Response of Foliar Application of Water, Salicylic Acid and Nutrient on Physiology of Chickpea Genotypes Growth and Productivity under Rainfed and Irrigated Late Sown Condition

THESIS

Submitted to the

Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur
In partial fulfillment of the requirements
For the Degree of

MASTER OF SCIENCE

In

AGRICULTURE

(PLANT PHYSIOLOGY)

By

Rahul Raghuwanshi

Department of Plant Physiology
College of Agriculture, Jabalpur 482004
Jawaharlal Nehru Krishi Vishwa Vidyalaya
Jabalpur, Madhya Pradesh

2018

CERTIFICATE – I

This is to certify that the thesis entitled, ***"Response of Foliar Application of Water, Salicylic Acid and Nutrient on Physiology of Chickpea Genotypes Growth and Productivity under Rainfed and Irrigated Late Sown Condition"*** *submitted in partial fulfillment of the requirement for the degree of* ***MASTER OF SCIENCE (Ag.)*** *in the* ***DEPARTMENT OF PLANT PHYSIOLOGY****, Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur is a record of the bonafide research work carried out by* ***Mr. Rahul Raghuwanshi*** *under my guidance and supervision. The subject of the thesis has been approved by the Student's Advisory Committee and the Director of Instructions.*

All the assistance and help received during the course of the investigation has been acknowledged by him.

Place: Jabalpur
Date:

(Sunil Kumar Pandey)
Chairman of the Advisory Committee

THESIS APPROVED BY THE STUDENT'S ADVISORY COMMITTEE

Committee	Name	Signature
Chairman	Dr. S. K. Pandey	_____
Member	Dr. S. D. Upadhyaya	_____
Member	Dr. (Smt.) A. Upadhayay	_____

Thesis is approved by

(Dr. A.S. Gontia)
Professor and Head

CERTIFICATE – II

This is to certify that the thesis entitled ***"Response of Foliar Application of Water, Salicylic Acid and Nutrient on Physiology of Chickpea Genotypes Growth and Productivity under Rainfed and Irrigated Late Sown Condition"*** *submitted by* ***Mr. Rahul Raghuwanshi*** *to the Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur in partial fulfilment of the requirements for the degree of* ***MASTER OF SCIENCE*** *in Agriculture in the* ***DEPARTMENT OF PLANT PHYSIOLOGY*** *has been, after evaluation, approved by the External Examiner and by the Student's Advisory Committee after an oral examination on the same.*

Place: Jabalpur
Date:

(Sunil Kumar Pandey)
Chairman of the Advisory Committee

MEMBERS OF THE ADVISORY COMMITTEE

Committee	Name	Signature
Chairman	Dr. S. K. Pandey	_____
Member	Dr. S. D. Upadhyaya	_____
Member	Dr. (Smt.) A. Upadhayay	_____
Head of the Department	Dr. A. S. Gontia	_____
Director of Instruction	Dr. D.Khare	_____

Declaration and Undertaking by the Candidate

I, **Rahul Raghuwanshi** s/o **Shri Bodh Singh** certify the work embodied in thesis ***"Response of Foliar Application of Water, Salicylic Acid and Nutrient on Physiology of Chickpea Genotypes Growth and Productivity under Rainfed and Irrigated Late Sown Condition"*** is my own first-hand bonafide work carried out by me under the guidance of **Dr. S.K. Pandey** at **Department of Plant Physiology** College of Agriculture, Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur and place during 2016-2017.

The matter embodied in the thesis has not been submitted for the award of any other degree/diploma. Due credit has been made to all the assistance and help.

I, undertake the complete responsibility that any act of misinterpretation, mistakes, and errors of fact are entire of my own.

I, also abide myself with the decision taken by my advisor for the publication of material extracted from the thesis work and subsequent improvement, on a mutually beneficial basis, provided the due credit is given, thereof.

