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Effect of Organic Nutrient Sources on Late Blight Incidence and Tuber Yield of Potato (*Solanum tuberosum* L.) in Southern Transitional Zone of Karnataka

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Abstract

A field experiment was conducted to study the Effect of organic nutrient sources on late blight incidence and tuber yield of potato (*Solanum tuberosum* L.) in southern transitional zone of Karnataka during *kharif* 2015 at College of Agriculture, Hassan. The experiment consisted of nine treatments with three replications laid out in RCBD design. At all the stages (30,45,60 and 75 DAS), late blight disease severity was significantly higher with application of 50 per cent RDN through FYM + 50 per cent RDN through vermi-compost, followed by 5 per cent bio-fuel oil cake foliar spray at 30, 45 and 60 DAP(T_4). Significantly lower severity was recorded in treatment (T_1) with application of recommended dose of nutrients of 25 t FYM ha^{-1} + 75:75:100 kg of NPK ha^{-1}. Application of recommended dose of nutrients (T_1) of 25 t FYM ha^{-1} + 75:75:100 kg of NPK ha^{-1} registered significantly higher tuber weight (139.3 g plant^{-1}), tuber number (5.1 plant^{-1}), tuber yield (17.1 t ha^{-1}) and also with respect to A, B, C and D grades (2.9, 5.3, 5.00 and 3.8 t ha^{-1}, respectively). The highest total nutrient uptake was observed in T_1: recommended dose of nutrients 25 t FYM ha^{-1} + 75:75:100 kg of NPK ha^{-1} (102.8kg ha^{-1}). The higher B: C ratio (2.24) was recorded in the treatment with 50 per cent RDN through FYM + 50 per cent RDN through vermicompost, followed by panchagavya foliar spray at 30, 45, 60 DAP, closely followed by treatments *viz*., application of 50 per cent RDN through FYM + 50 per cent RDN through vermicompost, followed by jeevamrutha foliar spray at 30, 45, 60 DAP and recommended dose of nutrients of 25 t FYM ha^{-1} + 75:75:100 kg of NPK ha^{-1} (2.14 and 2.14, respectively).

Keywords: Potato, Late blight, Organic nutrients, Tuber yield

Potato occupies an area of 19.2 million hectares in the world with an annual production of 373.5 mt and an average productivity of 19.40 t ha^{-1}. It constitutes nearly half of the world's annual output of all root and tuber crops, (Anonymous, 2013). At present, potato is grown in about 15 countries of the world on a wide range of soils and agro-climatic conditions (Khurana and Naik, 2003). In India, it is cultivated on an area of 2.18 million hectares with a production of 52.5 million tonnes and an average productivity of 23.68 tonnes per hectare (Anonymous, 2018). In Karnataka, potato occupies an area of 51,310 hectares with a production of 5.13 lakh tonnes per annum and an average productivity of 15 tonnes per hectare. The potato crop in Karnataka is mainly grown as rainfed crop in *kharif* (June to September) and as an irrigated crop during *rabi* (November to February). The potato (*Solanum tuberosum* L.) is native to the Andean region of South America. It ranks as the world's fourth most important food crop, after maize, wheat and rice and represent a valuable source of nutrients in a balanced diet. The potato is a member of the *Solanaceae* family and it has the capacity to produce more energy and protein per unit area per unit time. Potato protein is superior to that of cereals and rich in essential amino acid 'lysine' and 'vitamin C'. Hence, potato is one of the richest sources of calories needed to maintain day-to-day output of human energy. It is an herbaceous annual that grows up to 100 cm tall and produces tubers also called 'potato' which develops from an underground stem called 'stolon' or 'rhizome'. Potato is rich in starch. As the potato plant grows, its compound leaves manufacture starch that is transferred to the ends of its underground stems. Tubers have lenticels that facilitate gas exchange. The number of tubers that actually reach

maturity depends on available moisture and soil nutrients. Each tuber has from two to as many as 10 buds (or 'eyes') arranged in a spiral pattern around its surface. The buds generate shoots that grow into new plants when conditions are favourable.

Late blight is a serious disease of potato family (*Solanaceous*) crops worldwide, caused by the pathogen *Phytophthora infestans*. Most serious diseases of potato worldwide can completely destroy a crop, resulting in 100 per cent yield loss. During 1840s, affected the Irish potato that killed a quarter of a million people through starvation. Currently it causes substantial economic losses in both conventional and organic potato production system throughout the Europe. Late blight is favoured by high humidity, dew, wet weather and moderate temperatures (10 to 26.7 °C).

Material and Methods

A field experiment was conducted during *Kharif*-2015 on "Effect of organic nutrient sources on late blight incidence and tuber yield of potato (*Solanum tuberosum* L.) in southern transitional zone of Karnataka"

The experiment was conducted at College of Agriculture, Hassan, University of Agricultural Sciences, Bangalore. The experimental site is geographically situated in the Southern Transitional Zone (Zone - No.7) of Karnataka and located between 12º 13' and 13º 33' N Latitude and 75º 33' and 76º 38' E Longitude at an latitude of 827 m above the Mean Sea Level (MSL). The experiment consisted of nine treatments with three replications laid out in RCBD design. The treatments are as follows.

