20 Years EDUCATIONAL EXCELLENCE

GLA UNIVERSITY MATHURA
Recognised by UGC Under Section 2(f)
Accredited with A Grade by NAAC

GLAU/R/OFF/LIB/7556/19 17.01.2019

To,
Mr. Anand Bajpai
Account Manager
Turnitindia Education Private Limited
B-116, Second Floor
Noida-201301

Subject: **Acknowledgement towards the payment of Subscription of "Turnitin-Anti Plagiarism Web Tool" for 2018-2019.**

Dear Sir,

With reference to the subject as cited above, the full advance payment of ₹ 508168/- (Rupees Five Lac Eight Thousand One Hundred and Sixty Eight Only) has been made on 16.01.2019 through RTGS (UTR NO. IOBAN 19016667731) as per details given in your proforma invoice dated 31.10.2018 towards the renewal of subscription for the aforesaid Anti Plagiarism Web Tool for one year commencing from 01.10.2018 to 30.09.2019.

It is requested that the same may kindly be accepted and the receipt for the same may be sent to the undersigned at the earliest.

Thanking You,

Yours truly,

(Ashok Kumar Singh)
Registrar

Encl: as said above

GLA UNIVERSITY
MATHURA

08.01.2019

To,
The Vice-Chancellor
GLA University
Mathura

Through proper channel

Subject: Request to sanction the amount of **Rs. 508168/-** for renewal subscription of Turnitin Originality Check: Anti-Plagiarism Web Tool for 2018-2019.

Sir,

With due respect, I wish to state that Turnitin Originality Check: Anti-Plagiarism Web Tool is to be renewed for the year 2018-2019 commencing from 01.10.2018 to 30.09.2019. For which, the subscription renewal amount in **US Dollar which is $ 5830 (INR ₹ 508168/-) is** to be sent either through D.D in favor of "TurnitIndia Education Private Limited" or NEFT. The required details are enclosed along with this letter.

I, therefore, request you to kindly accord the approval and sanction the said amount for the same. The detailed information along with approval is herewith enclosed for your kind information.

Thanking You,

Yours sincerely,

Dr. P. M. Gupta
Deputy Librarian

Note:*conversion rates are subject to change as per RBI/GOC

Recommended for approval.

Recommended for approval of Hon'ble VC/EC

Anand Tiwari Agal

turnitin

B - 116, Second Floor
Sector 67
Noida - 201301
Uttar Pradesh
India
1-510-764-7600
GST ID: 09AAGCT1132P1Z1
PAN ID: AAGCT1132P

Date:	31 October 2018
Invoice No.	IN1153685
Quote/Purchase Order No.	Signed Quote
Sales Order No.:	SO851017
Due Date:	15 November 2018
Payment Terms:	Net 15
Service Start:	01 October 2018
Service End:	30 September 2019

TAX INVOICE

Billing Contact	Account Manager
GLA University 17 Km. Stone, NH-2, Mathura-Delhi Road Mathura, Uttar Pradesh 281406 India Our Ref: CN-160245 83273	Gupta, Pooran Mal e: librarian@gla.ac.in	Anand Bajpai e: abajpai@turnitin.com f: 1-510-764-7612

Description		Qty	Amount (INR)
Originality Check - Partial License	43 Faculty Includes Translated Match Integration		₹ 190,579.44
	100 Add on Student Includes Translated Matching Intergration, and eRater		₹ 18,467.00
License Administration Fee	License Administration Fee		₹ 221,604.00
	Subtotal		₹ 430,650.44
	CGST	9%	₹ 38,758.54
	SGST	9%	₹ 38,758.54
	Total Due		₹ 508,167.52

Total Invoice Amount in Words
INR: Five Lakh Eight Thousand One Hundred Sixty Seven And Five Two

EXCHANGE RATE US $1 = INR Rs 73.868

Invoice is system generated and thus does not need a signature

Make your cheque payable to: TurnitIndia Education Private Limited

TurnitIndia Education Private Limited
B - 116, Second Floor
Sector 67
Noida - 201301
India

BENEFICIARY BANK: Citibank N.A.
BENEFICIARY COMPANY: TurnitIndia Education Private Limited
BENEFICIARY COMPANY'S ACCOUNT #: 714093002
BENEFICIARY BANK BRANCH IFSC CODE: CITI0000002
BENEFICIARY BANK BRANCH MICR CODE: 110097002
BENEFICIARY BANK SWIFT CODE: CITINBX

2) Request that your originating bank reference your invoice number. If you do not have an invoice number, please request that your originating bank reference the name of your institution and your location.

3) Email ar@turnitin.com and southasia@turnitin.com with the confirmation that the transaction has been completed

23.12.2019

To,
The Vice-Chancellor
GLA University
Mathura

Through proper channel

Subject: Request to sanction the amount of ₹ 648414/- for renewal subscription of Turnitin Originality Check: Anti-Plagiarism Web Tool for 2019-2020.

Sir,

With due respect, I wish to state that Turnitin Originality Check: Anti-Plagiarism Web Tool is to be renewed for the year 2019-2020 commencing from **01.10.2019 to 30.09.2020.** For which, the subscription renewal amount in **US Dollar which is $ 8692(INR ₹ 648414/-) is** to be sent either through D.D in favor of "TurnitIndia Education Private Limited" or NEFT. The required details are enclosed along with this letter.

I, therefore, request you to kindly accord the approval and sanction the said amount for the same. The detailed information along with approval is herewith enclosed for your kind information.