Place: Jabalpur **(Rahul Raghuwanshi)**

Date:

Copyright Transfer Certificate

Title of the Thesis	-	**"Response of Foliar Application of Water, Salicylic Acid and Nutrient on Physiology of Chickpea Genotypes Growth and Productivity under Rainfed and Irrigated Late Sown Condition"**
Name of the candidate	-	Rahul Raghuwanshi
Subject	-	Agriculture
Department	-	Plant Physiology
College	-	College of Agriculture, Jawaharlal Nehru Krishi Vishwa Vidyalaya Jabalpur, Madhya Pradesh
Year of thesis submission		2018

Copyright Transfer

The undersigned **Rahul Raghuwanshi** assigns to the Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur Madhya Pradesh, all rights under Copyright Act, that may exist in and for the thesis entitled **"Response of Foliar Application of Water, Salicylic Acid and Nutrient on Physiology of Chickpea Genotypes Growth and Productivity under Rainfed and Irrigated Late Sown Condition"** Submitted for the award of M.Sc. (Ag.) degree.

Date:

Place: Jabalpur

(Sunil Kumar Pandey)
(Major Advisor)

(Rahul Raghuwanshi)
(Student)

ACKNOWLEDGEMENT

While traveling on a path of life and education many hands pushed me forward, enlighted by their knowledge and experience, present acknowledgment is much more than what I am expressing here.

It is my great opportunity and immense pleasure in availing this golden opportunity to express my deepest sense of gratitude and humble indebtedness towards my respected chairperson Dr. S. K. Pandey (Scientist) Department of Plant Physiology, J.N.K.V.V. Jabalpur for his kind, generous and valuable guidance, intellectual inspiration, keen interest, constant encouragement, unlimited patience and parental affection with cheerful smiling gesture. I consider myself fortunate in having guided by him.

I equally and ineffably cheered to place on record my obligation and gratitude to my Advisory Committee Member Dr. S. D. Upadhyaya (Professor and Head, Department of Forestry) and Dr. (Smt.) Anubha Upadhyay (Professor) Department of Plant Physiology, JNKVV, Jabalpur whose rationale, keen and continued interest, encouragement-inspiring advice and generous help in carrying out the relevant experiment required for my research work.

I have indebted my sincere thanks to all my teachers Dr. A. S. Gontia (Professor & Head) of the Department, Dr. S. K. Dwivedi (Professor) and Dr. R.K. Samiya (Professor); Department of Plant Physiology, College of Agriculture, JNKVV, Jabalpur for their infinite favor with which they encouraged me during the period of research work.

I also take the opportunity to thanks, Proff. P. K. Bisen, Hon'ble Vice-chancellor, JNKVV, Jabalpur, Dr. P.K. Mishra, Dean Faculty, JNKVV, Jabalpur, Dr. Dhirendra Khare, Director of Research Services, and Director of Instructions, College of Agriculture, JNKVV, Jabalpur, Dr. (Smt.) Om Gupta, Director of Extension Services, and Dean, College of Agriculture, JNKVV, Jabalpur and Dr. V.K. Pyasi, Dean Students Welfare, JNKVV, Jabalpur for providing me all necessary facilities during the M.Sc. (Ag.).

I wish my sincere thanks to my colleagues Govind, Jitendra, Malkit, Vivek, Kuleshwar, Laximi, Sradha, and my respected senior Shri om Verma, Pravinbisne, junior Alok

To express my sincere gratitude to my beloved parents in the form of words in restrictive both in expression and quantum, yet at this juncture, it is my esteem duty to reserve my high regards to my ideal, adorable and thinking father Shri Bodh Singh, my mother smt. Kantee my Sister Rashmi Raghuwanshi and other nearer and dearer ones without whose blessings and good wishes, it would not have possible for me to attain this position.

I am extremely thankful to my friends Jitendra, Malkit, Govind, Vivek, for the help renderd during the time of this investigation.

I would beg pardon and vendor my apologies to all those names which have not been included through oversight in the acknowledgment, they would kindly excuse me for the third blender.

Place: Jabalpur

Date: (Rahul Raghwanshi)

LIST OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF PLATE

ABBREVIATIONS

CGR	:	Crop Growth Rate
Chl.	:	Chlorophyll
DAF	:	Day After flowering
DAS	:	Day After Sowing
CCI	:	Chlorophyll Content Index
MSI	:	Membrane Stability Index
IRGA	:	Infrared Gas Analyser
Pn	:	Net Photosynthesis
E	:	Transpiration
gs	:	Stomatal Conductance
WUE	:	Water Use Efficiency
PGR	:	Plant Growth Regulators
HI	:	Harvest Index
RWC	:	Relative Water Content
RH	:	Relative Humidity
SA	:	Salicylic Acid
SPAD	:	Soil Plant Analysis Development
Tr	:	Treatment
WUE	:	Water Use Efficiency
*	:	Significant at 5% Level of Significant
D.f	:	Degree of Freedom
SE	:	Standard Error
SEm-+	:	Standard Error of Mean

