RESUME

Full Name :- Mr. Dipak Prakash Gite

Father's name :- Shri. Prakash Ambadas Gite

Permanent Address :- Flat no 9, Swapnashilp Apartment, Near Patil milk dairy, Old RTO Road, Giri Nagar, Akola (MS)- 444001

Date Of Birth :- 28th Dec 1995

Gender :- Male

Marital Status :- Unmarried

Nationality :- Indian

Contact No. :- 9552957364

E-mail :- dipakgite01@gmail.com

Languages Known :- Marathi, Hindi, English

Academic Qualification: -

Degree/Name of exam	University	Institution	Specialization	Year of Passing	Percentage
M.Sc	Lovely Professional University, Phagwara, Punjab	Lovely Professional University, Phagwara, Punjab	Agronomy	Likely to be completed (Up to 30th Sept.2021)	7.51 CGPA
B.Sc	Dr.Panjabrao Deshmukh Krushi Vidyapeeth, Akola	Shri. Shivaji College of Horticulture, Amravati	Horticulture	2017	7.13 CGPA
H.S.C	Maharashtra State Board, Amaravati	S.N collage Akola	Science	2013	49 %
S.S.C	Maharashtra State Board , Amaravati	D.R.Patil high school Akola	General	2011	54.60 %

Certifications:-

- Certification course in information technology -2013
- Discover the leader in you from aspire institute of human development -2018
- Industry institute meet on “coping agricultural student as an entrepreneur” - 2018
- The national symposium on smart and sustainable agriculture (agricon-2019) -Certificate awaited
- Workshop on trends, techniques, and opportunities for entrepreneurship in organic food -2020
- E-workshop on student entrepreneurship in current scenario of agriculture education (NAHEP) -2020
- Industry institute e- meet on innovative start-up in agriculture sector -2020
- Earth Observation for Carbon Cycle Studies -2021

Publications:-

Title	**Name of authors**	**Publication details**
The response of Bio-fertilizers to the production potential of cereal crops	Dipak P. Gite, Prakash A. Gite and Mayur S. Darvhankar	Plant Archives Vol. 21, Supplement 1, 2021 pp. 2401-2407 **doi link : https://doi.org/10.51470/PLANTARCHIVES.2021.v21.S1.392**
Zinc sulphate a potential micronutrient for wheat growth: A review	Dipak Gite, Harshada Gite, Mayur Darvhankar and Prakash Gite	The Pharma Innovation Journal 2021; 10(5): 473-475 www.ThePharmaJournal.com

I hereby declared that above mention information is correct to my knowledge.

Place – Akola

Date – 29th July 2021

(DIPAK. PRAKASH .GITE)

Provisional Academic Transcript

Student Name : **Gite Dipak Prakash**

Programme : **P26B-NN1 :: Master of Science (Agriculture - Agronomy)**

Prov. Regd. No. : **11902554**

Father's Name : **Mr. Prakash Ambasdas Gite**

Mother's Name : **Ms. Vandana**

Mode : Regular

Date of initial registration :August,2019

Term : I **SGPA : 7.29** **Equivalent percentage : 72.90**

S.No.	Course	Credit Hours	Credit Points	Status
1	AGR501 :: PRINCIPLES AND PRACTICES OF WEED MANAGEMENT	3.00	7.60	PASS
2	AGR514 :: MODERN CONCEPTS IN CROP PRODUCTION	3.00	7.30	PASS
3	AGR586 :: BASIC CONCEPTS IN LABORATORY TECHNIQUES	0.00 NC	6.80	S
4	AGR591 :: PRE DISSERTATION	2.00 NC	8.30	S
5	LIB201 :: LIBRARY AND INFORMATION SERVICES	0.00 NC	7.10	S
6	MTH520 :: STATISTICAL METHODS	2.00	6.80	PASS

Term : II **SGPA : 7.35** **Equivalent percentage : 73.50**

S.No.	Course	Credit Hours	Credit Points	Status
1	AGR528 :: PRINCIPLES AND PRACTICES OF SOIL FERTILITY AND NUTRIENT MANAGEMENT	3.00	7.80	PASS
2	AGR529 :: AGRONOMY OF MAJOR CEREALS AND PULSES	3.00	6.50	PASS
3	AGR530 :: PRINCIPLES OF PLANT PHYSIOLOGY	3.00	7.70	PASS
4	AGR587 :: AGRICULTURAL RESEARCH ETHICS AND RURAL DEVELOPMENT PROGRAMMES	0.00 NC	8.00	S
5	AGR596 :: DISSERTATION-I	2.00 NC	7.80	S
6	SOL529 :: SOIL EROSION AND CONSERVATION	3.00	7.40	PASS

Term : III **SGPA : 7.79** **Equivalent percentage : 77.90**

S.No.	Course	Credit Hours	Credit Points	Status
1	AGR533 :: PRINCIPLES AND PRACTICES OF ORGANIC FARMING	3.00	8.20	PASS
2	AGR560 :: TECHNICAL WRITING AND COMMUNICATIONS SKILLS	0.00 NC	6.90	S
3	AGR588 :: INTELLECTUAL PROPERTY AND ITS MANAGEMENT IN AGRICULTURE	0.00 NC	8.10	S
4	AGR590 :: SEMINAR	1.00	8.10	PASS
5	AGR659 :: DISSERTATION-II	6.00 NC	8.10	S
6	CHE136 :: DISASTER MANAGEMENT	0.00 NC	8.80	S
7	SOL508 :: SOIL FERTILITY AND FERTILIZER USE	4.00	7.60	PASS
8	SOL509 :: PRINCIPLES AND PRACTICES OF WATER MANAGEMENT	3.00	7.80	PASS
9	SOL563 :: SOIL BIOLOGY AND BIOCHEMISTRY	3.00	7.50	PASS

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Date of Printing: 29 Jul 2021
Place : Phagwara (Punjab)

Prepared By
IT Cell

Provisional Academic Transcript

Student Name : **Gite Dipak Prakash**

Prov. Regd. No. : **11902554**

Father's Name : **Mr. Prakash Ambasdas Gite**

Mother's Name : **Ms. Vandana**

Programme : **P26B-NN1 :: Master of Science (Agriculture - Agronomy)**

Mode : Regular

Date of initial registration :August,2019

Term : IV	SGPA : 7.50		Equivalent percentage : 75.00	
S.No.	**Course**	**Credit Hours**	**Credit Points**	**Status**
1	AGR540 :: CROPPING SYSTEMS AND SUSTAINABLE AGRICULTURE	2.00	7.50	PASS
2	AGR660 :: DISSERTATION-III	10.00	4.20	I

This is a provisional transcript and is valid till a regular transcript is issued	**CGPA : 7.51**
Student yet not completed the programme.	**Equivalent percentage : 75.1 %**

Associate Dean
Division of Examination
Lovely Professional University
Phagwara (Punjab)

This is system generated Academic Transcript does not require any seal.

Disclaimer: This Provisional Academic Transcript is issued on the basis of information available in the office of records on the date of its issue and the University reserves the right to update/change any information contained herein without notice. Further the University expressly disclaims all obligations to confirm the accuracy of any of the particulars in this Provisional Academic Transcript based upon information submitted by the candidate.