Treatment Details

Nine treatment combinations were laid out in randomized complete block design with three replications.

T_1 = Recommended dose of nutrients 25 t FYM ha^{-1} + 75:75:100 kg NPK ha^{-1}.

T_2 = 50 per cent RDN through FYM + 50 per cent RDN through VC, fb CU foliar spray at 30, 45, 60 DAP (1:1 dilution with water).

T_3 = 50 per cent RDN through FYM + 50 per cent RDN through VC, fb FBM foliar spray at 30, 45, 60 DAP (1:1 dilution with water).

T_4 = 50 per cent RDN through FYM + 50 per cent RDN through VC, fb 5 per cent BOC foliar spray at 30, 45, 60 DAP.

T_5 = 50 per cent RDN through FYM + 50 per cent RDN through VC, fb 0.5 per cent silica foliar spray at 30, 45, 60 DAP.

T_6 = 50 per cent RDN through FYM + 50 per cent RDN through VC, fb CT foliar spray at 30, 45, 60 DAP (500 l ha^{-1}).

T_7 = 50 per cent RDN through FYM + 50 per cent RDN through VC, fb PG foliar spray at 30, 45, 60 DAP (1:1 dilution with water).

T_8 = 50 per cent RDN through FYM + 50 per cent RDN through VC, fb JM foliar spray at 30, 45, 60 DAP (1:1 dilution with water).

T_9 = 50 per cent RDN through FYM + 50 per cent RDN through VC, fb CU + FBM foliar spray at 30DAP, fb PG + JM foliar spray at 45 DAP, fb 5 per cent BOC + CT foliar spray at 60 DAP.

Note: VC: Vermi-compost, fb: Followed by, CU: cow urine, FBM: Fermented butter milk, BOC: Bio-fuel oil cake solution CT: Compost tea, PG : Panchagavya, JM: Jeevamrutha, RDN : Recommended dose of nitrogen.

(25 tonnes of FYM is common to all the treatments)

Plot Size

Gross plot : 4.8 m X 3.6 m = 17.28 m^2

Net plot : 3.6 m X 3.2 m = 11.52 m^2

Field key for assessing potato late blight disease severity is based on visible symptoms shown by crop that is number of affected lesions on the leaves, veins, shoots and stem were compared with CIP scale.

Application of Organic Manures and Treatment Imposition

Well decomposed organic manures like FYM and vermicompost were collected from College of

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Agriculture, Hassan. They were analyzed for their nitrogen content, and were applied to the concerned beds on nitrogen equivalent basis of recommended dose of nitrogen (RDN) to all treatment except control (T_1). The manures were applied two weeks before sowing of the crop and mixed thoroughly with soil.

Preparation of Panchagavya

Panchagavya: In Sanskrit, panchagavya means the blend of five products obtained from cow. All these five products are individually called as gavya and collectively termed as panchagavya. It consists of ghee, milk, curd, cow dung and cow urine.

Ingredients of Panchagavya

Fresh cattle dung (kg)	7
Fresh cattle urine (L)	2
Water (L)	10
Cow ghee (kg)	1
Cow milk (L)	2
Cow curd (L)	2
Sugarcane juice (L)	3
Jaggary (g)	250
Tender coconut water (L)	2
Ripened banana (kg)	1

Procedure followed for Preparing Panchagavya

a) Seven kg cow dung and one kg cow ghee were mixed well and kept for two days

b) Two liter cow urine and 10 liter water were added to the mixture and left for 15 days

c) Then three liters of sugarcane juice + two liters of cow milk + two liters of curd + two liters tender coconut water + 250 g jaggery + one kg ripened banana were added to accelerate the fermentation

d) The mixture was left for 14 days in a drum and stirred twice a day for about 20 minutes both in morning and evening and then filtered

e) Application dose: spray 500 (l ha^{-1}) in 1:1 dilution.

Application of Panchagavya in the Field

Before spraying in the field, 1:1 dilution of panchagavya was prepared with water then the diluted solution was sprayed to treatment T_7 and T_9 at respective interval of time.