INTRODUCTION

Global food security and climate change major focuses on crop improvement needed production and development pulse crops and recognizes climate-resilient cultivars with improved pulse production. Chickpea, (*Cicer arietinum L.),* is a member of the legume, pea or pulse family, “FABACEAE”. Also called Leguminaceae, this family of flowering plants is one of the largest plant families and includes beans, peas, peanuts, lupines, alfalfa, clover, and acacia. The Leguminaceae family is classified into 650 genera with 18,000 species including chickpea (Varshney et al. 2009). Chickpea is an ancient self-pollinated leguminous crop, diploid annual (2n=16) grown since 7000 BC, in different areas of the world But its cultivation is mainly concentrated in the semi-arid environment (Saxena, 1990).

India is the largest producer contributing to 65% of world’s chickpea production. In India total pulses area 23.55 million ha and production 17.15 million tones and productivity is 728 kg ha^{-1}. Chickpea (*Cicer arietinum* L.) is most important pulse crop of India in terms of area and production and extensively grown for human consumption mainly in South Asia and the Middle East. Chickpea (*Cicer arietinum* L.*)* is a cool season legume crop and is grown in several countries worldwide as a food source. Chickpea is the third most important food legume crop. In India during 2014-15 chickpea were cultivated in an area about 8.25 million ha with the production about 7.33 million tones and 889 kg ha^{-1} productivity. In Madhya Pradesh during 2014-15 chickpea was cultivated in an area of 2853 thousand ha and production was 2964 thousand tones and Productivity 1039 kg ha^{-1} (Anonymous 2016). Chickpea is important resilience crop in climate change the effects of terminal drought leaf parameters, seed set, and pod abscisic acid concentrations are reported in chickpea (Pang et al*.* 2017). Moreover, the critical importance of root trait variability and its role in facilitating stress tolerance in chickpea is reported Chen et al. (2017).

Chickpea seeds contain on an average 23% protein, 64% total carbohydrates (47% starch, 6% soluble sugar), 5% fat, 6% crude fiber and 3% ash. High mineral content has been reported for phosphorus (340 mg 100^{-1} g), calcium (190 mg 100^{-1} g), and magnesium (140 mg 100^{-1} g), iron (7 mg 100^{-1} g) and zinc (3 mg 100^{-1} g). Recent studies have also shown that they can assist in lowering cholesterol in the bloodstream and Chickpea is a good source of protein (20–22%), and is rich in carbohydrates (around 60%), dietary fiber, minerals and vitamins (Pittaway et al. 2008 and Verma et al. 2017).

Salicylic acid (SA) is a natural phenolic compound and endogenous signal molecule that plays a key role in the regulation of plant growth, development, interactions with other organisms, and responses to environmental stress (Miura and Tada 2014)

Salicylic acid (SA) is an endogenous plant growth regulator that acts as a signal in the induction of specific plant responses to biotic and abiotic stresses. SA is involved in the protection of plants against multiple stresses, including freezing, salinity, ozone, ultra-violet radiation, water stress, drought stress (Patel and Hemantaranjan, 2012). Foliar application of salicylic acid exerted a significant effect on plant growth metabolism when applied at the physiological concentration and thus acted as one of the plant growth regulating substances (Kalarani et al. 2002). In chickpea, the focus of drought tolerance research is the ability to sustain greater biomass production and crop yield under seasonally increasing water deficit rather than the physiological aptitude for plant survival under extreme drought shock (Serraj and Sinclair 2002). Due to inadequate soil moisture availability were recorded significantly yield losses of chickpea, and up to a 50% increase in chickpea production was achieved when moisture stress was alleviated (Subbaro et al. 1995).

SA can manage cellular redox homeostasis by controlling antioxidant enzyme activity. The biochemical changes in per cent viz. nitrogen, protein carbohydrate and fiber along with osmolyte (Proline) level in JG11 and JG14 chickpea genotype priming with salicylic acid (SA) and hydro-priming, foliar

application SA of and water sh0wed significant responses in drought condition Verma et al. (2017).