Date of Printing: 29 Jul 2021
Place : Phagwara (Punjab)

Prepared By
IT Cell

BASIS OF EVALUATION

1. Basis of Credit Points in each Course :
The cumulative marks obtained by a student in a course (out of 100) are calculated by, taking into account weighted marks of all the evaluationcomponentsfor a semester i.e. continuous assessment, mid-term tests,end term examinations. The cumulative marks (obtained in a particular course) are converted into credit points by dividing the marks by 10.
2. Status :
A student's performance in a particular course is reported as "Status". The abbreviations or symbols used for status are as under:

Abbreviation/symbol	Description
PASS	Student has successfully cleared the course
S	Satisfactory (for non-credited courses only)
ReAPP	Student has not cleared the course
FAIL	Student has failed the course
U	Unsatisfactory (for non-credited courses only)
R	Resubmission (in case of projects/dissertations or other similar courses)

3. Semester Grade Point Average (SGPA) and Cumulative Grade Point Average (CGPA)
A student's overall academic performance within a given semester is represented by Semester Grade Point Average (SGPA) and the overall performance in all the courses completed up to and including the current semester is represented by Cumulative Grade Point Average (CGPA). SGPA and CGPA are calculated by the formula given as under:
SGPA / CGPA = $\sum Ci\ Hi / \sum Hi$, where Ci represents the credits associated with a course and Hi represents the credit hours associated with the ith course. While SGPA is calculated for courses of concerned semester, CGPA is calculated by using the same formula and considering all courses of previous semesters for which results have been declared.

4. If conversion from CGPA to marks is required, the equivalent percentage of marks may be calculated by multiplying CGPA with 10.

5. The CGPA requirement for award of diploma/UG degree will be 5.5 or above and for award of PG/Ph.D. degree will be 6.5 or above, subject to passing all the courses as per the programme scheme and satisfying other conditions as specified in the examination ordinances/ rules and programme details.

6. Division	CGPA
First with distinction	9.0 or more subject to the condition that student has passed all the courses in the 1st attempt.
First	7.0 or more but less than 9.0

7. This academic transcript can be authenticated by writing to Examination Division or via e-mail at examination@lpu.co.in / ao.records@lpu.co.in, Lovely Professional University, Jalandhar-Delhi GT Road, Phagwara
144411, Punjab, India.

Sr. No. 116

Enrolment No. LL/1973

Dr. Panjabrao Deshmukh Krishi Vidyapeeth

This is to certify that

Gite Dipak Prakash

has been admitted to the degree of

Bachelor of Science (Horticulture)

of this University in the year **2017** with Cumulative Grade Point Average **7.13** in the scale of 10.00 and was placed in **Second** Division.

In testimony whereof are set the seal of the said University and the signature of the said Vice-Chancellor.

Krishinagar, Akola
(Maharashtra) INDIA
Dated : 5th February, 2018

VICE-CHANCELLOR

महाराष्ट्र राज्य माध्यमिक व उच्च माध्यमिक शिक्षण मंडळ, पुणे
Maharashtra State Board Of Secondary and Higher Secondary Education, Pune

अमरावती विभागीय मंडळ / AMRAVATI DIVISIONAL BOARD

उच्च माध्यमिक प्रमाणपत्र परीक्षा – गुणपत्रक
HIGHER SECONDARY CERTIFICATE EXAMINATION - STATEMENT OF MARKS

शाखा STREAM	आसन क्रमांक SEAT NO.	केन्द्र क्रमांक CENTRE NO.	जिल्हा व उच्च माध्य. शाळा क्रमांक DIST & HR.SEC.SCHOOL NO.	परीक्षेचा महिना व वर्ष MONTH & YEAR OF EXAM.	गुणपत्रिकेचा अनुक्रमांक SR.NO. OF STATEMENT
SCIENCE	V002323	0115	01.01.010	FEBRUARY-13	003841

उमेदवाराचे संपूर्ण नाव (आडनाव प्रथम) / CANDIDATE'S FULL NAME (SURNAME FIRST)

Gite Dipak Prakash

उमेदवाराच्या आईचे नाव / CANDIDATE'S MOTHER'S NAME **Vandana**

विषयाचा सांकेतिक क्रमांक व विषयाचे नाव Subject Code No. and Subject Name	*माध्यम Medium	कमाल गुण Max. Marks	प्राप्त गुण / Marks Obtained	
			In Figures	In Words
01 ENGLISH	ENG	100	061	SIXTYONE
02 MARATHI	MAR	100	063	SIXTYTHREE
49 ECONOMICS	MAR	100	052	FIFTYTWO
54 PHYSICS	ENG	100	042	FORTYTWO
55 CHEMISTRY	ENG	100	040	FORTY
56 BIOLOGY	ENG	100	035	THIRTYFIVE
31 ENVIRONMENT EDUCATION (GRADE)	A			

Result / निकाल	Percentage / टक्केवारी	एकूण गुण / Total Marks			
PASS	48.83		600	293	TWO HUNDRED AND NINETYTHREE

H130288841

2903799707776

[illegible]

See overleaf for Important, Notes, Grades in Environment Education Subject and meaning of special characters.

विभागीय सचिव/Divisional Secretary

महाराष्ट्र राज्य माध्यमिक व उच्च माध्यमिक शिक्षण मंडळ, पुणे
Maharashtra State Board Of Secondary and Higher Secondary Education, Pune

अमरावती विभागीय मंडळ / AMRAVATI DIVISIONAL BOARD

माध्यमिक शालान्त प्रमाणपत्र परीक्षा - गुणपत्रक
SECONDARY SCHOOL CERTIFICATE EXAMINATION - STATEMENT OF MARKS

आसन क्रमांक SEAT NO.	केन्द्र क्रमांक CENTRE NO.	जिल्हा व शाळा क्रमांक DIST. & SCHOOL NO.	परीक्षेचा महिना व वर्ष MONTH & YEAR OF EXAM.	गुणपत्रिकेचा अनुक्रमांक SR.NO. OF STATEMENT
H005145	1039	01.01.048	MARCH-2011	005876

उमेदवाराचे संपूर्ण नाव (आडनाव प्रथम) / CANDIDATE'S FULL NAME (SURNAME FIRST)

Gite Dipak Prakash

उमेदवाराच्या आईचे नाव / CANDIDATE'S MOTHER'S NAME **Vandana**

विषयाचा सांकेतिक क्रमांक व विषयाचे नाव Subject Code No. and Subject Name	कमाल गुण Max. Marks	प्राप्त गुण किंवा श्रेणी / Marks or Grade Obtained In Figures	In Words
01 MARATHI (1ST LANG)	100	048	FORTYEIGHT
BD HINDI-SANSKRIT (2/3 LANG)	100	061	SIXTYONE
17 ENGLISH (2/3 LANG)	100	065	SIXTYFIVE
71 MATHEMATICS	150	053	FIFTYTHREE
72 SCIENCE & TECHNOLOGY	100	050	FIFTY
73 SOCIAL SCIENCES	100	049	FORTYNINE
K7 INFORMATION TECHNOLOGY	*	A	
P1 HEALTH & PHYSICAL EDUCATION	*	A	
P6 SOCIAL SERVICE	*	A	
R6 PERSONALITY DEVELOPMENT	*	A	
38 ENVIRONMENT EDUCATION	*	A	

Result / निकाल	£ Percentage/टक्केवारी	एकूण गुण / Total Marks			
PASS	54.60		500	273	TWO HUNDRED AND SEVENTYTHREE

S111505876

37144997275S8

[illegible]
See overleaf for important, Notes, Grades in work experience & school subjects and meaning of special characters.