Procedure for Preparation of Jeevamrutha

1. A plastic drum of 200 L capacity was filled with 90 L of water
2. Cattle dung (5 kg) was mixed with 10 liter water in a bucket and this mixture was added to drum followed by stirring with long stick
3. Then five L cattle urine was poured slowly with continuous stirring
4. Jaggery (one kg) was crushed to small pieces with pestle and mortar and added to drum with continuous stirring
5. Pulse flour (one kg) was added slowly to mixture with stirring to avoid formation of flour clods
6. One handful fertile soil was added to above mixture as source of beneficial micro-organisms
7. Jeevamruta was stirred well until mixture become homogenous
8. The drum was covered with plastic lid
9. Jevamruta was stirred twice in a day (morning - evening) during its incubation period
10. Jeevamruta was incubated for 120 - 144 hours

Ingredients

Fresh cattle dung (kg)	5
Fresh cattle urine (L)	5
Jaggery (kg)	1
Pulse flour (Horse gram) (kg)	1
Fertile soil	One handful
Water (L)	100

Application of Jeevamruta

Before spraying in the field, 1:1 dilution of Jeevamrutha was prepared with water then the diluted solution was sprayed to treatment T_8 and T_9 at scheduled period of time.

Compost Tea

Compost tea was prepared by using anaerobic decomposition of plant residues includes weeds like Eupatorium, Parthenium, Lantana and Calotrophis and tree species like Glyricedia, Pongemia, Subabul *etc*. Plants used preferably legume because it fixes nitrogen in their nodule and are scented plants hence these plants are mixed with cow dung in a cloth bag and dipped in cow urine and water solution for 30 days then the decoctions is taken by filtering with nylon cloth and used for application. In this anaerobic decomposition nitrogen is in ammonium condition so that plant can easily access to the nutrient and this also rich in iron, zinc, manganese micro nutrients.

Ingredients

Plants (cowpea plants)	30 to 40 kg
Cow dung	10 to 15 kg
Cow urine	10 to 15 L
Water	200 to 250 L

Procedure

In a 300 liter capacity plastic drum a bag is placed containing mixture of cow dung and cow urine and required quantity of water and cow urine mixture were added and kept these mixture for anaerobic decomposition for 30 days. The mixture was filtered with nylon cloth used for spraying to respective treatments at specified interval.

Bio Fuel Oil Cake Solution

Equal quantity of pongemia oil cake and water were mixed and kept over night. Then the solution mixture was taken and filtered with nylon cloth and this solution was used for application in field at 5 per cent concentration to the respective treatments at scheduled interval.

Cow Urine

Fresh cow urine was diluted in 1:1 proportion with water. Diluted mixture of cow urine (500 l ha^{-1}) was applied as foliar spray to the respective treatments at specified interval.

Fermented Butter Milk

Clear butter milk was taken and kept for fermentation for 25 to 30 days and it was then diluted with water in 1:1 dilution and sprayed to respective treatments at regular interval.

Silica Solution

Commercially available di atomacious silica solution was sprayed in 0.5 per cent concentration to the treatment (T_5) just to know their effect in controlling late blight disease. This is one of the farmer practice in and around Hassan district to control late blight disease.

Results and Discussion

I. Late Blight Disease Severity (%)

The data on disease severity at different growth stages as influenced by organic nutrient sprays in potato are presented in Table 1.

At 30 DAP, significantly lower disease severity was recorded in T_1 : Recommended dose of nutrients of 25 t FYM ha^{-1} + 75:75:100 kg of NPK ha^{-1} (1.5), T_7 : 50 per cent RDN through FYM + 50 per cent RDN through VC, fb PG foliar spray at 30, 45, 60 DAP (1:1 dilution with water). (1.5), T_8 : 50 per cent RDN through FYM + 50 per cent RDN through VC, fb JM foliar spray at 30, 45, 60 DAP (1:1 dilution with water) (1.6) and T_9 : 50 per cent RDN through FYM + 50 per cent RDN through VC, fb CU + FBM foliar spray at 30 DAP, fb PG + JM foliar spray at 45 DAP, fb 5 per cent BOC + CT foliar spray at 60 DAP. (1.8). Significantly higher disease severity was recorded with the application of T_4 : 50 per cent RDN through FYM + 50 per cent RDN through vermi-compost, followed by 5 per cent bio-fuel oil cake foliar spray at 30, 45, 60 DAP (2.5 %). Similar trend was also noticed at 45 DAP. At 60 DAP, significantly lower late blight disease severity was recorded in T_7 (35.7 %): 50 per cent RDN through FYM + 50 per cent RDN through VC, fb PG foliar spray at 30, 45, 60 DAP (1:1 dilution with water), T_8 (39.7 %) : 50 per cent RDN through FYM + 50 per cent RDN through VC, fb JM foliar spray at 30, 45, 60 DAP (1:1 dilution with water) (1.6) and T_9 (40.1 %) : 50 per cent RDN through FYM +

TABLE 1

Effect of different organic nutrient sprays on severity of late blight disease of potato caused by *Phytophthora infestans* at different growth stages

