technology, 36: 703–725.

Knapp, S., L. Bohs, M. Nee and D.M. Spooner. 2004. Solanaceae a model for linking genomics with biodiversity, Com Functional Genomics, 5: 285-291.

Kumari, A., A. K. Parida, J. Rangani and A. Panda. 2017. Antioxidant activities, metabolic profiling, proximate analysis, mineral nutrient composition of Salvadora persica fruit unravel a potential functional food and a natural source of pharmaceuticals. Frontiers in Pharmacology, 8: 61.

Londonkar, R., C. V. Reddy and A. K. Kumar. 2011. Potential antibacterial and antifungal activity of *Achyranthes aspera* L. Recent Research in Science and Technology, 3: 53-57.

Mathur, K. and K.S. Shekhawat. 1986. Chemical control of early blight in Kharif sown tomato. Indian Journal of Mycology Plant Pathology, 16: 235-238.

Meitei, K.M., G.C. Bora and P.K. Borah. 2012. Screening of tomato genotypes for resistance to early blight (*Alternaria Solani*). International Journal of Science and Research, 3: 351 -358.

Momel, T.M. and K.L. Pemezny. 2006. Florida plant disease management guide: Tomato. Florida Cooperation Extensive Service, Institute of Food and Agriculture Sciences, Gainesville, 32611 (http\\edis.infas.ufl.edu).

Moore, W.D. and H.R. Thomas. 1942. Some cultural practices that influence the development of *Alternaria solani* on tomato seedlings. Indian Journal of Phytopathology, 32: 1176-1184.

Nadkarni, K.M. 1998. Indian Plants and Drugs with their medicinal properties and uses. Asiatic Publishing House, New Delhi.

NashwA, S. M. and K. A. Abo-ElyouSr. 2013. Evaluation of various plant extracts against the early blight disease of tomato plants under greenhouse and field conditions. Plant Protection Science, 48: 74-79.

Nikam, P., A. Suryawanshi and A. Chavan. 2015. Pathogenic, cultural, morphological and molecular variability among eight isolates of *Alternaria solani*, causing early blight of tomato. African Journal of Biotechnology, 14: 871-877.

Peralta, I.E., S. Knapp and D.M. Spooner. 2005. New species of wild tomatoes (*Solanum* section *Lycopersicon*: Solanaceae) from Northern Peru System Botany, 30: 424-434.

Phatak, S., R. Srivastava and E. Subbarao. 1972. Elastic constants of orthorhombic KNbO3 by X-ray diffuse scattering. Acta Crystallographica Section A: Crystal Physics, Diffraction, Theoretical and General Crystallography, 28: 227-231.

Rahman, S.M.M., S.M. Maniruzzaman, S. Nusrat and A. Khair. 2015. *Invitro* evaluation of botanical extract, bio-agents and fungicides against purple blotch diseases of bunch onion in Bangladesh. Advances in Zoology and Botany, 3: 179-183.

Raigón, M. D., J. Prohens, J. E. Muñoz-Falcón and F. Nuez. 2008. Comparison of eggplant landraces and commercial varieties for fruit content of phenolics, minerals, dry matter and protein. Journal of Food Composition and Analysis, 21: 370–376.

Rani, A., S. Arora and A. Goyal. 2017. Antidiabetic plants in traditional medicines: A review. International Research Journal of Pharmacy, 8:17-24.

Roopa, R. S., K.B. Yadahalli and K.B. Kavyashree. 2014. Evaluation of natural plant extracts, antagonists and fungicides against early blight caused by *A. solani in vitro*. The Biosciences Journal, 9: 1309-1312.

Rotem, J. 1998. The genus Alternaria; biology, epidemiology and pathogencity 1st edition. The American Phytopathological Society Press Station Paul, Minnesota.

Saha, P. and S. Das. 2012. Assessment of yield loss due to early blight (*Alternaria solani*) of tomato. Indian Journal of Plant Protection, 40: 195-198.

Sahu, D.K., C.P. Khare and R. Patel. 2014. Eco friendly management of early blight of tomato using botanical plant extracts. Journal of Industrial Pollution Control, 30: 215-218.

Sherf, A.F. and A.A. Macnab. 1986. Vegetable diseases and their control. John Wiley and Sons, New York, 634-640.

Simmons, E.G. 2000. Alternaria themes and variations (244- 286) species on Solanaceae. Mycotaxon, 75: 1-115.

Singh, R.S. 1987. Diseases of Vegetable Crops. Oxford and IBH Publisher Company Private Limited, New Delhi, Bombay and Calcutta, pp. 419.

Verma, N. and S. Verma. 2010. Alternaria disease of vegetable crops and new approach for its control. Asian Journal of Experimental Biological Sciences, 1: 681- 692.

Contribution of Authors:

Mohammad S.U. Rahman	:	Conceive the research idea
Waqas Ashraf	:	Wrote manuscript
Muhammad Raheel	:	Conducted research
Qaiser Shakeel	:	Make statistics analysis
Muhammad A. Khan	:	Reviewed the manuscript
Awais A. Khan	:	Prepared tables