विभागीय सचिव/Divisional Secretary

महाराष्ट्र शासन पंजीकृत (महाराष्ट्र २२६४०)

उच्च व तंत्र शिक्षण विभाग महाराष्ट्र राज्य पुरस्कृत
महाराष्ट्र माहिती तंत्रज्ञान सहाय्यता केंद्र आयोजित

युवाजागर
अभियान

MAHARASHTRA INFORMATION TECHNOLOGY SUPPORT CENTER

CERTIFICATE

This is certify that

GITE DIPAK PRAKASH

has successfully completed

CERTIFICATE COURSE IN INFORMATION TECHNOLOGY (CCIT)

passed the exam held in the month of **DECEMBER 2013** *has awarded with the Grade* **"A+"** *,Duration of the course from* **OCTOBER 2013 TO DECEMBER 2013**

P.S. Yelaja
Secretary
MAHARASHTRA INFORMATION TECHNOLOGY SUPPORT CENTER

Jasswant
President
MAHARASHTRA INFORMATION TECHNOLOGY SUPPORT CENTER

Place : Uvak Kalyan Kaksha, Amravati

Date : 2nd Dec. 2013

Center Name : Shivaji Horticalture College, Amravati

Sr No 001438

Aspire

Aspire The Institute Of Human Development

DISCOVER THE LEADER IN YOU

3 Days Workshop

Certificate

This certificate is gratefully presented to

Dipak Gite

for his/her outstanding and an active contribution as a participation in the 'Discover The Leader In You', three days workshop. We hope that you will continue to perform better. All the best!

Director
Aspire-TIHD

Research and Development Head
Aspire-TIHD

Date: 12 - 14 Oct 2018

NATIONAL AGRICULTURAL HIGHER EDUCATION PROJECT
Dr. PANJABRAO DESHMUKH KRISHI VIDYAPEETH, AKOLA
MAHARASHTRA STATE, INDIA - 444104

ICAR

CERTIFICATE OF PARTICIPATION

This is to certify that Prof./Dr./Mr./Ms. D. P. Gite has actively participated in Industry-Institute Meet on "Coping Agricultural Students as an Entrepreneur" supported by Indian Council of Agricultural Research, New Delhi and organized by National Agricultural Higher Education Project (Innovation Grant) on Capacity Building and Skill Development in Renewable Energy, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola on December 14, 2018. This Industry-Institute meet has provided the platform to the students and faculties to interact with the leading innovative industrialists and established the linkage between academic program and industry.

Place: Akola
Date: December 14, 2018

Principal Investigator
NAHEP-Dr. PDKV, Akola

Co-Principal Investigator
NAHEP-Dr. PDKV, Akola

HUMAN RESOURCE DEVELOPMENT CENTER

[Under the Aegis of Lovely Professional University, Jalandhar-Delhi G.T. Road, Phagwara (Punjab)]

Certificate No. 198796

Certificate of Participation

This is to certify that **Mr. Dipak Gite**, S/o Sh. Prakash Gite participated in **Workshop on Trends Techniques and Opportunities for entrepreneurship in Organic foods** organized at Lovely Professional University w.e.f **January 24, 2020** to **January 25, 2020** and obtained **"O"** Grade.

Head
School of Agriculture

Sumaira Ahuja
Head
Human Resource Development Center

NAHEP

National Agricultural Higher Education Project

Faculty of Agricultural Engineering

Dr. Panjabrao Deshmukh Krishi Vidyapeeth Akola

P.O. Krishi Nagar Akola-444 101 (M.S.) India

www.pdkv.ac.in nahep.akl@gmail.com

NAHEP BSW 2020

Certificate

of participation

This is to certify that

Mr. Dipak Prakash Gite

Participated in One Day Brainstorming e-Workshop on

"Student Entrepreneurship in Current Scenario of Agricultural Education"

held on July 20, 2020 at Department of Unconventional Energy Sources and Electrical Engineering, Dr. panjabrao Deshmukh Krishi Vidyapeeth Akola, (M.S) India.

(M. B. Nagdeve)	(S. R. Kalbande)	(V. P. Khambalkar)
Dean, Faculty of Agril. Engg., Dr. PDKV, Akola	Principal Investigator, NAHEP, Dr. PDKV, Akola	Co-Principal Investigator NAHEP, Dr. PDKV, Akola

Verify the authenticity of the certificate at https://www.pdkv.ac.in/Circulars/registeredcand-brainstormingworkshop-200720.pdf

NAHEP

IIM

2020

National Agricultural Higher Education Project

Faculty of Agricultural Engineering

Dr. Panjabrao Deshmukh Krishi Vidyapeeth Akola

P.O. Krishi Nagar Akola-444 101 (M.S.) India

www.pdkv.ac.in   nahep.akl@gmail.com

ICAR

Certificate

of participation

This is to certify that

Dipak Prakash Gite

Participated in One Day Industry Institute e-Meet on

"Innovative Start-Ups in Agricultural Sector"

held on July 30, 2020 organized by NAHEP-IG on Capacity Building and Skill Development in Renewable Energy, Department of Unconventional Energy Sources and Electrical Engineering, Faculty of Agricultural Engineering, Dr. Panjabrao Deshmukh Krishi Vidyapeeth Akola, (M.S) India.

(M. B. Nagdeve)	(S. R. Kalbande)	(V. P. Khambalkar)
Dean, Faculty of Agril. Engg., Dr. PDKV, Akola	Principal Investigator, NAHEP, Dr. PDKV, Akola	Co-Principal Investigator NAHEP, Dr. PDKV, Akola

Verify the authenticity of the certificate at https://www.pdkv.ac.in/Circulars/industryinstituteemeet-participants-300720.pdf

अंतरिक्ष विभाग /DEPARTMENT OF SPACE
भारत सरकार/GOVERNMENT OF INDIA
भारतीय अंतरिक्ष अनुसंधान संगठन /INDIAN SPACE RESEARCH ORGANISATION
भारतीय सुदूर संवेदन संस्थान, देहरादून / INDIAN INSTITUTE OF REMOTE SENSING, DEHRADUN

नामांकन सं. / Enrolment No.: 2021801067426

CERTIFICATE OF PARTICIPATION IN ONLINE COURSE

यह प्रमाणपत्र
श्री गिते दिपक प्रकाश
को "भू-प्रेक्षण द्वारा कार्बन चक्र का अध्ययन"
मे ऑनलाईन पाठ्यक्रम में भाग लेने पर प्रदान किया जाता है।
इस ऑनलाइन पाठ्यक्रम का आयोजन **21 जून, 2021 से 25 जून, 2021 (कुल पाठ्यक्रम की अवधि = 7 घंटे 30 मिनट)** के दौरान किया गया ।

THIS CERTIFICATE IS
AWARDED TO
MR. GITE DIPAK PRAKASH
ON HAVING PARTICIPATED IN THE ONLINE COURSE ON
"Earth Observation for Carbon Cycle Studies"
THIS ONLINE COURSE WAS CONDUCTED DURING **21-06-2021 to 25-06-2021** (Total course duration was = 7 hours and 30 minutes).

Date: **02-07-2021**
Place: Dehradun

निदेशक/ Director
आई.आई.आर.एस, देहरादून/ IIRS, Dehradun

UID- f7e9530da15fbc9313ba10be21c93947 .This Certificate can be validated using URL- https://certificate.iirs.gov.in

Plant Archives Vol. 21, Supplement 1, 2021 pp. 2401-2407 e-ISSN:2581-6063 (online), ISSN:0972-5210

Plant Archives

Journal homepage: http://www.plantarchives.org
doi link : https://doi.org/10.51470/PLANTARCHIVES.2021.v21.S1.392

THE RESPONSE OF BIO-FERTILIZERS TO THE PRODUCTION POTENTIAL OF CEREAL CROPS

Dipak P. Gite[1], Prakash A. Gite[2] and Mayur S. Darvhankar[1*]
[1]School of Agriculture, Lovely Professional University, Phagwara (Punjab), India
[2] Dr. Punjabrao .Deshmukh .Krishi.Vishvavidyalaya. Akola (M.S.), India
*Corresponding author - mayur.21878@lpu.co.in

ABSTRACT

The land is a limited resource. Due to the increase in population; it is necessary to increase crop yield from the viewpoint of food security. The sole use of inorganic fertilizers may create an imbalance in soil health by the reduction in crop yield. For sustainable crop production, it is necessary to balance the soil health using organics and bio-fertilizers along with the optimum use of chemical fertilizers. Bio-fertilizers are important in the nutrient management of crops because of their role in nutrient supply leading to reduce the use of chemical fertilizers. The use of Bio-fertilizers is a cost-effective and eco-friendly technology in crop production which is gaining importance in crop production the commonly used biofertilizers are azotobactor, azosprillium, PSB, VAM fungi.