Weather abnormality and climate change created rainfall or water deficit (drought) and high-temperature situation affects the crop phenology in reproductive stages. Physiological associated traits and yield and yield components traits along with nutritional status in JG11 and JG14 genotypes, when the foliar application of SA, water, and nutrient ameliorate the affect abiotic stress. Therefore the present investigation was formulated on entitled **"Response of Foliar Application of Water, Salicylic Acid and Nutrient on Physiology of Chickpea Genotypes Growth and Productivity under Rainfed and Irrigated Late Sown Condition**"

Keeping in view of the above facts the present investigations are undertaken with the following objectives

Objectives

1. To study morpho - physiological traits influenced by the foliar application of water salicylic acid and nutrients.
2. To find out the effect of various treatment on yield attributes traits, productivity and quality rainfed and irrigated late sown condition.

REVIEW OF LITERATURE

2.1 Phenophases

2.1.1 Days to Flower Initiation (DFI)

JG11 (43.66 days) and minimum (40.33days) and JG14 maximum range (44.33 days) and minimum (40.33 days) DFI (Table 4.1 and Figure 3). The similar finding showed days to first flowering in chickpea genotypes reported by Patel and Hemantranjan (2012).

Kumar et al. (2017) reported the early flower initiation provides the plants to have the longer reproductive period which may enhance the economic output provided the seed development occurs early and pod filling rate was most favorable. Photo-thermal unit and relative temperature depression indicated that involvement of gene action and possibilities of effective selection for improvement of these traits.

2.1.2 Days to 50% Flowering (DFF)

Kotula et al. (2015) recorded under stress in chickpea, reproductive success stress has been associated with the production of more tertiary branches and flowers.

2.1.3 Days to Pod Initiation (DPI)

SA and nutrient component and water spraying produced an increasing trend of DPI rate. Nevertheless, increased grain yields under abiotic stress reported by (Khan et al. 2016).

2.1.4 Days to Flower End (DFE)

Bahuguna et al., (2012) that the time to the first flower was significantly shortened under mild temperature stress (MTS) in the chickpea genotypes, flower abortion increased that days to flower and early flower end.

2.1.5 Days to Pod End (DPE)

Mild temperature stress (MTS) treatment decreased seed number, seed size and seed weight plant^{-1} and pod end in the chickpea genotypes, while pod set and pod growth rate decreased reported by Bahuguna et al. (2012).

2.1.5 Days to Physiological Maturity (DPM)

Rai et al. (2016) observed that under high temperature by more dry matter partitioning towards pods instead of temperature induced partitioning towards vegetative plant parts, showed early physiological maturity assessment. The Dry matter partitioning was determined from the dry mass of individual plant parts as a percentage of total plant dry mass at physiological maturity..

2.2 Growth Analysis and Dry Matter Production

2.2.1 Crop Growth Rate (CGR)

SA and nutrient component have provided strengthening and the internal mechanism to protect and develop systemic acquired resistant chickpea plant in compared to without used of SA and nutrient component similar pattern for CGR in genotypic differences reported by Pandey et al. (2016).

2.2.2 Partition Coefficient (*p*).

Kuttimani and Velayutham (2011) observed that salicylic acid sprayed as individual and in combination at vegetative and flowering stages revealed that combined applications of 2%DAP+100 ppm salicylic acid+0.05% sodium molybdate increased the yield attributes (partitioning coefficient 49.18%) per plant in green gram.

2.2.3 Number of Nodules Plant^{-1}

Galloway et al. (2013) according to the legume-rhizobium symbiosis, rhizobia form nodules on the roots of legume hosts and fix dinitrogen (N2) into ammonium (NH4 +) and other chemically active forms of nitrogen performs in nodules plant-1. In plant some plant species having the Nod gene or nodulin,

that different type of nodA, nodB, and nod C. and regulated nodules by nod D gene responsible in Rhizobium in nodule formation.

2.2.4 Fresh Weight of Nodules Plant^{-1} (g)

Regus et al. (2017) according to deposition intensity was tightly correlated with nitrogen concentration in soils. The growth benefits of rhizobial nodulation were dramatically reduced by even modest levels of mineral nitrogen.