Recommended for payment of Rs 648414/-

Thanking You,

Yours sincerely,

Dr. Ajay Kumar Sharma
Assistant Librarian

Note:*conversion rates are subject to change as per RBI/GOC

Recommended for approval of Hon'ble CM/EC Subject

21 Years

GLA UNIVERSITY
MATHURA
Recognised by UGC Under Section 2(f)

Accredited with A Grade by NAAC

GLAU/R/OFF/LIB/ 984/20

13.01.2020

To,
Mr. Utkarsh Tyagi
Territory Manager-North-HE Subscriptions
TurnitIndia Education Private Limited
B-116, Sector 67, Second Floor, Noida
Uttar Pradesh-201301
Mob: +91-7303398743

Subject: **Acknowledgement towards the payment of Subscription of "Turnitin-Anti Plagiarism Web Tool" for 2019-2020.**

Dear Sir,

With reference to the subject as cited above, the full advance payment of ₹ 648414/- (Rupees Six Lac Forty Eight Thousand Four Hundred and Fourteen Only) has been made on 08.01.2020 through RTGS (UTR NO. IOBAN 20008388421) as per details given in your proforma invoice dated 21.11.2019 towards the renewal of subscription for the aforesaid Anti Plagiarism Web Tool for one year commencing from 01.10.2019 to 30.09.2020.

It is requested that the same may kindly be accepted and the receipt for the same may be sent to the undersigned at the earliest.

Thanking You,

Yours truly,

(Ashok Kumar Singh)
Registrar

Encl: as said above

turnitin

TAX QUOTE

Bill To			Company	
	Institution Name	GLA University		TurnitIndia Education Private Limited
	Billing Address	17 Km. Stone, NH-2, Mathura-Delhi Road Mathura, Uttar Pradesh 281406 India		B - 116, Sector 67, Second Floor, Noida, Uttar Pradesh 201301, India
Contact Name	Dr.Ajay Sharma		PAN	AAGCT1132P
Contact Designation	Librarian		GSTIN	09AAGCT1132P1Z1
Phone	91 9119783113		Account/Subscription Manager	Utkarsh Tyagi
Email	librarian@gla.ac.in		Phone	7303398743
Fax			Email	utyagi@turnitin.com
			Quote Number	TEPL/GLA/2019-2020
			Quote Date	21-Nov-2019
			Quote Valid Till	10-Dec-2019
			Order Type	Renew
			Proposed Subscription Start Date	1-Oct-2019
			Proposed Subscription End Date	30-Sep-2020

APPLICATION/SERVICE DESCRIPTION	INSTITUTION FTE	SUBSCRIPTION DETAILS	END-USER LICENCES	ENTERPRISE SUBSCRIPTION VALUE ($)
			Maximum	
Turnitin Originality Check	6972	Single-campus Enterprise Subscription 12M	6972	$14,732

PAYMENT OPTIONS	YEAR 1	YEAR 2 (RENEWAL)
Enterprise Subscription - 2 Step Growth Plan	$7,366	$15,469
GST (18%)	$1,326	$2,784
Total Payable	$8,692	$18,253

NOTES

1. GST @18% is included in the above amounts; however, the GST rate for Year 2 is subject to change as per rate notified by Government of India at the time of invoicing.

2. Upon acceptance of this QUOTE in writing via a Purchase Order; TurnitIndia Education Pvt. Ltd. will provide an INVOICE payable in equivalent Indian Rupees. The US$ QUOTE AMOUNT will be converted to equivalent INR INVOICE AMOUNT as per the Market Exchange Rate as applicable on the Invoice Date.

3. Under this single-campus Enterprise Subscription - 2 Step Growth Plan, GLA University will be able to activate a maximum of 6972 EULs with a submission benchmark of 3486 with a 25% elasticity. The total submissions in Year 1 will be evaluated against the submission benchmark including elasticity. If the total submissions are within the benmchmark, then the subscription fee for Year 2 Renewal will be 7734.3 plus GST.

PURCHASE ORDER/CONFIRMATION

1. Please raise your Purchase Order in the name of TURNITINDIA EDUCATION PRIVATE LIMITED, as follows:

TURNITINDIA EDUCATION PRIVATE LIMITED, B-116, Second Floor, Sector -67, Noida - 201301, Uttar Pradesh, India

2. Please e-mail the Purchase Order/Confirmation to your Account Manager or to southasia@turnitin.com

3. The original Purchase Order/Confirmation may be kindly be posted/mailed to :
TURNITINDIA EDUCATION PRIVATE LIMITED
B-116, Second Floor, Sector-67, NOIDA - 201301
Uttar Pradesh, India

BANK DETAILS	
	BENEFICIARY BANK: CITIBANK N.A.
	BENEFICIARY COMPANY: TURNITINDIA EDUCATION PRIVATE LIMITED
	BENEFICIARY COMPANY'S ACCOUNT #: 0714093002
	BENEFICIARY BANK BRANCH IFSC CODE: CITI0000002
	BENEFICIARY BANK BRANCH MICR CODE: 110037002
	BENEFICIARY BANK SWIFT CODE: CITIINBX

GLA UNIVERSITY MATHURA

Librarian GLA <librarian@gla.ac.in>

623,678

Regarding the Adjustment of the Renewable Amount- 2019-20

Seema Bhatt <sbhatt@turnitin.com> Wed, Feb 26, 2020 at 12:26 PM
To: Librarian GLA <librarian@gla.ac.in>
Cc: Hunny Agarwal <hagarwal@turnitin.com>, Utkarsh Tyagi <utyagi@turnitin.com>

Dear Sir,

Greetings of the day

Please find the transaction reference number mentioned below for your reference

This Payment to GLA University, Mathura for the amount of INR 24,736.84 value dated 02/21/2020 has been authorized successfully.
The Transaction Reference Number is : 05200PYP3SL

Kindly advise if any further assistance is required

Thanking in anticipation

Kind Regards
Seema Bhatt
Senior Sales Development Executive-Higher Ed
TurnitIndia Education Pvt. Ltd.