Keywords **:** Bio-fertilizer, Grain yield, Growth, Production

Introduction

The sole use of inorganic fertilizers with suboptimal doses of organics deteriorates soil fertility leading to a reduction in crop production and its sustainability. For sustainable crop production, it is necessary to use organics and bio-fertilizers consistently leading to improvement in soil biota for the transformation of organics in available nutrients and essential soil enzymes important to crops. Mohammadi and Sohrabi (2012) stated that soil microorganisms play important role in physical, chemical, and biological processes. Bio-fertilizers are the products containing viable cells of different microorganisms essential for plant growth. Nutrients in the soil are available through elemental transformations, solubilization, fixation, and other mechanisms. Bio-fertilizer helps to supply N and P through fixation and solubilization respectively and acts as a supplement to inorganic fertilizer in an eco-friendly manner. In cereals, azotobactor is generally used in wheat and maize which is a non-symbiotic and contributes 20-25kg N ha^{-1}. Phosphorous solubilizing bacteria (PSB) can solubilize 20-30% of insoluble phosphate and increases yield up to 20 %. (Kachroo and Razdan, 2006). Other bio-fertilizers like azosprillium and vesicular-arbuscular mycorrhiza (VAM) fungi also improves plant growth and production by fixing and solubilizing phosphorous (Tarafdar and Rao, 1997).

Classification of Bio-fertilizers

A) N-Fixing Bio-fertilizers.

1. Free-living: Azotobactor, Clostridium, Anabaena, Nostoc.
2. Symbiotic: Rhizobium, Frankia.
3. Associative symbiotic: Azosprillium.

B) P- Solubilizing Bio-fertilizers.

1. Bacteria: Bacillus megaterium var. phosphaticum, Bacillus circulans, Pseudomonas striata
2. Fungi: Penicillium spp. , Aspergillus awamori.

C) P-mobilizing Bio-fertilizers

1. Arbuscular mycorrhiza : Glomus sp. , Gigaspora sp.
2. Ectomycorrhiza : Boletus sp., Amanita sp.
3. Orchid mycorrhiza: Rhizoctonia solani

D) Bio-fertilizers for micronutrients.

1. Silicates and Zinc solubilizer: Bacillus sp.

(source: www.Krishisewa.com)

Bio-fertilizers application

1. Seed treatment
2. Seedling root dip treatment
3. Soil application

Bio-fertilizers in cereal crops

Cereal crops are grown on a large scale for food and energy throughout the world. Cereals are stapled food crops and reach in CHO's, proteins, vitamins, minerals, etc. In India, important cereal crops are rice, wheat, maize, sorghum, pearl millet, etc. are grown on a large scale. The use of biofertilizers in these crops is beneficial for increasing production by reducing the cost of nutrient management. The role and importance of biofertilizers in cereal crops have been reviewed by some authors and presented below.

Effect of bio-fertilizers on wheat production

Agrawal *et al*. (2004) reported that at 80 DAS, about 72.03% N uptake was increased over the control due to Azotobacter inoculation and it was at par with treatment of 20 kg N ha^{-1} alone in wheat. Azotobacter alone and 20 kg N ha^{-1} were statistically at par in affecting the nitrogen content in grain and straw of wheat. Inoculation alone increased about 37.97, 39.17, and 37.37 % P uptake over the control in the grain, straw, and total yield of wheat respectively; whereas, potassium uptake was 95.25, 43.23, and 44.81%

respectively. Ram and Mir., (2006) stated that both biofertilizers, i.e. Azospirillum and Azotobacter, significantly enhanced all the growth parameters and grain and straw yields over the control. The combined application of Azospirillum + Azotobacter showed significant improvement over their individual application. Dileep and Ravinder, (2006) conducted an experiment at Jammu to study the effect of biofertilizers on wheat crop And observed that Azotobacter + Azospirillum in a 1:1 ratio was found to be effective in increasing the growth, yield attributes, and yield of wheat crop to significant levels. It also resulted in higher NUE. Prasanna *et al*. (2008) stated that the application of vermicompost in combination with BGA biofertilizer (biofertilizer + vermicompost + N40 P30 K30) has resulted in a significant increase in Nitrogenase activity. They also reported that inoculation with Azotobacter + BGA resulted in the highest value of chlorophyll (1.19 $\mu g\ g^{-1}$ soil).

Katiyar *et al*., 2011, reported that the inoculated wheat seed by Azotobacter increased the yield up to 1.92–2.0 % as compared to a non-inoculated seed. Similarly, Ahmed *et al*., 2011 also reported that azotobacter plays a very important role in the growth of plants especially it improves the yield of wheat. The yield of wheat increases when it was inoculated with yeast + Azotobacter with 20 m^{-3} fad. The combined application of Azospirrillum, Azotobacter significantly increases the spikes, no of tillers, grain weight, grain size, spikelet per plants, spike length, etc, therefore the use of 75 % mineral nitrogen and biofertilizer with Azospirrillum and Azotobacters increases all the growth character in wheat (Chauhan *et al*., 2011).

Kaushik *et al*., 2012 stated that Inoculation of Azospirillum plus PSB significantly recorded 23.2 and 11.9, 21.6 and 9.9, 32.3, and 15.7 % higher grain and straw yield and net returns over control and Azospirillum respectively in wheat crop. Minaxi *et al.,* 2013 also reported a significant increase in growth, yield, and nutrient uptake by wheat due to PSB and VAM fungi. A significant increase in seed yield was also recorded by 92.08% over control.

Singh *et al*., 2016 reported that Azotobactor and PSB inoculation, being at par caused significant improvement in the growth and yield attributes of wheat over the control. It was also reported that the co-inoculation of Azotobactor and PSB further increase the growth and yield attributes of wheat over individual inoculation.

Kumar *et al*., 2017 concluded that the Rhizobacterial inoculation in wheat crop either alone or in a consortium of different combinations significantly increased the growth and yield of the wheat crop as compared to the mock-inoculated controls. In both the field and pot trials, the combination of Rhizobacterial isolates was found to be more effective as compared to single inoculation. Mukhtar *et al*., 2017 reported that biogas sludge and enriched soil-based P biofertilizers showed the highest phosphate solubilization activity. It has increased the growth of the wheat by 20.13% and 15.51% as compared to non inoculated controls using biogas sludge and enriched soil-based P biofertilizers respectively.

Sanjay Mahato and Asmita kafle (2018) conducted a pot experiment on wheat and reported that inoculation of azotobactor only increased 16.05%-19.42% grain yield over control; while with other fertilizers, the increase was of range 19.42-63.1% increase over control. The increase in yield was 23.3% with only chemical fertilizers NPK @120:80:80 kg^{-1} respectively over control so azotobactor can be used as a biofertilizer when it is used along with FYM and chemical fertilizers (NPK).