2.2.5 Dry Weight of Nodules Plant^{-1} (g)

Hayat et al. (2012) reported that Similar finding showed by the foliar application of salicylic acid (SA), used an increase of nodule dry mass and leg hemoglobin content in chickpea.

2.2.6 Total Dry Matter Accumulation (g)

Shekari, (2014) find out the SA more effective in biomass production than seed yield in this chickpea cultivars

Rai et al. (2016) reported that dry matter partitioning was determined from the dry mass of individual plant parts as a percentage of total plant dry mass at physiological maturity. The biomass partitioning was more towards vegetative plant parts attributing enhanced biomass.

2.3 Physiological traits

2.3.1 Chlorophyll Content Index (CCI)

Heidari et al. (2015) reported that the lowest chlorophyll index was observed in control (no priming) and hydro priming, while SA at 2250 µM increased significantly chlorophyll index. So that, chlorophyll content in the plant grown under 750, 1500 and 2250 µM of SA showed 24.7%, 64.0%, and 74.7% increase when compared with control, respectively in pinto bean.

Zandonadi et al. (2016) reported chlorophyll content index (CCI) values have the positive linear correlation with nitrogen content in the phenological stage.

Trankner et al. (2017) observed that due to more accumulation of starch at pod filling stage showed higher SPAD value at pod filling stage and foliar application of SA and nutrient enhanced the CCI.

2.3.2 Membranes Stability Index (MSI)

Membrane stability was drastically reduced under imposed water deficit stress. However foliar application of SA and Nutrient component during rainfed maintained higher MSI values over the water deficit stress reported by Vineeth et al. (2017).

2.3.3 Relative Water Content (RWC %)

Rao et al. (2012) recorded that application of 100 ppm salicylic acid (SA) maintained highest RWC (79.37 %).

Shekari, (2014) reported that relative water contents (RWC%) were affected by the interaction of SA and cultivars. The highest amount of this parameter seen in 750 µM of SA and in Kaka cultivar. In non-primed seeds, RWC showed the lowest amount and between two cultivars Pirooz showed lower amounts than Kaka in control seeds of chickpea.

Application of bioregulators maintained the integrity of mesophyll tissue and chloroplast structure thereby protected the chickpea plants from the detrimental effects of water deficit reported by Vineeth et al. (2017).

2.3.4 Photosynthetic Rate ($\mu mol\ Co_2\ m^{-2}s^{-1}$)

Hayat et al. (2014) reported that the net photosynthetic rate increased in response to the exogenous application of SA. However, out of the three concentrations of SA, maximum response was generated in the plants sprayed with 10^{-5} $molL^{-1}$of SA, showing a statistically significant increase of 46.92% net photosynthesis (Pn) over that of the control in chickpea.

Boukraa et al. (2015) reported that SA different concentration level was affected plant functions and physiology, some have promoted and some inhibited.

Photosynthetic assimilation in SA and nutrients component under rainfed foliar application. Photosynthetic rate (Pn). However, bioregulators application maintained higher Pn under water deficit stress. Under imposed water stress, compact palisade layers of the mesophyll tissue were disrupted and cell size of the mesophyll cells displayed drastic reduction. Chloroplast, under water stress, displayed a number of grana with losing type of thylakoid, the large increase in osmiophilic granules, reduction in a number of starch granules and overall disruption of the thylakoid membrane reported by Vineeth et al. (2017).

2.3.5 Stomatal Conductance (mol $H_2om^{-2}s^{-1}$)

Alyemeni et al. (2014) recorded that foliar application of 10^{-5}M of salicylic acid was significantly increased of stomatal conductance (gs) 30.3%, 31.7% in chickpea.

Hayat et al. (2014) reported that the stomatal conductance was increased in response to the exogenous application of SA. However, out of the three concentrations of SA, maximum response was generated in the plants sprayed with 10^{-5} $molL^{-1}$ of SA, showing a statistically significant increase of 20.6% (g_s) over that of the control. The stomatal conductance which is a component of photosynthesis exhibited the positive association with photosynthetic rate (Pn) and Total Dry Matter (TDM) reported by Marques et al. (2016).

2.3.6 Transpiration Rate (m mol H_20 $m^{-2}s^{-1}$)

Sarde et al. (2011) reported that the in chickpea transpiration rate was highest at 50% flowering and after 15 days decrease.