Max Towers, 16th Floor, Spaces, Suits # 1603-05, 1608,1610,

Sector 16-B, Noida, Uttar Pradesh, 201301
E: sbhatt@turnitin.com
M:9811464480

turnitin

"Revolutionizing the experience of writing to learn"

[Quoted text hidden]

turnitin

Payment Receipt

Date: 01/08/2020

Payment Method: Wire Transfer

TurnitIndia Education Private Limited
B - 116, Sector 67, Second Floor
Noida
India - 201301

Date	Description	Original Amount	Amount Due	Disc. Taken	Payment
11/30/2019	IND12000517	INR 623,677.16	INR 623,677.16	INR 0.00	INR 623,677.16

Total	INR 623,677.16

GLAU/LIB/06/2020

VCK- 990
4/11/20

VCO-50
4/11/20

GLA UNIVERSITY
Accredited with A Grade by NAAC

31.10.2020

To,
The Vice-Chancellor
GLA University
Mathura

Through proper channel

Subject: Request to sanction the amount of **₹ 783764/-** for renewal subscription of Turnitin Originality Check: Anti-Plagiarism Web Tool for 2020-2021.

Sir,

With due respect, I wish to state that Turnitin Originality Check: Anti-Plagiarism Web Tool is to be renewed for the year 2020-2021 commencing from **01.10.2020 to 30.09.2021.** For which, the subscription renewal amount in **US Dollar which is** $ 10613 **(INR ₹ 783764/-) is** to be sent either through D.D in favor of "TurnitIndia Education Private Limited" or NEFT. The required details are enclosed along with this letter.

I, therefore, request you to kindly accord the approval and sanction the said amount for the same. The detailed information along with approval is herewith enclosed for your kind information.

Thanking You,

Yours sincerely,

Dr. Ajay Kumar Sharma
Assistant Librarian

May be approved
Sub pl.
Anand Dhar Agarwal

Note:*conversion rates are subject to change as per RBI/GOC

Recommended for the procurement

Chancellor

GLAU/R/OFF/LIB/10481/20

23.11.2020

To,
Mr. Utkarsh Tyagi
Territory Manager-North-HE Subscriptions
Turnitin India Education Private Limited
Max Towers, 16th Floor,
Spaces Suites # 1603-05,1608, 1610, Sector 16-B, Noida,
Uttar Pradesh-201301
Mob: +91-7303398743

Subject: **Acknowledgement towards the payment of Subscription of "Turnitin-Anti Plagiarism Web Tool" for 2020-2021.**

Dear Sir,

With reference to the subject as cited above, the full advance payment of ₹ 783764/- (Rupees Seven Lac Eighty Three Thousand Seven Hundred and Sixty Four Only) has been made on 19.11.2020 through RTGS (UTR NO. IOBAN 20324440770) as per details given in your proforma invoice dated 12.10.2020 towards the renewal of subscription for the aforesaid Anti Plagiarism Web Tool for one year commencing from 01.10.2020 to 30.09.2021.

It is requested that the same may kindly be accepted and the receipt for the same may be sent to the undersigned at the earliest.

Thanking You,

Yours truly,

(Ashok Kumar Singh)
Registrar

turnitin

Max Towers, 16th Floor, Spaces
Suites # 1603-05, 1608, 1610, Sector 16-B

Noida - 201301

Uttar Pradesh
India
1-510-764-7600
GST IN: 09AAGCT1132P1Z1
PAN : AAGCT1132P

Date: 12 October 2020

Pro-Forma Invoice No. Q-TEPL/GLA_Rev/2020

Due Date: 27 October 2020
Proposed Service Start: 01 October 2020
Proposed Service End: 30 September 2021

TAX PRO-FORMA INVOICE

Bill To	Billing Contact	Account Manager
GLA University	Prof. Phalguni Gupta	Utkarsh Tyagi
17 Km. Stone, NH-2, Mathura-Delhi Road Mathura, Uttar Pradesh 281406, India	vc@gla.ac.in	utyagi@turnitin.com
		7303398743

Item/description	Product Description		Amount INR
Turnitin Feedback Studio (Faculty Members/Academic Staff+Research/Ph.D. Scholars+P.G.+U.G. Students)	Subscription Term - 12M / Subscribed End-User Access - 2941) Academic (H.E.) - Growth Subscription		₹ 6,64,206.90
		Subtotal	₹ 6,64,206.90
		IGST - 18%	₹ 1,19,557.24
		Total Due	₹ 7,83,764

$10,613 USD = ₹ 7,83,764 INR

Total Invoice Amount in Words
INR: Seven Lakh Eighty Three Eight Thousand Seven Hundred and Sixty Four Only

EXCHANGE RATE US $1 = INR Rs. 73.85

Rate of Exchange is valid only for 15 days and in case of any delay in payment, an additional invoice for the difference in Exchange Rate, if any, as on the date of payment shall be raised on the customer.

Pro-forma Invoice is system generated and thus does not need a signature

Make your cheque payable to: TurnitIndia Education Private Limited

Remit Cheque Payment to:	TurnitIndia Education Private Limited Max Towers, 16th Floor, Spaces Suites # 1603-05, 1608, 1610, Sector 16-B Noida - 201301 India
Wire Instructions:	BENEFICIARY BANK: Citibank N.A. BENEFICIARY COMPANY: TurnitIndia Education Private Limited BENEFICIARY BANK ACCOUNT: 0714093002 BENEFICIARY BANK BRANCH IFSC CODE: CITI0000002 BENEFICIARY BANK BRANCH MICR CODE: 110037002 BENEFICIARY BANK SWIFT CODE: CITIINBX 2) Request that your originating bank reference your invoice number. If you do not have an invoice number, please request that your originating bank reference the name of your institution and your location. 3) Email ar@turnitin.com and southasia@turnitin.com with the confirmation that the transaction has been completed

of

GLA UNIVERSITY MATHURA
Accredited with A Grade by NAAC
12-B Status from UGC

18.10.2021

To,
The Vice-Chancellor
GLA University
Mathura

Through proper channel

Subject: Request to sanction the amount of ₹ 824563/- for renewal subscription of Turnitin Originality Check: Anti-Plagiarism Web Tool for 2021-2022.