Trichoderma shows a slight increase in the plant height, panicle weight, number of grains, grain yield, biological yield, and biomass yield over control; while rooting length, number of leaves, tiller number, panicle number, panicle length highlight the negative impact of Trichoderma on the wheat plant. Trichoderma shows antagonism with inorganic fertilizer. In most of the parameters, more is the inorganic fertilizer with Trichoderma, higher is the antagonism. When Trichoderma and NPK are accompanied with farmyard manure, most of the growth and yield parameter shows the highest value, but the yield was slightly higher than NPK alone treatment. This finding indicates that while sowing seed, the use of Trichoderma with FYM and NPK may not improve the yield over NPK to a greater extent. Hence it is indicated that Trichoderma viride can be a growth promoter and be used as a biofertilizer. Mahato *et al*. (2018)

Effect of bio-fertilizers on maize production

MEENA *et al.,* 2013 reported that maize Grain yield was increased with increasing levels of nitrogen, and a maximum grain yield of 4.3 Mg/ha was obtained by use of 150 kg N/ha with FYM @ 5 t/ha and Azotobacter inoculation. Significant uptake of nitrogen, phosphorus, and potassium was recorded under the application of 150 N kg/ha over the control. Protein content in maize grain increased significantly by conjoint use of organic manure and biofertilizers with each level of nitrogen application, over application of each nitrogen level alone.

Umesha *et al*., 2014 reported that the treatment (T_{13}) having recommended dose of NPK +Azotobacter chroococcum + Bacillus megaterium + Pseudomonas fluorescence + enriched compost has shown the highest plant height at 30, 60, 90 days after sowing and at harvest (120 days) (31.70, 180.93, 186.07 and 188.13 cm respectively). The highest total dry matter production at harvest (375.80 g) and yield parameters like Weight of cob (207.63 g), Grain yield per plant (158.93 g), Grain yield per ha (54.53 q) and Test weight of seeds (33.10 g) was also found highest in this treatment and available nutrient content in the soil after crop harvest i.e., nitrogen (185.40 Kg ha^{-1}), phosphorous (38.83 Kg ha^{-1}) and potassium (181.47 Kg ha^{-1}) was also found highest in the same treatment combination.

Amin Farnia and Hamidreaza Torkaman (2015) conducted an experiment on maize with three treatments of N fertilizers (Nitroxin, Nitrokara, and azot barvar 1) and P biofertilizers (Phosphate barvar 2, biosuperphosphate, and Phosphatin) with control for them. Results showed that the effect of N fertilizer, P fertilizer, and interaction between them on all traits was significant instead of the number of rows per cob and harvest index. The comparison of the mean values showed that the Nitroxin phosphate barvar 2 treatment had the highest cob weight, cob length, and biomass. However, the combined application of Nitroxin and Biosuperphosphate treatment had the highest 1000 grain weight and grain yield. Also, a single application of Nitrokara had the highest number of rows per cob. A single application of Biosuperphosphate biofertilizer had the highest number of row per cob and HI. The final results of this study reviled that application N and P biofertilizers increased yield and yield components of maize.

Two field experiments were conducted at Sudan University of Science and Technology, College of Agricultural Studies, The Demonstration Farm, Shambat, during two successive winter seasons of 2011/2012 and 2012/2013 under irrigation conditions to study the effect of bio-fertilizer (Effective Microorganisms, EM) on two maize (*Zea mays* L.) cultivars for some growth and yield characters using a split-plot design with four replications. The liquid bio-fertilizer levels were (Zero, 06.25, 12.5, 18.75, and 25.00 L/Ha) corresponding to F1, F2, F3, F4, and F5 treatments. The two maize cultivars were HUDAIBA (HD) and MUGTAMA45 (MG). The results revealed that Plant height, stem diameter, leaf area, 100-grain weight, and grains number per cob were increased due to the increase in the level of bio-fertilizer. Also, the aforementioned characters were significantly increased for HD cultivar particularly under the application of F4 and F5 levels. Further, the highest grain yield was obtained from the application of an F4 dose to the two cultivars in both seasons. This high response of the two maize cultivars to bio-fertilizer could be of great value in using it in maize nutrition in Sudan. (Obid *et al*., 2016)

Gao *et al*., 2020 carried out a field experiment on maize and the Seeds were treated with Azotobacter chrocoocum, arbuscular mycorrhizal fungi (AMF), Bacillus circulans, biogas slurry, humic acid (HA), and their combination aiming to increase the growth and yield of maize and to reduce the need for chemical fertilizers. The results showed that the combined application of the biofertilizer mixture (Azotobacter chrocoocum, AMF, and Bacillus circulans) with organic fertilizers enhanced maize growth, yield, and nutrient uptake. Moreover, bio-organic fertilization has improved the soluble sugars, starch, carbohydrates, protein, and amino acid contents in maize seeds. Additionally, the bio-organic fertilization caused an obvious increase in the microbial activity by enhancing acid phosphatase and dehydrogenase enzymes, bacterial count, and mycorrhizal colonization levels in the maize rhizosphere as compared with the chemical fertilization. Additionally, the bio-organic fertilizers have improved α-amylase and gibberellins (GA) activities and their transcript levels, as well as decreased the abscisic acid (ABA) level in the seeds as compared to the chemical fertilizers. The obtained results of bio-organic fertilization on the growth parameters and yield of maize recommend their use as an alternative tool to reduce chemical fertilizers.

Effect of bio-fertilizers on rice production.

A field experiment was conducted by Karmakar *et al*., 2011 to evaluate the various components of the integrated plant nutrient system on transplanted rice in the plateau region of Jharkhand during wet seasons of 2006 to 2008. Combined application of 50% of recommended dose through chemical fertilizers and 25 % N through farmyard manure along with insitu green manuring and blue-green algae improved growth and yield attributing characters increased yield of rice variety Lalat (19.3%) as compared to that of recommended fertilizer dose. Increase in nutrient uptake (21.4, 29.0 and 16.9 % of N, P, and K, respectively) and improvement of the soil physico-chemical properties like organic carbon (0.34 to 0.44%), available N (220.3 to 254.0 kg ha^{-1}), P (21.2 to 25.8 kg ha^{-1}) and K status (153.0 to 159.0 kg ha^{-1}) were also recorded. The maximum net return (Rs 22160 ha^{-1}) and benefit-cost ratio of 2.23 were also noted under the combined nutrient application.

Azospirillum inoculation increased the rice yield significantly by 1.6–10.5 g $plant^{-1}$ (32–81% increase) in greenhouse conditions (Mirza *et al*., 2000; Malik *et al*., 2002). However, in field conditions, the estimated yield increase was around1.8 t ha^{-1} (22% increase) as reported by (Balandreau 2002).

Studies conducted at the IRRI showed that rhizobium inoculation increased the growth and yield of rice, and N, P, and K uptake by rice plants significantly (Biswas *et al*. 2000a, 2000b).

Naher *et al*., 2016 experimented and showed that N and P (50%) with biofertilizer (10 t ha^{-1}) increased the number of tillers (29), panicle length (28 cm), weight of 1000 grain (21.31 g), and produced the highest grain yield (7.26 t ha^{-1}). There was no significant difference found among the N, P (75%) with biofertilizer (5 t ha^{-1}) and N, P (50%) with biofertilizer (10 t ha^{-1}) treatments for plant height, number of panicle $plant^{-1}$, and harvest index (%). The application of biofertilizer with beneficial microbes improved the leaf chlorophyll, plant nutrient uptake, and grain protein content in rice. Hence, the use of chemical N and P fertilizer can be minimized by 50 percent and improve rice yield with the supplement of 5 ton ha-1 of bio-organic fertilizer**.**

A field experiment was carried out to evaluate the feasibility of inoculating rice seedlings with biofertilizers (Azospirillum and Trichoderma) in order to reduce the use of chemical inorganic nitrogen (N) fertilizer on rice variety BU D han 1. The plant performances were better when 25% less inorganic N was applied with Trichoderma and the combined application of Trichoderma and Azospirillum. Plants contained the highest chlorophyll concentrations when they were treated with 75% N + Trichoderma. Considering the yield attributes, 75% N + Trichoderma, and 75% N + Trichoderma + Azospirillum performed similar to the control. The grain yield of rice was similar to the recommended dose even with 25% less N application. The application of Trichoderma resulted in a higher yield, followed by a combined application with Azospirillum. Results revealed the greater scope of applying biofertilizer (Trichoderma) to supplement chemical N fertilizer with an optimum yield of rice (Haider Iqbal Khan 2018).