Mate et al. (2013) reported that the genotypes, Digvijay, Vijay, ICC-16862, ICC-6120, and ICC-1913 had comparatively higher transpiration rate in chickpea.

The transpiration rate expresses at the lower level and higher depends on the genotypic variations. Nutrient component and SA application only genotypic significant effect reported by Marques et al. (2016).

2.3.7 Intrinsic and Instantaneous Water Use Efficiency (μmol $mmol^{-1}$)

Alyemeni et al. (2014) Reported the foliar application of 10^{-5} M of salicylic acid was significantly increase of Water Use Efficiency 86.8%, 92.7% in chickpea. Nevertheless, the transcriptional reprogramming that occurs during the plant defense response against abiotic stress was reported to be modulated by SA, where the transcription of different sets of defense genes can be controlled in a spatio-temporal manner via SA-mediated mechanisms explained by Herrera-Vásquez et al. (2015)

2.3.8 Carboxylation Efficiency [μmol m^{-2} s^{-1}(μmol m^{-1})-1]

The ratio of net photosynthesis rate to intercellular Co_2 concentration is term carboxylation Efficiency (CE). SA and nutrient availability also influenced the CE rate reported by Meena et al. (2015).

2.4 Yields and Yield Components

2.4.1 Plant Height (cm)

Aliloo et al. (2012) reported that plant height of Azad cultivar was significantly higher than that of ILC 482 in chickpea.

Vaisnad et al. (2015) reported that application of exogenous SA could help to reduce the adverse effects of drought stress and might have a key role in providing tolerance to stress by promoting.

The SA and nutrient helpful for plant height in chickpea irrigated condition height increased. Although some hormones activity and metabolites changes. Plant height was genotype devolvement and the stronger selection was observed when crosses were made between stiff stalk and tropical germplasm reported by Hu et al. (2017).

2.4.2 Number of Node and Total Number of Branches $Plant^{-1}$

Boukraa et al. (2015) reported that applications of SA increased the number of leaves under stress conditions. The result showed by treated plants

with SA survive more, exhibit higher relative growth rate, enhanced the leaf area and the dry mass production.

Das, (2017) similar observation reported by Number of nodes was increased in the foliar application of SA and nutrients and water, however, inter-nodal length was enlarged compare without irrigated chickpea genotypes. Although each node bears branches and number of branches were increased and only genotypic variation expressed.

2.4.3 Number of Pods Plant^{-1}

PakMehr et al. (2011) reported that seed priming with salicylic acid increased the number of the pod in cowpea (*Vigna unguiculata* L.).

Rajabi et al. (2013) recorded that foliar application of 1.2 mM salicylic acid increased the maximum number of pod per plant (40.73) in chickpea.

Pang et al. (2016) find out the rainfed and irrigated were reduced number pod and increased number of empty pod per plant

The foliar application of SA, nutrients, and water under the rainfed number of pod bearing was enhanced. Nevertheless, the reproductive period was showed enlarge in rainfed condition. However in irrigation condition plant express delay and few flowering came and a number of fewer pods occurs. Nutrient uptake is also helpful for the pod to retain in plant observed by Das, (2017).

2.4.4 Seed Weight Plant^{-1} and Hundred (100) Seed Weight (g)

PakMehr et al. (2011) reported that seed priming with salicylic acid increased 100 seed weight in cowpea (*Vigna unguiculata* L.).

The nutrients mobilization also the important availability of sugar translocation at the time of seed formation and pod filling stage. Which is enhances the rate of accumulation, when the foliar application direct leaf absorbed nutrient through diffusion and utilized by plant reported by Verma et al. (2017) and Das, (2017).

2.4.5 Biological Yield (kg ha^{-1})

Farjam et al. (2014) Reported that Plant biomass was significantly increased through foliar application of SA in well watered and rainfed condition

Tanner et al. (2016) observed that the foliar application of SA and nutrient composition and water were enhanced the chlorophyll content and Rubisco protein and SA presence delay senescence in leaves.

2.4.6 Seed Yield (kg ha^{-1})

Rajabi et al. (2013) reported that foliar application of 1.2 mM salicylic acid increased grain yield by 25% as compared with control in chickpea.