Sir,

With due respect, I wish to state that Turnitin Originality Check: Anti-Plagiarism Web Tool is to be renewed for the year 2021-2022 commencing from 01.10.2021 to 30.09.2022. For which, the subscription renewal amount in US Dollar which is $ 11142.74 (INR ₹ 824563/-) is to be sent either through D.D in favor of "Turnitindia Education Private Limited" or NEFT. The required details are enclosed along with this letter.

I, therefore, request you to kindly accord the approval and sanction the said amount for the same. The detailed information along with approval is herewith enclosed for your kind information.

Recommended for approval

Thanking You,

Yours sincerely,

Dr. Ajay Kumar Sharma
Assistant Librarian

Recommended

18/10

GLA UNIVERSITY MATHURA

Amt. 824563/-
Date 23/10/21
Head :
Signature 23/10/21

23/10

turnitin

Tax Quote

Bill To	GLA University 17 Km. Stone, NH-2, Mathura-Delhi Road, Mathura, Uttar Pradesh 281406 India
Contact Name	Ajay Sharma
Phone	05662-250935
Email	pm.gupta@gla.ac.in
Fax	
PAN	
GSTIN	Not Registered

Company Name & Address	TurnitIndia Education Private Limited Max Towers, 16th Floor, Spaces, Suites #1603-05, 1608, 1610 Sector 16-B Noida, Uttar Pradesh 201301 India
PAN	AAGCT1132P
GSTIN	09AAGCT1132P1Z1
Account Manager	Utkarsh Tyagi
Phone	
Email	utyagi@turnitin.com
Quote Number	Q-457390-1
Quote Date	8/28/2021
Quote Valid Till	9/30/2021
Order Type	Renewal Business
Proposed Subscription Start Date	10/1/2021
Proposed Subscription End Date	9/30/2022

SERVICE DESCRIPTION	LICENSE FEE DESCRIPTION	QUANTITY	AMOUNT
Feedback Studio Growth License	Turnitin Feedback Studio: Originality Checking and Feedback	1	USD 9,443.00
		TOTAL:	USD 9,443.00

GST	18%
TOTAL	USD 11,142.74

Quote (with Tax)

KINDLY NOTE:
Upon acceptance of this QUOTE in writing via a Purchase Order; TurnitIndia Education Private Limited will provide an INVOICE payable in equivalent Indian Rupees. The US$ QUOTE AMOUNT will be converted to equivalent INR INVOICE AMOUNT as per the Market Exchange Rate applicable as on the Invoice Date

PURCHASE ORDER/CONFIRMATION

PLEASE RAISE YOUR PURCHASE ORDER IN THE NAME OF TURNITINDIA EDUCATION PRIVATE LIMITED, AS FOLLOWS:
TURNITINDIA EDUCATION PRIVATE LIMITED,
Max Tower, 16th Floor, Space, Suites #1603-05, 1608,1610 Sector 16-B, Noida - 201301, Uttar Pradesh, India

Please send Purchase Order/Confirmation to your Account Manager or e-mail to southasia@turnitin.com

The original Purchase Order/Confirmation may be kindly be posted/mailed to :

Book Chapter

by Hemangini 15.9.21

Submission date: 15-Sep-2021 08:09AM (UTC+0800)
Submission ID: 1648640944
File name: Combined.docx (26.28K)
Word count: 4192
Character count: 25408

Physiological Responses

Water and Nutrient Relations

Numerous factors influence plant water relations therefore on exposure to drought; leaf water potential, leaf canopy temperature, stomatal conductance and transpiration all of these get affected specifically stomatal conductance (Farooq et al., 2009b). A substantial decrease in transpiration rate and leaf water potential has been investigated in course of stress conditions thus an eventual increase in leaf and canopy temperature take place (Turner et al., 2001). Water use efficiency is the foremost attribute in plant physiological regulation; defines as the ratio of the dry matter accumulated to the water consumed (Monclus et al., 2006). It have been reported that certain efficient wheat cultivars have higher water use efficiency under drought (Abbate et al., 2004). Therefore the enhancement in water use efficiency is triggered by utilization of minimal amount of water because of less rate of transpiration and stomatal closure urge the accumulation of dry matter.

Photosynthesis

Photosynthesis plays crucial role in physiology of plant which may get disturbed on exposure to drought; in terms of improper functioning of the photosynthetic machinery, reduced leaf expansion and leaf senescence (Farooq et al., 2009b, Wahid et al., 2007). CO2 availability rate drop off due to stomatal closure in course of drought thus increasing plant sensitivity towards photo damage (Lawlor and Cornic, 2002). When the available humidity subsided it exhibits adverse alterations in photosynthetic pigments, impair the photosynthetic machinery and deplete the performance of key enzymes as a result of plant growth and yield extensively reduced (Fu and Huang, 2001, Monakhova and Chernyadev, 2002)

Photosynthetic Pigments

Thylakoid membranes and photosynthetic pigments get mutilated under drought (Anjum et al., 2011). The chlorophyll content also reflects inconsistent behaviour, enzymes involved in chlorophyll biosynthesis indicates altered variation in their activities, in presence of stress conditions although it depends on cultivar type and crop species. In addition to this the concentration of chlorophyll a was higher in case of chlorophyll b in drought stressed plants (Jain et al., 2010, Din et al., 2011). Previous reports suggests, the ratio of chlorophyll a/b was decreased in some Brassica species on exposure to drought (Ashraf and Mehmood, 1990). It has been reported in some cultivars of black gram [Vigna mungo (L.) Hepper] in drought stress

the chlorophyll content was increased while in some others it get decreased (Ashraf and Karim, 1991).