Effect of bio-fertilizers on sorghum production

A field experiment was conducted at College Farm, Navsari Agricultural University, Navsari (Gujarat) during the rabi season of the year 2017-18 to study the "Effect of fertilizer levels, bio compost and biofertilizer effect on yield and yield attributes of fodder sorghum. Twelve treatment combinations consisting of three levels of fertilizer, two levels of bio compost, and two levels of biofertilizer were tried in a factorial randomized block design with three replications. The result showed that among different treatment combinations, the application of 100% RDF with bio compost and biofertilizer significantly registered maximum green and dry fodder yield, plant height, and stem girth. While, in interaction maximum plant height, green and dry fodder yield was recorded in 100% RDF with biofertilizer which was statistically at par with 75% RDF with biofertilizer (Chauhan *et al*., 2019).

A pot experiment was carried with biofertilizers of N2-fixers (A. chroococcum + A.brasilense), P-dissolvers (*Bacillus megaterium*), and K-dissolvers (*Bacillus circulans*) for sorghum (Sorghum bicolor) grown on a light clay torrifluvent soil. Different combinations of such N_1, P_1, and K_1 biofertilizers were compared with the $N_{0,}$ $P_{0,}$ K_0 non-addition which gave 15.2 g pot^{-1}. All additions giving one or more or all of the 3 biofertilizers caused a positive response. Ranges of % increase were: 63 ($N_{1,}P_{0,}K_0$) to 81($N_{1,}P_{1,}K_0$) for yield; 63 ($N_{0,}P_{0,}K_1$) to140 ($N_{1,}$ P1, K_0) for N uptake; 88 (N_1,$P_{0,}K_1$) to 224 (N_1,P_1,K_1) for P uptake and 69 (N_0,P_1,K_0) to 130 (N_0,P_0,K_1) for K uptake. When given singly (solely), the percentage increase caused by any of the 3 biofertilizers was higher than when given in presence of any or both of the others (i.e. interaction effects). For yield, increases of 63, 67, and 65 % occurred due to a sole application of N, P, and K biofertilizers respectively. Main (average) increases were 13, 14, and 12 % for each biofertilizer respectively (irrespective of presence or absence of the others). The average increase by one was greater in absence of each of the others, and generally non-effective in presence of the other. Similar patterns occurred regarding uptake of N, P, and K. The interactions among the 3 biofertilizers were evident. An indication of competition among the microorganisms could have taken place. Practical implications indicate that biofertilizers could be used to decrease total dependence on chemical fertilizers. Ali *et al*. (2015)

Akhtar *et al*. (2020) conducted an experiment and concluded that all the treatments enhanced the growth, yield, and quality attributes but the maximum improvement was recorded by the combined application of chemical and biological fertilizers. Application of N @ 60 kg ha^{-1} + P @ 35 kg ha^{-1} + PSB @ 1.25 kg ha^{-1} + Biozote @ 1.25 kg ha^{-1} showed an increase of 12.45%, 78.11%, 34.4%, and 25.38% in plant height, green fodder yield, grain yield and crude proteins over the control respectively. The results of the current study are very promising regarding the combined use of chemical and bio-fertilizers to improve the productivity of sorghum crop.

The combination of PGPR-mix (Azospirillum, Azotobacter, Bacillus) with hydrogels as bio-organic fertilizer and CMC as carriers has promoted the growth of the roots, shoots, and vigor index of in vitro sorghum germination, as well as increased the root length, shoot length, and total dry weight of sorghum seedlings in pots containing sterile sand. The best result of in vitro experiment (root length = 8.67 cm; shoot length = 12.6 cm, and vigor index = 2127.00) was obtained by sorghum seed inoculated with a single PGPR inoculant (A. lipoferum) with a carrier of CMC. The root length, shoot length and total dry weight of the highest sorghum seedlings were obtained by PGPR-mix inoculants without carriers (46.5 cm, 12 cm, and 0.477 g), PGPR-mix with a carrier of CMC (48.67 cm, 15.67 cm, and 0.431 g), and PGPR-mix with a carrier of hydrogel (48.67 cm, 15 cm, and 0.430 g). S Widawati and Suliasih 2020

Verma *et al*.,(2014) showed that the growth parameter like plant height, number of leaves, fresh weight of leaf, fresh weight of stem, fresh weight of the plant, LAI, dry matter accumulation on leaf, stem, and plant, leaf stem ratio, and CGR were significantly higher in T10 (100% RDN @ 60 kg ha^{-1} + Azotobacter +Azospirillum) as compare to other treatments and it was at par with T9(100% RDN @ 60 kg ha^{-1}+Azospirillum) and T8(100%RDN @ 60 kg ha^{-1} + Azotobacter). Among all the treatments, T10 (100% RDN @ 60 kg ha^{-1} + Azotobacter + Azospirillum) recorded significantly higher green and dry fodder yield over other treatments and it was at par with T8(100% RDN @ 60 kg ha^{-1} +Azotobacter) and T9 (100% RDN @ 60 kg ha^{-1}+ Azospirillum) and it may be due to cumulative effect of the higher value recorded by this treatment for most of the yield contributing characters. The combination of inorganic fertilizer with biofertilizers significantly increased the overall growth and development of the sorghum plant.

Effect of bio-fertilizers on pearl millet production

Choudhary R.S., Gautam R.C (2005) conducted an experiment for 2 years (2002 and 2003) to evaluate the effect of nutrient management practices on growth and yield of pearl millet [*Pennisetum glaucum* (L.) R. Br. emend. Stuntz.]. Nutrient-management practices comprised the control, 30 kg N/ha + 20 kg P_2O_5/ha, 60 kg N/ha + 40 kg P_2O_5/ha, 5 tonnes FYM/ha + bio-fertilizer (Azotobacter + vesicular-arbuscular mycorrhizae), 10 tonnes FYM/ha + bio-fertilizer (Azotobacter + VAM), 30 kg N/ha + 20 kg P_2O_5/ha + 5 tonnes FYM/ha + bio-fertilizer, 30 kg N/ha + 20 kg P_2O_5/ha + 10 tonnes FYM/ha + bio-fertilizer and 60 kg N/ha + 40 kg P_2O_5/ha + 10 tonnes FYM/ha + bio-fertilizer in randomized block design with three replications. The total rainfall received during the Kharif season of 2002 and 2003 was 405.5 mm and 823.0 mm respectively. Application of 60+40 kg/ha of N + P_2O_5 along with 10 t FYM/ha and biofertilizer gave significantly higher grain yield and N, P uptake by pearl millet than control and FYM (5 or 10 t/ha) + biofertilizers use.

The diazotrophic bacteria namely: *Pseudomonas fluorescens, Azotobacter chroococcum, Azospirillum lipoferum, and Acetobacter diazotrophicus*, one fungus: *Trichoderma viride* alone and in combinations were treated to the pearl millet seeds @ 10-20 g kg^{-1}, followed in randomized block design with three replications. The results proved that combined inoculation of all these bio-inoculants enabled to enhance the plant height (163.54 cm), dry weight (91.15 g), length of the ear (31.27 cm), grain yield (3.01 t ha^{-1}), and stover yield (10.77 t ha^{-1}) of pearl millet crop, while least results obtained in the control. Singh *et al*. (2016).