Treatments	Late blight severity (%)			
	30 DAP	45 DAP	60 DAP	75 DAP
T_1= Recommended dose of nutrients of 25 t FYM ha^{-1}+75:75:100 kg of NPK ha^{-1}.	1.5	28.5	27.9	30.1
T_2= 50% RDN through FYM + 50% RDN through VC, fb CU foliar spray at 30, 45, 60 DAP (1:1 dilution with water).	2.1	41.2	56.5	60.1
T_3= 50% RDN through FYM + 50% RDVN through C, fb FBM foliar spray at 30, 45, 60 DAP (1:1 dilution with water).	1.9	38.7	46.1	53.2
T_4= 50% RDN through FYM + 50% RDN through VC, fb 5% BOC foliar spray at 30, 45, 60 DAP.	2.5	42.1	58.1	61.4
T_5= 50% RDN through FYM + 50% RDN through VC, fb 0.5% silica foliar spray at 30, 45, 60 DAP.	2.1	40.9	47.1	55.9
T_6= 50% RDN through FYM + 50% RDN through VC, fb CT foliar spray at 30, 45, 60 DAP (500 l ha^{-1}).	1.8	38.1	43.4	54.1
T_7= 50% RDN through FYM + 50% RDN through VC, fb PG foliar spray at 30, 45, 60 DAP (1:1 dilution with water).	1.5	32.2	35.7	37.9
T_8= 50% RDN through FYM +50% RDN through VC, fb JM foliar spray at 30, 45, 60 DAP (1:1 dilution with water).	1.6	33.3	39.7	41.8
T_9= 50% RDN through FYM +50% RDN through VC, fb CU + FBM foliar spray at 30 DAP, fb PG + JM foliar spray at45 DAP, fb 5% BOC + CT foliar spray at 60 DAP.	1.8	33.7	40.1	42.1
S.Em.±	0.1	2.0	1.5	1.2
CD (P= 0.05)	0.3	5.9	4.5	3.8

Note: VC: Vermicompost, CU: cow urine, FBM: Fermented butter milk, BOC: Biofuel oil cake solution, CT: Compost tea, PG: Panchagavya, JM: Jeevamrutha, RDN: Recommended dose of nitrogen.

50 per cent RDN through VC, fb CU + FBM foliar spray at 30 DAP, fb PG + JM foliar spray at 45 DAP, fb 5 per cent BOC + CT foliar spray at 60 DAP late blight disease severity was significantly higher with application of 50 per cent RDN through FYM + 50 per cent RDN through vermi-compost, followed by 5 per cent bio-fuel oil cake foliar spray at 30, 45 and 60 DAP. Significantly higher late blight disease severity was recorded in T_4 (58.1) : 50 per cent RDN through FYM + 50 per cent RDN through VC, fb 5 per cent BOC foliar spray at 30, 45, 60 DAP. At 75 DAP, significantly lower late blight disease severity was recorded in T_7 (37.9 %): 50 per cent RDN through FYM + 50 per cent RDN through VC, fb PG foliar spray at 30, 45, 60 DAP (1:1 dilution with water), T_8 (41.8 %) : 50 per cent RDN through FYM + 50 per cent RDN through VC, fb JM foliar spray at 30, 45, 60 DAP (1:1 dilution with water) (1.6) and T_9 (42.1%): 50 per cent RDN through FYM + 50 per cent RDN through VC, fb CU + FBM foliar spray at 30 DAP, fb PG + JM foliar spray at 45 DAP, fb 5 per cent BOC + CT foliar spray at 60 DAP late blight disease severity was significantly higher with application of 50 per cent RDN through FYM + 50 per cent RDN through vermi-compost, followed by 5 per cent bio-fuel oil cake foliar spray at 30, 45 and 60 DAP. Significantly higher late blight disease severity was recorded in T_4 (61.4): 50 per cent RDN through FYM + 50 per cent RDN through VC, fb 5 per cent BOC foliar spray at 30, 45, 60 DAP. The organic nutrient sources compost tea,

panchagya, jeevamrutha, cow urine fermented butter milk in the treatments T_7, T_8 and T_9 have enhanced the growth and yield of potato crop including pest and disease resistance. These will have antifungal properties and may be attributed to the presence of antimicrobial substances particularly in cow dung such as patulodin like compound CK-2108 and CK-2108b produced by *Eupencillium bouifirmosum* present in cow dung. The effect was highest in panchagavya. *Basak* and *Lee* (2005) had found inhibitory activities of cow urine and cow dung in both in vitro and in vivo condition. The study revealed that the cow urine at different concentrations had considerable effect on vegetative growth of *Rhizoctonia solanai, Fusarium oxsporium* and *Sclerotium rolfizia* and it is found that 15 per cent concentration of cow urine showed maximum inhibition of growth of all the three fungal pathogens (Savita jandaik and Vishakha Sharma, 2016)

II. Yield Parameters

i) Tuber Weight Plant^{-1}

Higher tuber weight (139.3 g plant^{-1}) was recorded in treatment (T_1) with application of recommended dose of nutrients of 25 t FYM ha^{-1} + 75:75:100 kg of NPK ha^{-1} and lower tuber weight (98.0 g plant^{-1}) was recorded in treatment (T_4) with application of 50 per cent RDN through FYM + 50 per cent RDN through vermi-compost, followed by 5 per cent bio-fuel oil cake foliar spray at 30, 45, 60 DAP (Table 2).

ii) Number of Tubers Plant^{-1}

There were non significances among treatments. However higher, number of tuber (5.1 plant^{-1}) was recorded in treatment (T_1) with application of recommended dose of nutrients of 25 t FYM ha^{-1} + 75:75:100 kg of NPK ha^{-1}. Lower number of tuber were recorded in treatment (T_4) with application of 50 per cent RDN through FYM + 50 per cent RDN through Vermi-compost, followed by 5 per cent bio-fuel oil cake foliar spray at 30, 45 and 60 DAP (3.8 plant^{-1}) (Table 2).