Photosynthetic Process

Stomatal closure is the foremost response plants confer to circumvent the water loss through transpiration in case of drought. In case of, decreased level of atmospheric humidity or leaf water potential leads to stomatal closure (Ludlow and Muchow, 1990, Maroco et al., 1997). As a result of stomatal closure heat dissipation in leaves increases along with level of CO2 intake .. causes oxidative damage and no assimilation (Yokota et al., 2002). Remarkably, soil moisture status affects stomatal regulation more than leaf water content, possibly stomata counters the production of ABA via roots under drought (Turner et al., 2001). Nonetheless, the stomatal responses greatly varies among plant species on exposure to drought stress (Lawlor and Cornic, 2002). Reduced stomatal conductance limits rate of photosynthesis though causes impaired Rubisco functioning which majorly affects photosynthesis subjected to drought (Bota et al., 2004). Lack of water availability triggers shrinkage of cells owing to reduced cellular volume, as a result the viscosity of cellular material increased which instigates denaturation of proteins (Hoekstra et al., 2001). Ion toxicity seriously influences enzymes activity involved in photosynthesis and other plant processes which in course caused by elevated concentrations of solute in cytoplasm (Hoekstra et al., 2001). Rubisco enzymes concentration depends on the rate of synthesis and degradation, having a half-life of several days it sustains stability under water deficit conditions (Hoekstra et al., 2001). Although decrease in small subunits of rubisco due to reduced rate of synthesis leads to severe damage (Vu et al., 1999). Inhibitors binding on the catalytic site of Rubisco like 2- Carboxyaribintiol 1- Phosphate affects the enzyme activity commonly under drought stress. Likewise, another essential enzymes intricated in the process of photosynthesis are also adversely get affected by heat and drought stresses. Previous reports suggests that under drought the loss in the production of nicotinamide adenine dinucleotide phosphate .. give rise to down regulation of the non-cyclic electron transport chain as a consequence the phosphorylation and ATP synthesis decreases which is a major limiting factors for photosynthesis (Lawlor and Cornic, 2002).

Assimilate Partitioning

Water deficit conditions interrupts equilibrium of the assimilates because generally they translocated to the roots for the improvement of water uptake (Leport et al., 2006). Generally export of assimilates from source to sink is governed by the concentration of sucrose in leaves and rate of photosynthesis (Komor, 2000). The export rate from source to sink eventually

decline in presence of drought which lowers the process of photosynthesis and reduce the sucrose content as well as hinders the capability of the sink for consumption of incoming assimilates (Zinselmeier et al., 1999). Furthermore, the phloem loading and unloading perturbed due to the activity of acid invertase. In such a manner, drought stress adversely affect dry matter partitioning.

Oxidative Damage

Generally, oxidative damage is the most common consequent in plants on exposure to drought stress as a result of reactive oxygen species (ROS) formation takes place. ROS jeopardized cell functioning thereby it triggers impairment of lipids and proteins. As compared to normal conditions lipid peroxidation intensified four times in pea under drought (Moran et al., 1994). Usually, the generation of ROS happens in chloroplast while mitochondria is also involved in the process as electron transport chain components reacts with oxygen (Reddy et al., 2004 Moller, 2001). Previously, it has been reported that ROS are produces under higher temperatures and the mechanism of generation maybe enzymatic or non -enzymatic (Liu and Huang, 2000; Wahid et al., 2007 Apel and Hirt, 2004). In order to facilitate with the oxidative stress, plants adapt antioxidant defense mechanism either non enzymatic or enzymatic. Therefore, enzymatic defense mechanism is more efficient which involves POD, CAT, GR, and SOD enzymes (Farooq et al., 2008, 2009b).Together with these enzymes some non-enzymatic components such as carotenoids and glutathione also involved in antioxidant system. Plants protect themselves by scavenging ROS directly through enzymes such CAT, SOD and POD or by managing indirectly the non-enzymatic defense system (Anjum et al., 2011). Detrimental outcomes of ROS has been counteract strategically by plants through maintaining the elevated levels of anti-oxidants hence, it has been reported the content of malondialdehyde raised in response to ROS consider as indicator of drought induced oxidative damage (Sharma and Dubey, 2005 Moller et al., 2007). Phytohormones assist plants to adapt under altering environmental conditions by facilitating their nutrient allocations, source/ sink transitions, growth and development additionally they act as natural defense molecules and retains the antioxidant levels under stress (Fahad et al., 2015a).

Physiological and Biochemical Responses

Various biochemical and physiological variations occurs at cellular level acquainted with drought stress comprises of alteration in solute concentrations, membrane fluidity and

composition, loss of turgor, protein-lipid and protein-protein interactions [8]. Morphological and developmental traits stipulates tolerance mechanism such as capacity of roots to invades dense soil layers ,root depth, mass and thickness helps plant tissues to escape dehydration via maintaining turgor[9,10]. Plants acclimates osmotic adjustment and dehydration tolerance which evolve in case of water deficit conditions [11]. In response to drought some common physiological and biochemical characteristics are conversions in carbohydrate metabolism, deposition of osmolytes and organic acids and drop off in photosynthetic activity. Osmoprotectants comprises of amino acids polyols, tertiary sulfonium and quaternary ammonium compounds. Through synthesizing osmolytes and compatible solutes plants evolve themselves to cope up under adverse environments because they exhibit osmotic balancing and their accumulation in plant cells tends to provide tolerance under drought. Previous studies suggests in case of the manipulation in carbohydrate metabolism of plants on exposure of drought stress persuade that, the hydroxyl group of polyhydroxy compounds can form a hydrogen bond with the polar heads of membrane phospholipids therefore these hydrophobic interactions are very crucial to maintain the membrane stability [8,14–16].