Togas *et al.,*(2017) conducted an field experiment having eight treatments of fertilizers /manures (Control, RDF (60:30:0), FYM @ 12 t/ha, FYM @ 6 t/ha + ½ RDF, vermicompost @ 5 t/ha, Vermicompost @ 2.5 t/ha + ½ RDF, Poultry Manure @ 4 t/ha, Poultry Manure @ 2 t/ha + ½ RDF) and two treatments of microbial inoculation (without inoculation and with Azotobacter) thereby making sixteen treatment combinations were tested in randomized block design with three replications. The recommended dose of fertilizer for pearl millet was 60 kg N and 30 kg P2O5/ha. Results indicated that seed inoculation with Azotobacter significantly increased plant height, dry matter accumulation, total number of tillers, chlorophyll content effective tillers, ear length, grains/ear, test weight, grain, stover and biological yield, protein content, total uptake of N, P and K and their concentration in grain and stover. The seed inoculation with Azotobacter was found economical fetching the highest returns (29615/ha).

To study the beneficial effect of biofertilizers on the performance of pearl millet (*Pennisetum glaucum* L.) a field experiment was conducted in randomized block design during the rainy (Kharif) season of 2014 at Sam Higginbottom University of Agriculture, Technology and Sciences, Allahabad, India. Seeds of pearl millet were treated with diazotrophic bacteria namely- *Pseudomonas fluorescens, Azotobacter chroococcum, Azospirillum lipoferum, Acetobacter diazotrophicus*, and one fungus- *Trichoderma viride* @ 10-25 g kg^{-1} alone and in combinations. The combined treatment with all the bio inoculants enhanced the grain yield (44%), nutrient uptake (N by 79.9% and P by 87.9%), and grain quality (Protein by 58.9% and carbohydrate by 17%), single inoculation was also found profitable over the control (Un-inoculated). Therefore, inoculation of pearl millet seed with different biofertilizers could produce pollution-free and healthy (better quality) food for an increasing population and may able to reduce chemical fertilizer application without any significant reduction in grain yield. Singh *et al*. (2018).

Savita *et al*. (2019) conducted an experiment having Twelve treatments i.e. T1(Control), T2 (Seed treatment with Biomix), T3 (Foliar spray of Azotobacter isolate JFS5 @ 108cfu ml^{-1} at 15 DAS), T4(Foliar spray of Azotobacter isolate JFS5 @ 108cfu ml^{-1} at 30 DAS), T5[RDF (40 kg N + 20 kg P_2O_5 ha^{-1})], T6[75 % RDF (30 kg N + 15 kg P_2O_5 ha^{-1}], T7(T5 + seed treatment with Biomix), T8(T5 + foliar spray of Azotobacter isolate JFS5 @ 108cfu ml^{-1} at 15 DAS), T9(T5 + foliar spray of Azotobacter isolate JFS5 @ 108cfu ml^{-1} at 30 DAS), T10(T6 + seed treatment with Biomix), T11(T6 + foliar spray of Azotobacter isolate JFS5 @ 108cfu ml^{-1} at 15 DAS), T12(T6 + foliar spray of Azotobacter isolate JFS5 @ 108cfu ml^{-1} at 30 DAS) were laid out in RBD in three replicates. The combined application of biomix along with RDF (recommended dose of fertilizer) increased the protein content in grain over the control up to the extent of 16 percent. N content, Nand P uptake in grain was significantly increased in treatment T7 [T5 + seed treatment with Biomix] then T1- control. The N and P uptake ranged from 28.41-59.01 and 4.30-9.70 kg/ha among different treatments with the maximum with T7. The highest protein yield recorded with the combined application of biomix along with RDF (T7) was 107.8 and 17.3 percent higher over control (T1) and RDF (T5), respectively.

Conclusion

This study showed that the bio-fertilizers are very important for the crop growth and yield of the crops. It maintains the soil health, improves plants nutrition, increases the organic matter content and also maintains the soil p^H. The use of bio-fertilizers by farmers is useful for increasing the outcome from the crops and helps for increasing farmer's income.

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Zinc sulphate a potential micronutrient for wheat growth: A review

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Abstract
Wheat is a major cereal and staple food crop of India. The productivity of wheat in India varies among the states. The highest productivity of wheat is in Punjab. The productivity of wheat varies with soils, genotypes, and input management like irrigation and the use of fertilizers. There is stagnation in the yield of wheat in various states of India over some time; however, by identifying sub-optimal conditions it is necessary to apply efficient scientific management that can improve the production of wheat to meet the future demand of food grain for food security in the country. Zinc is one of the important micronutrients essential for higher yields in cereals in spite of major nutrients like N, P and K. The sub-optimal applications of nutrients along with judicious irrigation are the two important parameters for higher yields considering plant protection measures. Among the literature surveyed it has been observed that monohydrate and heptahydrate zinc sulphateare important sources of zinc that have increased the yield of wheat grain and zinc content in grain and fodder. Zinc is generally recommended by the scientist in the form of $ZnSO_4.H_2O$ and $ZnSO_4.7H_2O$ to the wheat grower based on the zinc status of the soil.

Keywords: Fertilizer, production, yield, zinc

Introduction
Wheat (*Triticum aestivum*) is the second most important food crop after rice in the country, which contributes nearly one-third of total food grain production. It is consumed in the form of chapati, wheat straw used for cattle feed. Wheat contains more protein than other cereals and high in niacin and thymine. Wheat protein is called gluten which is essential for bakery products. Zinc is an essential element for the production of crop and optimal size of fruit, also required in the carbonic enzyme which presents in all photosynthetic tissues, and required for chlorophyll biosynthesis (Ali *et al.,* 2008; Graham *et al*., 2000) [2, 13]. Most of the soils are deficient in micronutrients mainly in zinc due to mining of nutrients in continuous cropping, increasing demand of zinc by crops, geogenic low status of zinc in soil, etc., which results in poor crop yield and causes the problem in human health due to its deficiency. Zinc deficiency is related to soil pH and its value is very low in calcareous soils with high pH (Alam *et al*., 2010; Alloway, 2008) [1, 3]. In wheat, zinc can be applied by foliar application, soil application, and seed treatment. Zinc can also be applied in chelated form. Zinc has its important role in the production of growth regulators for the vegetative and reproductive growth of plants. Zinc sulphate heptahydrate and monohydrate are the sources of zinc that decrease the cost of production with an increase in yield due to its low price as compared to other sources. The balanced use of major nutrients and recommended doses of zinc are responsible for higher productivity of wheat.

Zinc potential micronutrient
Zinc is a transition metal also known as heavy metal of atomic number 30 and 23rd abundant element on earth. It is important for auxin synthesis in plants. It synthesizes protein by activating some enzymes. It is also important in chlorophyll formation and carbohydrate metabolism. It helps in the growth of stems through elongation. Zinc helps to increases wheat yield by improving protein content. Zinc deficiency can reduce yield through leaf chlorosis leaf necrosis, leaf bronzing, stunting of plants, etc. Zinc deficiency in soilcan is corrected by application of zinc in soils, seed treatment, and foliar sprays. Zinc sulphate is available in various forms like Zinc sulphate monohydrate ($ZnSo_4.H_2O$)-33% Zn, Zinc sulphate heptahydrate ($ZnSo4.7H_2O$)-21% Zn, Chelated zinc (Zn EDTA)-9% Zn, Zinc coted urea (Zn urea)-2% Zn, Zinc oxide (ZnO)-60-80% Zn, Zinc carbonate ($ZnCO_3$)-52-56% Zn, Zinc chloride ($ZnCl_3$)-48-50% Zn, Zinc applied in small quantities i.e. 15-55 ppm on an average required to plant.

Effect of zinc sulphate on growth and yield of wheat

A series of recent studies have indicated that Indian soils are highly deficient in zinc. Due to zinc deficiency plant growth is inhibited and ultimately yields are reduced. Zinc deficiency in soils leads to low zinc content in wheat grain and straw.