III. Quality Parameters

Tuber Grading

D Grade (< 25 g)

Higher D grade tuber yield (3.8 t ha^{-1}) was recorded in treatment T_1 with recommended dose of nutrients of 25 t FYM ha^{-1} + 75:75:100 kg of NPK ha^{-1}. Lower number of D grade tuber yield was recorded in treatment T_9 with 50 per cent RDN through FYM + 50 per cent RDN through vermi-compost, followed by cow urine + butter milk foliar spray at 30 DAP, followed by Panchagvya + Jeevamrutha foliar spray at 45 DAP, followed by 5 per cent bio-fuel oil cake + compost tea foliar spray at 60 DAP (3.1 t ha^{-1}) (Table 2).

C Grade (25 - 50g)

Significantly higher C grade tuber yield (5.0 t ha^{-1}) was observed in treatment (T_1) with application of recommended dose of nutrients of 25 t FYM ha^{-1} + 75:75:100 kg of NPK ha^{-1}. Which was on par with 50 per cent RDN through FYM + 50 per cent RDN through vermi-compost, followed by cow urine foliar spray at 30, 45, 60 DAP (4.9 t ha^{-1}) and 50 per cent RDN through FYM + 50 per cent RDN through vermi-compost, followed by fermented butter milk foliar spray at 30, 45, 60 DAP (4.9 t ha^{-1}). While, 50 per cent RDN through FYM + 50 per cent RDN through vermi-compost, followed by panchagavya foliar spray at 30, 45, 60 DAP was recorded significantly lower C sized tuber yield (3.4 t ha^{-1}) (Table 2).

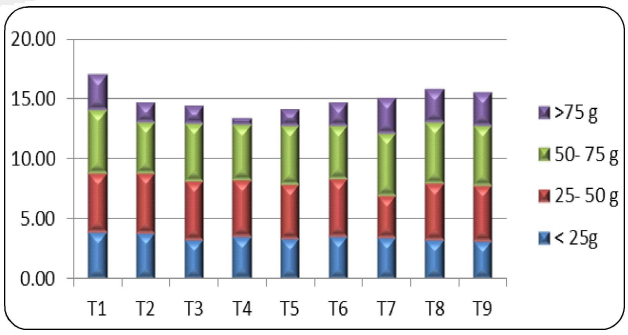

Fig. 1 : Effect of organic nutrients sources on different grades of potato

B Grade (50-75 g)

Higher B grade tuber yield (5.3 t ha^{-1}) was observed by the treatment (T_1) with recommended dose of

TABLE 2

Effect of different organic nutrient sprays on tuber grading and tuber yield of potato at harvest

Treatments	Tuber weight (g)	No. of tubers (No.)	Tuber grading (t ha^{-1})				Tuber yield (t ha^{-1})
			D (<25 g)	C (25 - 50 g)	B (50 - 75 g)	A (>75 g)	
T_1= Recommended dose of nutrients of 25 t FYM ha^{-1}+75:75:100 kg of NPK ha^{-1}	139.3	5.1	3.8	5.0	5.3	2.9	17.1
T_2= 50% RDN through FYM + 50% RDN through VC, fb CU foliar spray at 30, 45, 60 DAP (1:1 dilution with water)	122.2	4.3	3.8	4.9	4.2	1.7	14.8
T_3= 50% RDN through FYM + 50% RDVN through C, fb FBM foliar spray at 30, 45, 60 DAP (1:1 dilution with water)	108.1	4.2	3.2	4.9	4.8	1.5	14.5
T_4= 50% RDN through FYM + 50% RDN through VC, fb 5% BOC foliar spray at 30, 45, 60 DAP	98.0	3.8	3.5	4.8	4.5	0.5	12.3
T_5= 50% RDN through FYM + 50% RDN through VC, fb 0.5% silica foliar spray at 30, 45, 60 DAP	103.8	3.9	3.3	4.6	4.8	1.3	14.2
T_6= 50% RDN through FYM + 50% RDN through VC, fb CT foliar spray at 30, 45, 60 DAP (500 l ha^{-1})	111.8	4.2	3.5	4.8	4.4	1.9	14.7
T_7= 50% RDN through FYM + 50% RDN through VC, fb PG foliar spray at 30, 45, 60 DAP (1:1 dilution with water)	134.7	4.9	3.4	3.4	5.2	2.9	16.5
T_8= 50% RDN through FYM +50% RDN through VC, fb JM foliar spray at 30, 45, 60 DAP (1:1 dilution with water)	130.4	4.8	3.3	4.7	5.1	2.7	15.9
T_9= 50% RDN through FYM +50% RDN through VC, fb CU + FBM foliar spray at 30 DAP, fb PG + JM foliar spray at45 DAP, fb 5% BOC + CT foliar spray at 60 DAP	127.2	4.3	3.1	4.6	4.9	2.7	15.5
S.Em.±	9.5	0.3	0.3	0.2	0.3	0.1	0.7
CD (P= 0.05)	28.5	0.9	NS	0.8	NS	0.4	2.1