Pang et al. (2016) reported that application of SA and nutrient component increased seed size and nutrient, which is responsible for the accumulation of sucrose from source (leaves) to sink (seed) in presence of SA.

Verma et al. (2017) observed that chickpea expressed significant response on seed yield plant^{-1} under drought (8.71%) by the priming of salicylic acid (SA) with a foliar spray of 500nm SA in drought.

2.4.7 Harvest Index (%)

Shekari, (2014) reported that the HI was a little decreased in SA treatments and it shows that SA more effective in biomass production than seed yield in this chickpea cultivars.

Purushothaman et al. (2017) reported that at the foliar application of SA treatment combination showed higher HI (%).

2.5 Biochemical Analysis

2.5.1 Nitrogen (%)

Brijnandan et al. (2014) recorded that seed priming and foliar application of 2% urea at flower initiation stage the highest nitrogen content (3.09%) in chickpea.

Verma et al. (2017) reported the genotypic differences occur only but in seed size helpful for nutrient treatment.

2.5.2 Protein (%)

Patel and Hemantaranjan (2013) reported that protein percentage was recorded maximum in genotype ICC 4958 and Tyson. Whereas, the minimum was recorded in JG 315 and DCP 92-3 on the treatment of SA@1.5 mM in chickpea genotype.

Boukraa et al. (2015) reported that application of SA was significantly enhancing protein contents during germination or seedling stage under salt stress.

Verma et al. (2017) reported that the protein percent was increased in genotype JG11 (25.42%) in Salicylic acid primed seed + Foliar spray of 500nm salicylic acid at 15 days interval combination and significantly dominated over JG14.

2.5.3 Carbohydrate (%)

Patel and Hemantaranjan, (2013) reported that protein percentage was recorded maximum in genotype ICC 4958 and Tyson. Whereas, the minimum was recorded in JG 315 and DCP 92-3 on the treatment of SA@1.5 mM in chickpea genotype.

Boukraa et al. (2015) reported that application of SA was significantly enhancing protein contents during germination or seedling stage under salt stress.

Verma et al. (2017) the foliar application of SA and nutrient composition and water. SA and Nutrient composition may be enhancing carbohydrate and maintaining the homeostasis in the cell system. The foliar application JG11 have expressed higher carbohydrate.

2.5.4 Proline (μmolg^{-1})

Patel and Hemantranjan, (2012) show that the proline content in plants treated with salicylic acid at the rate of 1.5 mM. Under drought stress, proline content was maximum [310.67 μg g^{-1}] in Tyson and minimum in DCP 92-3 (188.0 μg g^{-1}) in chickpea.

Farjam et al. (2013) reported that the salicylic acid spraying in complete drought stress condition significantly increased the proline content in chickpea.

Verma et al. (2017) reported the JG14 has recommended for late sown and high-temperature tolerant genotype. JG14 may be having strong scavenging system or osmolyte formation. Proline is an also osmolyte that maintains the homeostasis inside the cytosol.

2.5.6 Fiber and Fat (%)

Tosh and Yada (2010) reported that the dietary fibers can be classified into soluble and insoluble. Soluble fiber is digested slowly in the colon whereas the insoluble fiber is metabolically inert and aid in bowel movement.

Bellaloui et al. (2011) reported the application of SA and nutrient composition fat content was slightly higher in JG11. However, in JG14 has shown slightly high fiber content and low fat may be an application of nutrient composition the level of fat increases in chickpea genotypes.

2.5.7 Mineral Contents and Heavy Metals

2.5.7.1 Potassium (mg100g^{-1})

Atieno et al. (2017) reported that the role of K+ and its uptake, efflux, translocation at the time of seed filling and needed to examine the role of K+ and its uptake, efflux, translocation and interaction with Na+ during salinity stress in chickpea.

2.5.7.2 Calcium (mg100g^{-1})

Bevilaqua et al. (2012) and Verma et al. (2017) reported that important macronutrient of Ca^{++}play role in a plant in a formation of a middle lamina,

along with seed coat strengthen.The foliar application of SA and nutrients may provide strengthen seed of chickpea.

2.5.7.3 Sodium (mg100g^{-1})

Pushpavalli, (2015) reported that the moderate negative correlation between Na+ content in leaves and seed yield under salinity. The moderate negative correlation between Na+ accumulation and seed yield demonstrates that salinity tolerance in the chickpea reference set was partly explained by sodium exclusion.