Sharma *et al*., (2000) [24] conducted an experiment to determine the effect of N at 0, 40, 80, 120, and 160 kg ha^{-1} and Zn at 0, 5, and 10 kg ha^{-1} on wheat and observed that wheat responded only to 5 kg Zn ha^{-1}, and Zn at this rate resulted in 13.62% and 6.14% higher grain yield compared to the control and 10 kg Zn ha^{-1}, respectively. Also Sundar *et al.,* (2003) [26] observed that grains per ear, test weight, grain, and straw yields increased significantly only up to 10 kg Zn ha^{-1}; beyond this level, adverse effects on the yield were observed. Grains per ear, test weight, grain, and straw yields were influenced by the soils and were highest with the application of 10 kg Zn ha^{-1}. Atak *et al*., (2004) [5] experimented on the effects of Zinc on the yield and yield components of wheat cv. Kiziltan-91 and they observed zinc application increased the grain yield, number of seeds spike-1, and seed weight spike-1 of the wheat crop. Chandrakumar *et al*., (2004) [7] found that combined application of RDF + FYM @10 t ha-1 + Soil application of ZnSO4 @10 kg ha-1 accumulated significantly higher dry matter in leaves, stem, and spikes and also recorded significantly higher dry matter production (297.10 g m-1 row length) and grain yield of wheat crop (38.65 q ha-1). According to Dewal and Pareek (2004) [8] The soil application of 10 kg Zn ha^{-1} exhibited higher plant height (89.5 cm), higher dry matter accumulation (242.4 g m^{-1} row), more number of effective tillers (94.2 m^{-1} row), maximum test weight (35.2 g), higher grain yield (37.2 q ha^{-1}) and straw yield (49.06 q ha^{-1}). Singh (2004) [25] was carried out a field experiment on wheat during the *rabi* season of 1998-2000 and observed the application of 5.0 kg Zn ha^{-1} significantly increased the growth and yield of wheat over the control, while it was at par with 6.25 and 7.5 kg Zn ha^{-1}. The highest ICBR 1:5.72 was estimated with 5.0 kg Zn ha^{-1}.A field experiment was carried out by Mahendra and Yadav (2006) [20] observed maximum growth and yield parameters of wheat were recorded with the application of 40 kg $ZnSO_4$ ha^{-1}. However, it was statistically at par with 30 kg $ZnSO_4$ ha^{-1}. Ranjbar and Bahmaniar (2007) [23] experimented to investigate the effects of soil and foliar application of Zn Fertilizer on Yield and Growth Characteristics of Bread Wheat (*Triticum aestivum* L.) and found that Zn had increasing effects on total dry matter, grain yield, 1000-grain weight, number of tillers, grain Zn content, flag leaf Zn content, plant height, number of nodes, protein content, and grain Fe content. Habib (2009) [15] conducted a field experiment on clay-loam soil to investigate the effect of foliar application of zinc and iron on wheat and the results showed that the foliar application of Zn and Fe increased seed yield and its quality compared with control. Among treatments, the application of (Fe + Zn) obtained the highest seed yield and quality. Hussain *et al*., (2010) [16] reported that the zinc content of wheat inherently low when it is grown on zinc deficit calcarious soils therefore to enrich wheat grain at the farmer field is the best solution against human zinc deficiency. Soil and foliar application of zinc to wheat in zinc deficient soils enhance both grain yield and grain zinc content. Gul *et al*. (2011) [14] conducted an experiment on the foliar spray of zinc in wheat and observed that the number of plants emerged m^{-2}, number of tillers m^{-2}, and plant height (cm) were significantly affected while the number of days to anthesis was not affected significantly by foliar spray. Dhaliwal *et al.* (2012) [9] conducted an experiment at Ludhiana and Hoshiarpur in sandy loam and loamy sand soils and they concluded that various plant parameters of wheat variety PBW 550 such as plant height, no of tillers m^{-2} increased with soil application of $ZnSO_4.7H_2O$ was applied @ 62.5 kg ha^{-1}. Zoz *et al*., (2012) [29] observed that the foliar application of zinc increased the number of fertile tillers and yield of wheat, however, have little effect on the agronomic characteristics of the no-tilled crop with high nutrient content in the soil. Keram *et al.,* (2013) [17] concluded that the grain and straw yield, as well as harvest index, increased with the increasing levels of Zn as compared to N:P: K alone. Mathpal *et al*., (2015) [21] showed a marked difference in Zn accumulation and grain Zn content. Khattak *et al.* (2015) [19] observed that foliar application of zinc at 1.0% $ZnSO_4$ solution and 5 Kg $ZnSO_4$/ha soil application increased the yield and they also concluded that the zinc application increased the protein content in grains. Bhutto *et al.* (2016) [6] reported that the application of N:P: K 168:84:60 kg ha^{-1} with Zn 2.0 kg ha^{-1} as a foliar spray with the standard dose statically showed significant effect with an increasing number of tillers m^{-2}, plant height, spike length, number of grains $spike^{-1}$, seed index and grain yield. Khattab *et al.,* 2016 [18] stated that dry matter of wheat increased by increasing rates of Zn above the optimum rate, the higher rates of Zn application decreased the dry weight of crop plants from the control had lower Zn concentrations. Ahmadi and David (2016) observed that the treatment combination (120 kg Nitrogen ha^{-1} + @ 30 kg Zinc ha^{-1}) gave the best results with respect to plant height, yield straw yield and test weight. Arif *et al*., (2017) [4] stated that the application of potassium fertilizer (375 $kgha^{-1}$) and zinc (15 $kgha^{-1}$) significantly improved the plant height, number of fertile tillers per unit area, spike length, number of spikelet's per spike, number of grains per spike, 1000-grain weight, biological yield, grain yield, and harvest index. Dahshowri *et al*., (2017) [10] concluded that Zn foliar application treatments significantly increased grain yield and its components of the two wheat cultivars as well as plant nutritional status and grain protein, Zn and Fe content. The highest Zn concentration and uptake in grain, and Zn use efficiencies were recorded with the application of 1.25 kg Zn/ha through Zn-EDTA as soil application + 0.5% foliar spray at maximum tillering and booting stage. Ghasal *et al*., (2017) [12].

Firdous *et al*., (2018) [11] showed that the effect of Zn application was significant on the grain yield (q/ha), straw yield (q/ha), and sterility percentage but had no effect on spike length, test weight, and Harvest index. Tao *et al*., (2018) [27] showed that HTS and zinc fertilizer had greater impacts on the strong gluten cultivar compared to the medium gluten cultivar. Vora *et al*., (2019) [28] reported that in sandy soils $ZnSO_4$ @20Kg ha^{-1} as a basal dose along with two sprays of $ZnSO_4$ @0.5% (50gm L^{-1} water) at heading and milking stages with RDF 120:60:60 NPK Kg/ha recorded higher yield as compared to other treatments like only RDF, $ZnSO_4$ @ 15 Kg ha^{-1} and $ZnSO_4$ 20 Kg ha^{-1}only through soil application. Paramesh *et al*., (2020) [22] suggested that 50% recommended dose of P (RDP) through phospho-enriched compost (PEC) + 50% RDP through fertilizer and soil application of 12.5 kg $ZnSO_4.7H_2O$ ha^{-1} + one foliar spray of 0.5% $ZnSO_4.7H_2O$ recorded significantly higher grain yield, straw yield and protein content.

Conclusion

From the overall review, it can be concluded that the deficiency of zinc varies from soil to soil due to various factors like mono-cropping of cereals, cereal after cereals, double cropping, multiple cropping patterns in agriculture no use or sub-optimal use of organics, calcarious soils, imbalanced use of fertilizer, etc. Therefore it is necessary to know the zinc deficiency in soil and the use of zinc fertilizer along with organic to maintain the sufficient level of zinc in soil from the various experimentation. It is concluded that zinc is very important for normal and luxurious physiological and reproductive crop growth to get improvement in qualitative and quantitative wheat yield.

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