Note : VC: Vermicompost, CU: cow urine, FBM: Fermented butter milk, BOC: Biofuel oil cake solution, CT: Compost tea, PG: Panchagavya, JM: Jeevamrutha, RDN: Recommended dose of nitrogen.

nutrients of 25 t FYM ha^{-1} + 75:75:100 kg of NPK ha^{-1}. While, 50 per cent RDN through FYM + 50 per cent RDN through vermi-compost, followed by treatment (T_2) cow urine foliar spray at 30, 45, 60 DAP was recorded lower B sized tuber yield (4.2 t ha^{-1}) (Table 2).

A Grade (> 75 g)

Significantly higher A grade tuber yield (2.9 t ha^{-1}) was observed with the recommended dose of nutrients of 25 t FYM ha^{-1} + 75:75:100 kg of NPK ha^{-1}. Closely followed by 50 per cent RDN through FYM + 50 per cent RDN through vermi-compost, followed by panchagavya foliar spray at 30, 45, 60 DAP (2.9 t ha^{-1}) and 50 per cent RDN through FYM + 50 per cent RDN through vermi-compost, followed by jeevamrutha foliar spray at 30, 45, 60 DAP (2.7 t ha^{-1}). While, 50 per cent RDN through FYM + 50 per cent RDN through vermi-compost, followed by 5 per cent bio-fuel oil cake foliar spray at 30, 45, 60 DAP recorded significantly lower A grade tuber yield (0.5 t ha^{-1}) (Table 2).

Tuber Yield (t ha^{-1})

Application of recommended dose of nutrients of 25 t FYM ha^{-1} + 75:75:100 kg of NPK ha^{-1} recorded significantly higher tuber yield (17.1 t ha^{-1}) in T_1, closely followed by treatment in T_7 with application of 50 per cent RDN through FYM + 50 per cent RDN through vermi-compost, followed by panchagavya foliar spray at 30, 45, 60 DAP (16.5 t ha^{-1}) and 50 per cent RDN through FYM + 50 per cent RDN through vermi-compost, followed by jeevamrutha foliar spray at 30, 45, 60 DAP (15.9 t ha^{-1}) (T_8). While, significantly lower tuber yield was recorded in treatment in T_4 (12.3 t ha^{-1}) DN through vermi-compost, followed by 5 per cent bio-fuel oil cake foliar spray at 30, 45, 60 DAP (Table 2).

Crop yield is controlled by the interaction between the genetic potentialities of crop plants and the environment in which they grow. Variations in the genotype and in the environment, including weather and cultural practices, act through physiological processes to control growth. Thus the physiological processes of plants are the machinery through which both the genetic potentialities and the environment operate to produce the quantity and quality of growth or phenotype which is termed as yield.

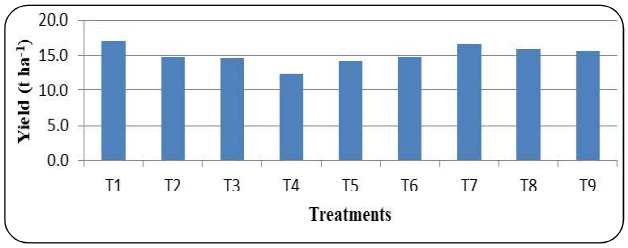

Fig. 2 : Effect of organic nutrients sources on tuber yield of potato

The higher yield recorded might be due to the fact that nitrogen and phosphorus play an important role in the synthesis of chlorophyll and amino acids, fertilizer addition ensure the more availability and uptake of plant nutrients. Application of fertilizer at right time and in right quantity in right place will meet the crop nutrient demand at right time so, it ultimately resulted in higher yield. Application of FYM besides supplying N, P and K also supplies micro nutrients and improved the soil condition, which enhanced the root proliferation and source to sink relationship. Increase in yield in these treatments may also be attributed to synergistic effect of combined use of fertilizer and FYM.