Biochemical Response of Rice under Drought

Plants maintains the turgor pressure by accumulating the organic and inorganic solutes in course of drought stress as a result of the osmotic potential of cytosol decreased [170]. Water deficit conditions promotes the biochemical response in plants mainly osmotic adaptions arises through the accumulation of soluble sugars, sucrose, proline , glycine betaine and other solutes in cytoplasm along with stimulating the capacity of water uptake from soil.

Role of Proline under Drought.

In plants, proline is most widely studied amino acid which act as an osmolyte proline under several unfavourable environmental constraints especially drought is one of them [172]The role of proline was first investigated in 1954 by Kemble and Mac Pherson in rye grasses on exposure to stress reflects accumulation of free proline [173]. In rice, variation in proline accumulation have been studied in terms of adverse and favourable conditions therefore, to screen drought tolerant rice cultivars proline content could be consider as a suitable marker. [128, 133, 136, 174, 176]. Furthermore, under drought stress proline functions as an antioxidative defence molecule, signalling molecule and a metal chelator [175].

Role of Antioxidants under Drought.

Reactive oxygen species (ROS) production in plants increased under adverse climatic conditions, due to metabolic perturbation of cells which in terms, leads to serious cellular impairment as a result of oxidative damage to biomolecules[1,8]. Subsequently, earlier reports reviewed that uplifting of endogenous enzymatic and non-enzymatic ROS scavenging systems achieve more stress tolerance [8,9]. Antioxidant enzymes are present in cell organelles and cytoplasm like catalase(CAT), superoxide dismutase(SOD), glutathione reductase(GR), ascorbate peroxidase (APX), dehydroascorbate reductase(DHAR), monodehydroascorbate reductase (MDHAR) **[178]** and non-enzymatic antioxidants carotenoids, a-tocopherol, ascorbate, glutathione perform a vital role in detoxifying the reactive oxygen species(Shao et al. 2008). Oxidative stress leads to generation of methionine sulfoxide residues in proteins causes damage. Therefore, this could be prevent by other class of antioxidant enzyme methionine sulfoxide reductases uses thioredoxin to reduce the residues for ROS generation in plastids (Rouhier et al. 2006). Reactive oxygen species comprises of hydrogen peroxide, singlet oxygen, superoxide radicals and hydroxyl free radicals triggers various destructive activities such as, cellular oxidative damage, lipid peroxidation, disruption in cellular homeostasis, denaturation of protein, mutation in DNA. Plants cope up with the negative impact of ROS via complex system of enzymatic antioxidants and non-enzymatic molecules. The expression of these enzymes reflects enhancement in drought tolerance in rice, these antioxidants play very crucial role in crops act as a ROS scavengers [179]. Additionally, the tendency of antioxidant defence system is to enhance the enzyme activity in order to counteract the oxidative impairment in cells on exposure to drought stress in rice. Consequently, an increase in the activity of phenylalanine ammonia lyase, CAT, AsA, DHAR, MDHAR, SOD, APX, GSH, GR reflects the elevation in drought stress levels in rice considerably decreases the effect of ROS[169,171,174,180,181].

Role of soluble sugars in drought

Amino acids, polyamines and numerous soluble sugars act as antioxidants and signalling molecules produced in response to stress, allow to maintain cell turgor and stabilizing cellular membranes. It has been reported that remarkably increased concentrations of soluble sugars leads to scavenging reactive oxygen species [20]. Therefore, by manipulating the sugar metabolism via transgenic approach improves oxidative stress tolerance in plants [21]. Along with soluble sugars polyamines soluble sugars in plants plays major role against stress conditions, these are positively charged molecules includes putrescine (Put), spermidine (Spd

and spermine (Spm).[182, 183]. By interacting with various signalling networks polyamines regulate osmotic potential, ionic homeostasis and membrane stability. On exposure to drought the elevated levels of polyamines directly correlates with improved osmotic adjustments and detoxification, enhancement of photosynthetic activity and reduce water loss capacity though the mechanism was not clearly understood. Polyamines are involved in the regulation of gene expression through maintaining ion balance, precluding senescence via protein phosphorylation and transition in DNA conformation, enabling DNA binding of transcription factor. Recent studies shown under drought stress in rice polyamines biosynthesis has been increased[185]. Application of exogenous polyamines improves water use efficiency, leaf water level, soluble phenolics and anthocyanins content, net photosynthesis rate and reduces cellular damage via oxidative stress [138]. Furthermore, there are some emerging facts reflects about sugars such as oligosaccharides of raffinose family and fructans, may possibly act as signal for hormones and stress related networking pathways [20]. Consequently, these potential novel targets exhibit advance role to improve stress tolerance in crops.

Plants response to drought stress

Drought stress meant to be water deficit situation where soil moisture content is low and rapid evaporation leads to continuous water loss occurred by climatic conditions. Plant growth and development is affected by dehydration. Therefore, for survival under such adverse conditions various biochemical, morphological, physiological and molecular mechanism has been adapted by plants (Fang and Xiong 2015). Plants opt four possible ways to overcome under stress to build resistance against drought; drought escape (DE), drought recovery (DR) drought avoidance (DA), and drought tolerance (DT) (Fang and Xiong 2015). Drought escape plants modify their lifecycle or growth pattern period before the onset of drought to adapt naturally under water stress./ In case of, drought escape before the onset of drought plants modify their lifecycle or growth pattern period to adapt naturally under water stress