Grades of potato was significantly higher in application of recommended dose of nutrients of 25t FYM ha^{-1} + 75:75:100 Kg of NPK ha^{-1} with respect to A, B, C and D grade (2.9, 5.3, 5.0 and 3.8 t ha^{-1} respectively) compared to other treatments. This might be due to combined effect of fertilizer and FYM. In this treatment application of fertilizer along with FYM matched with crop demand and nutrient supply. The increased size pertaining to different grade is might be attributed to improvement in the growth components such as plant height, number of shoots, number of leaves $plant^{-1}$, leaf area and total dry matter. Foliar spray of panchagavya and cow urine was found to be beneficial in the improvement of plant growth vigor as plant growth promoter and might be the factor for induction of disease resistance in crop plant. Similar findings were reported by Anand and Krishnappa, 1989.

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TABLE 3

Effect of different organic nutrient sprays on total nutrient uptake by potato at harvest

Treatments	Total (kg ha^{-1})		
	N	P_2O_5	K_2O
T_1= Recommended dose of nutrients of 25 t FYM ha^{-1}+75:75:100 kg of NPK ha^{-1}	102.8	34.2	111.3
T_2= 50% RDN through FYM + 50% RDN through VC, fb CU foliar spray at 30, 45, 60 DAP (1:1 dilution with water)	88.9	29.6	96.3
T_3= 50% RDN through FYM + 50% RDVN through C, fb FBM foliar spray at 30, 45, 60 DAP (1:1 dilution with water)	87.3	29.1	94.6
T_4= 50% RDN through FYM + 50% RDN through VC, fb 5% BOC foliar spray at 30, 45, 60 DAP	74.0	24.6	80.1
T_5=50% RDN through FYM + 50% RDN through VC, fb 0.5% silica foliar spray at 30, 45, 60 DAP	85.2	28.4	92.3
T_6= 50% RDN through FYM + 50% RDN through VC, fb CT foliar spray at 30, 45, 60 DAP (500 l ha^{-1})	88.6	29.5	96.0
T_7= 50% RDN through FYM + 50% RDN through VC, fb PG foliar spray at 30, 45, 60 DAP (1:1 dilution with water)	99.3	33.1	107.6
T_8= 50% RDN through FYM +50% RDN through VC, fb JM foliar spray at 30, 45, 60 DAP (1:1 dilution with water)	95.7	31.9	103.6
T_9= 50% RDN through FYM +50% RDN through VC, fb CU + FBM foliar spray at 30 DAP, fb PG + JM foliar spray at45 DAP, fb 5% BOC + CT foliar spray at 60 DAP	93.5	31.1	101.3
S.Em.±	4.3	1.4	4.7
CD (P= 0.05)	13.0	4.3	14.1

Note : VC: Vermicompost, CU: cow urine, FBM: Fermented butter milk, BOC: Biofuel oil cake solution, CT: Compost tea, PG: Panchagavya, JM: Jeevamrutha,RDN: Recommended dose of nitrogen.

IV. Total Uptake of Nutrients

The data on total nutrient uptake by potato as influenced by different organic nutrient sprays in potato are presented in Table 3. Different organic nutrient sprays significantly influenced the nitrogen uptake by potato crop. Significantly higher nitrogen uptake by potato was recorded with recommended dose of nutrients 25 t FYM ha^{-1} + 75:75:100 kg of NPK ha^{-1} (102.8kg ha^{-1}), closely followed by 50 per cent RDN through FYM + 50 per cent RDN through vermicompost, followed by panchagavya foliar spray at 30, 45, 60 DAP (99.3kg ha^{-1}) and 50 per cent RDN through FYM + 50 per cent RDN through vermicompost, followed by jeevamrutha foliar spray at 30, 45, 60 DAP (95.7kg ha^{-1}). Significantly lower nitrogen uptake by potato (74.0 kg ha^{-1}) was found with 50 per cent RDN through FYM + 50 per cent RDN through vermicompost, followed by 5 per cent biofuel oil cake foliar spray at 30, 45, 60 DAP.

Significantly higher phosphorus uptake by potato was recorded with recommended dose of nutrients of 25 t FYM ha^{-1} + 75:75:100 kg of NPK ha^{-1} (34.2kg ha^{-1}), closely followed by 50 per cent RDN through FYM + 50 per cent RDN through vermicompost, followed by panchagavya foliar spray at 30, 45, 60 DAP (33.1kg ha^{-1}) and 50 per cent RDN through FYM + 50 per

TABLE 4

Economics of potato as influenced by different organic nutrient sources

Treatments	Tuber yield (t ha-1)	Cost of cultivation (Rs. ha-1)	Gross returns (Rs. ha-1)	Net returns (Rs. ha-1)	B:C
T_1= Recommended dose of nutrients of 25 t FYM ha^{-1}+75:75:100 kg of NPK ha^{-1}	17.1	65568	205560	139992	2.14
T_2= 50% RDN through FYM + 50% RDN through VC, fb CU foliar spray at 30, 45, 60 DAP (1:1 dilution with water)	14.8	65896	192660	126764	1.92
T_3= 50% RDN through FYM + 50% RDVN through C, fb FBM foliar spray at 30, 45, 60 DAP (1:1 dilution with water)	14.5	66093	189280	123186	1.86
T_4= 50% RDN through FYM + 50% RDN through VC, fb 5% BOC foliar spray at 30, 45, 60 DAP	12.3	66028	160333	94306	1.43
T_5= 50% RDN through FYM + 50% RDN through VC, fb 0.5% silica foliar spray at 30, 45, 60 DAP	14.2	66093	184643	118551	1.79
T_6= 50% RDN through FYM + 50% RDN through VC, fb CT foliar spray at 30, 45, 60 DAP (500 l ha^{-1})	14.7	65962	192097	126135	1.91
T_7= 50% RDN through FYM + 50% RDN through VC, fb PG foliar spray at 30, 45, 60 DAP (1:1 dilution with water)	16.5	66358	215237	148879	2.24
T_8= 50% RDN through FYM +50% RDN through VC, fb JM foliar spray at 30, 45, 60 DAP (1:1 dilution with water)	15.9	66028	207350	141322	2.14
T_9= 50% RDN through FYM +50% RDN through VC, fb CU + FBM foliar spray at 30 DAP, fb PG + JM foliar spray at45 DAP, fb 5% BOC + CT foliar spary at 60 DAP	15.5	66061	202670	136609	2.07

Note : VC : Vermicompost, CU: cow urine, FBM: Fermented butter milk, BOC: Biofuel oil cake solution, CT: Compost tea, PG: Panchagavya, JM: Jeevamrutha, RDN: Recommended dose of nitrogen.

cent RDN through vermicompost, followed by jeevamrutha foliar spray at 30, 45, 60 DAP (95.7kg ha^{-1}). Significantly lower phosphorus uptake by potato (24.6kg ha^{-1}) was found with 50 per cent RDN through FYM + 50 per cent RDN through vermicompost, followed by 5 per cent biofuel oil cake foliar spray at 30, 45, 60 DAP.

Significantly higher potassium uptake by potato was recorded with recommended dose of nutrients of 25 t FYM ha^{-1} + 75:75:100 kg of NPK ha^{-1} (111.3kg ha^{-1}), closely followed by 50 per cent RDN through FYM + 50 per cent RDN through vermicompost, followed by panchagavya foliar spray at 30, 45, 60 DAP (107.6kg ha^{-1}) and 50 per cent RDN through FYM + 50 per cent RDN through vermicompost, followed by jeevamrutha foliar spray at 30, 45, 60 DAP (103.6kg ha^{-1}). Significantly lower potassium uptake by potato (80.1kg ha^{-1}) was found with 50 per cent RDN through FYM + 50 per cent RDN through vermicompost, followed by 5 per cent biofuel oil cake foliar spray at 30, 45, 60 DAP. The results are in confirmity with the findings of Upadhayay and Grewal, 1987.

V. Economics

Economics of potato as influenced by organic nutrient sprays are presented in Table 4. The higher gross returns and net returns (215237 and 148879 $Rs.ha^{-1}$) were recorded in the treatment with application of 50 per cent RDN through FYM + 50 per cent RDN through vermicompost, followed by panchagavya foliar spray at 30, 45, 60 DAP, closely followed by 50 per cent RDN through FYM + 50 per cent RDN through vermicompost, followed by jeevamrutha foliar spray at 30, 45, 60 DAP (207350 and 141322 $Rs.ha^{-1}$) and lower gross returns and net returns (160333 and 94306 $Rs.ha^{-1}$) was noticed in the treatment with 50 per cent RDN through FYM + 50 per cent RDN through vermicompost, followed by 5 per cent biofuel oil cake foliar spray at 30, 45, 60 DAP.

The higher B:C ratio (2.24) was recorded in the treatment with 50 per cent RDN through FYM + 50 per cent RDN through vermicompost, followed by panchagavya foliar spray at 30, 45, 60 DAP, closely followed by treatments *viz*., application of 50 per cent RDN through FYM + 50 per cent RDN through vermicompost, followed by jeevamrutha foliar spray at 30, 45, 60 DAP and recommended dose of nutrients of 25 t FYM ha^{-1} + 75:75:100 kg of NPK ha^{-1} (2.14 and 2.14 respectively) and lower B:C ratio (1.43) was noticed in the treatment with 50 per cent RDN through FYM + 50 per cent RDN through vermicompost, followed by 5 per cent biofuel oil cake foliar spray at 30, 45, 60 DAP.

From the investigation it can be inferred that, recommended dose of nutrients of 25 t FYM ha^{-1} + 75:75:100 kg of NPK ha^{-1} followed by 50 per cent RDN through FYM + 50 per cent RDN through VC, fb PG foliar spray at 30, 45, 60 DAP (1:1 dilution with water) is the best practice which recorded significantly lower disease severity.

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