Likewise, drought recovery reflects plant ability to reinstate its vivacity and growth after the exposure to severe drought stress. In case of , drought avoidance plants alters morphological structures to maintain normal physiological processes and upholds higher level of tissue water content despite of low soil moisture (Luo 2010). Plants attains avoidance via wax accumulation, stomatal closure pattern, reduces vegetative growth, comprises number and

leaves size and increases water uptake by deep rooted system to avoid dehydration. Contrastingly, the capability of plants to perform physiological activities under extreme drought stress by regulating stress responsive genes and signalling pathways indicates drought tolerance (Fang and Xiong 2015). On contrary, by regulating stress responsive genes and signalling pathways plants build ability to perform physiological activities under extreme drought stress condition shows drought tolerance (Fang and Xiong 2015). Drought tolerance is recognised by the efforts of one or more combination of these mechanisms in plants at different developmental stages. As drought tolerance is incredibly a complex quantitative polygenic trait and its quite challenging to understand the molecular and physiological mechanisms involved in it. Drought resistance plants are evaluated on the basis of morphological and physiological traits, includes proline content, abscisic acid (ABA) content, water potential, osmotic adjustments, root traits and leaf traits act as indicators (Fang and Xiong 2015). Moreover, under water deficit condition antioxidants and osmo-protectants also allow plants to cope up in stress condition (Luo 2010). Leaf morphology is an important agronomic trait to generate drought tolerant genotypes (Walter et al. 2009). Earlier, studies suggested that genotypes showing leaf rolling shows decrease in water loss by decreasing rate of transpiration and increases drought tolerance (Xiang et al. 2012). In response to dehydration several signalling molecules, including calcium, ABA, reactive oxygen species(ROS) and phytohormones and cross talk among distinct factors play significant role in signal transmission (Hu and Xiong 2014). Expression of multiple dehydration responsive genes is a resultant of signalling and phytohormone biosynthesis, encodes ion transporters, calcineurin interacting protein kinases (CIPKs),sucrose non fermenting protein (SNF1)-related kinase 2 (SnRK2), calcium dependent protein kinases (CDPKs), calcineurin B-like interacting protein kinase (CIPK), mitogen-activated protein kinases (MAPKs) and transcription factors (Fang and Xiong 2015). OsCIPK23 and OsCDPK7 up regulation expression in rice positively switch drought tolerance (Yang et al. 2008). In previous, studies OsMPK5 and MAP kinase kinase kinase (M3K) gene DSM1 of MAP kinase cascade in rice identified as a key molecule involves in the regulation of drought tolerance (Sinha et al. 2011). Drought tolerance in plants is exhibited by several transcription factors (TFs) comprises of zinc-finger, AP2/EREBF, AREB/ABFs, MYB, NAC TFs families (Joshi et al. 2016). Arabidopsis SnRK2C confers stress responsive genes regulation & expression in response to it provides drought tolerance (Umezawa et al. 2004). In Arabidopsis ABA mediated positive regulation of drought tolerance is mediated by the coordination of AREB1, AREB2 and AREB3 (Yoshida et al. 2010). Similarly, wax biosynthesis in Arabidopsis activates AP2/EREBF TF SHN subsequently enhance tolerance

for drought (Aharoni et al. 2004). Phytohormones are associated with signalling pathways among them ABA is nearly linked to the drought stress. Therefore, coordination of three classes of proteins, includes (a) the Pyrabactin Resistance 1 (PYR1) and/or PYR1-like protein (PYL) and/or Regulatory component of the ABA receptor (RCAR) (herewith referred as PYLs), (b) Protein phosphatase 2C (PP2C) and (c) SnRK2s regulates ABA mediated drought tolerance in plants (Joshi et al. 2016). PP2Cs are associated with SnRK2s kinases remains inactive (dephosphorylated) in the absence of ABA. In water deficit circumstances, phosphatase activity of PP2C is inhibited because of ABA binds with PYLs. Subsequently, auto phosphorylated SnRK2s releases via PP2C which in turn phosphorylate effector molecules downstream aims to provide drought tolerance. (Fig. 1). Thus, improve plant growth and drought resistance would be achieved by altering some key enzymes of ABA biosynthetic pathways (Park et al. 2008). Calcium and ABA along with late embryogenesis abundant (LEA) protein (osmoprotective proteins) and glycine betaine, mannitol, sorbitol, proline (osmolytes) are solely responsible for diminution in water loss via stomatal closure. The antioxidant enzymes for instance glutathione peroxidase (GPX), ascorbate peroxidase (APX) and superoxide dismutase (SOD) get activated via effector proteins and allows ROS detoxification. Hence, developing better insight in such molecular mechanisms facilitate for the improvement of drought resistance in plants via conventional breeding and transgenic approaches. In previous years, traditional breeding, molecular marker approach and genetic engineering deliver remarkable outcome in unravelling these molecular mechanism of drought resistance in plants (Kulkarni et al. 2017; Cao et al. 2017; Sahebi et al. 2018). Various genes responsive to drought stress have been characterise and validated for conferring drought resistance in plants by identification of RNA-Sequencing data as well as QTLs associated with physiological traits and root & leaf structures also been mapped (reviewed in Hu and Xiong, 2014). Though, traditional breeding methods are labour intensive and time consuming and genetically modified transgenic plants requires stringent regulatory clearances which encourage plant breeders to prefer novel approaches in the area of genetic engineering such as genome editing that could accelerate rapid development of drought resistance crops.

Introduction 1

Due to Global warming and climate change consistently plants encounter with multiple biotic and abiotic combination of stresses, harshly which leads to effect their yield and developmental growth. To sustain crop productivity its necessary to improve agriculturally important traits thus reduces the effect of adverse climatic conditions. By adapting novel technologies and efficient approaches for the development of resistant varieties. Among various environmental constraints drought is one of the major stress initiates huge agricultural loss and challenge the food security globally (Lobell and Gourdji 2012). Drought indicates low water availability for the prolonged period of time under such conditions plants adapts themselves for survival in response to cope up in adverse situations. Therefore, several strategies exhibited by plants to counteract water loss, uphold cellular water content and provide optimal supply to essential organs and withstand in drought. Plants activate the survival mechanism to endure in stress condition is known as drought resistance; is a complex trait resultant of various mechanisms: (a) drought escape (Stimulate the reproductive phase of plant earlier to the exposure of stress.),(b) drought avoidance (resilience the internal higher level of water content and inhibit tissue damage), (c) drought tolerance (by maintaining lower level of internal water content for growth under prolonged period of drought) (Gupta et al.2020). To improve drought tolerance effectively in crops such as rice, wheat, maize, soyabean transgenic approaches and conventional breeding methods are successful (Ashraf 2010). . In previous years, conventional breeding is reliable approach for developing better drought tolerant cultivars. Although it is much more laborious and time consuming approach on the other hand molecular marker technology; (QTLs) quantitative trait loci based characterization plays remarkable role in the analysis of broad array of genetic sections of plants under stress (Rao et al. 2016). Various, quantitative trait loci (QTLs) have been identified in different crops responsible for drought tolerance but the accuracy and assurance in QTLs detection is challenging (Khan et al. 2016). Though, newly developed varieties are not more capable to sustain in water deficit conditions and elevated yield. Therefore, genetically engineered improved crops are quite effective against biotic and abiotic stresses. Thus, still a hope that the novel approaches; CRISPR/CAS9 in the area of crop improvement may able to resolve the problem of crop productivity under drought stress.

Introduction 2

Water scarcity is foremost issue for agriculture it threatened food security globally. Subsequently, agriculture is solely dependent on availability of water climate change increased the risk of agricultural drought.[1] drought stress is most devastating condition for crop productivity, resulting in altered growth of plants hereafter yield of crop is restricted due to environmental stress; approximately 10% of the farmable land in the world is remain unaffected by stress. Vascular plants endure notable capability via they are able to survive and tolerate harsh drought condition and recover them after reinstatement of water balance ,only minor damage occur to plants in this process. Thus, identification of such mechanism of plant response against unfavourable environment would help in future to develop drought resistance in crops via using molecular level improvement approaches results in improve growth and yield. Water deficit conditions disrupts normal development of plant as a resultant leaf size, stem extension, root proliferation reduces also affects water and nutrient relations along with it decreases water use efficiency, rate of photosynthesis, assimilate partitioning and eventually cause a substantial reduction in crop yields (Farooq et al., 2009b; Praba et al., 2009). Plant response towards drought usually differs from species to species depending upon the growth stage of plant and additional environmental factors (Demirevska et al., 2009).[2]

Introduction 3

Almost 70% of the entire available freshwater is required for agriculture as food production is water demanding process. To generate kilogram of wheat and rice approx. 1350 and 3000 l and for maize 900 l of water is required respectively. Though, 40 % of the world's food is produced by 16 % of irrigated cropland [3]. This situation is perturbing, in view of the above-mentioned record. Indicate that a short period of water scarcity in the most effective cropping environs gives rise to an extensive drop in biomass yield per year The effect of drought stress on productivity vary as per the growth stage of crop and depending on the intensity, onset time and duration of drought. For instance, average yield loss is higher than 50% because of drought stress during reproductive stage (Boyer 1982,Venuprasad et al. 2007). Moreover, plants suffering from abiotic stresses are usually more vulnerable to biotic stress, like insects, pathogens, and weeds, which enhance the losses significantly (Boyer 1982). In response to drought plant productivity and performance get affected causes cellular dehydration and decreases the cytosolic and vacuolar volumes subsequently, promotes reactive oxygen species generation which negatively affect metabolism and cellular structures.[3] Drought tolerance mechanism in plants involved with biochemical and physiological processes, these mechanisms are stimulated at different plant development stages involves increase in water

uptake via deep rooted systems, enhances osmolytes biosynthesis and stomatal resistance by reducing water loss.(Farooq et.al. 2009). Likewise, at the molecular level, the stress-responsive signalling pathways play significant roles during abiotic stress via connecting the sensing mechanism and genetic responses. Multiple genes are responsible for the regulation of abiotic stress tolerance mechanism. Along with the tolerance mechanisms acquired by plants, different laboratories have been working around the world to understand molecular principles and exploring drought-responsive genes in order to develop drought-resistant crop varieties. For the improvement of targeted traits genetically engineered plants were develop according to farmer's benefit and majorly emphasized on commercial benefits as nutritional value. Genetic engineering techniques requires knowledge on candidate genes involved in biochemical and physiological processes related to abiotic stress tolerance. Commercial uses are restricted to genetically engineered crop varieties for abiotic stress tolerance due to the regulations and inadequate field performance. Since, these varieties are expose to a diverse combinations of biotic and abiotic stresses to resist themselves under adverse conditions. Genetic modification at genome level by utilizing genome editing technology is an alternative approach to gene transfer. It allow researchers to alter or replace some alleles at nucleotide level in addition to silencing or insertion of novel gene(s) to targeted region of the genome. ~~For~~ the development of stress tolerant cultivars by using site specific endonucleases for genome editing is not a new concept. In recent, years highly precise site specific genome editing technique is used by most of the scientists worldwide known as (CRISPR)/CRISPR-associated protein 9 (Cas9) Clustered regularly interspaced short palindromic repeats, it dominate the other alternatives such as zinc-finger nucleases (ZFNs) and transcription activator-like effector nucleases (TALENs) because of high accuracy, less time consuming and cost effective along with this allows multiplexing of different targeted genes at the same time. As their some limitations with Cas9 new alternative endonucleases are available as Cpf1 lately in consideration. These transgene free editing techniques applications are recently introduced to public domain for acceptance under law regulations which is quite debilitating for researchers.[5,6]

Book Chapter

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