2.5.7.4 Copper (mg100g^{-1})

Khan et al. (2015) reported that Foliar application of SA and nutrients to develop stress tolerance, plants trigger a network of hormonal cross talk and signaling, among which ethylene production and signaling processes optimum concentration.

2.5.7.5 Zinc (mg100g^{-1})

Pandey et al. (2017) reported by The foliar application of SA and Nutrients may be provided strengthen to seed and sugar translocation and reduced the production of free radical.

2.5.7.6 Iron (mg100g^{-1})

Connorton et al. (2017) reported that in the grains, *TaVIT1* and *TaVIT2* both expressed in the aleurone, correlating with high levels of iron in this tissue which is removed from white flours during the milling process. In contrast, expression of *TaVIT1* and *TaVIT2* was very low in the starchy endosperm, the tissue from which white flour extracted.

2.5.7.7 Manganese (mg100g^{-1})

The important key role in photolysis of water during PSII pigment and in the presence breakdown of water, and It is also possible that wheat and barley differ in iron and manganese transport efficiency from roots to shoots, thus

affecting the total amount of iron and manganese that were (re)mobilized to the grain reported by Connorton et al. (2017).

MATERIALS AND METHODS

A field experiment entitled **"Response of Foliar Application of Water Salicylic Acid and Nutrient on Physiology of Chickpea Genotypes Growth and Productivity under Rainfed and Irrigated Late sown condition"** was conducted the experiment in Adhartal Farm Department of Plant Breeding and Genetics, College of Agriculture JNKVV, Jabalpur (M.P.) during Rabi season year of 2016-17 under All India Coordinated Research Project on Chickpea. The material and methodologies used to conduct the experiment have been briefly described as follows.

3.1 Details of the Experimental Material

3.1.1 Climate

Jabalpur is situated at 23^0 90' N latitude and 79^0 58' E longitudes at an altitude of 411.78 m above the mean sea level. It comes in sub tropical region and thus enjoys the features of dry and sub humid climate. Based on 20 years data, the mean annual rainfall of Jabalpur is 1253.4 mm. The rains mostly received by southwest monsoon in between mid-June to the first week of October. There is an occasional and normal rainfall (nearly 75 to 100 mm) during winter and summer months. The mean monthly temperature goes down to the limit of 3^0C in December to January month, while maximum temperature goes as high as 46^0C in May or June. Generally, the relative humidity remains very low (15 to 30%) during summer months, moderate (60 to 75%) during winter and it attains high value (80 to 90%) during the rainy season.

The weekly weather conditions viz., temperature, rainfall, relative humidity and sunshine hours etc. during crop season were recorded at the meteorological observatory, Department of Physics and Agro-meteorology Farm, College of Agricultural Engineering, JNKVV, Jabalpur. This observation are presented in (Table 3.1) and illustrated through fig.1.

Table 3.1: Weekly meteorological parameters during crop season (Nov. to April 2016-17)

Months	Meto. Week (#)	Temp. (°C) Max.	Min	R.H (%) Max	Min	Wind Velocity	Sunshine (hrs/Day)	Rainfall (mm)	No. of rainy days
NOV	45	29.7	10.6	91	24	2.2	8.1	0	0
	46	28.3	8.1	88	24	2	8.1	0	0
	47	28.8	8.4	87	23	1.4	8.3	0	0
	48	28.8	8.7	89	27	1.7	8.7	0	0
DEC	49	25.1	7.9	93	43	2.1	6.2	0	0
	50	26.1	7.3	91	28	2	7.8	0	0
	51	24.7	5.5	91	30	1.8	7.4	0	0
	52	25.7	5.6	88	29	1.9	8.6	0	0
JAN	1	23.9	9.1	20	48	2.8	6.5	0	0
	2	21.7	6.6	86	42	2.9	7.2	0.2	0
	3	24.1	9.2	89	47	3.1	6.4	0	0
	4	25.7	10.1	97	45	2.9	6.5	3.2	1
	5	25.4	7.5	92	38	2.3	9.6	0	0
Feb	6	27.2	9.8	84	42	3.2	9	0	0
	7	26.4	10.6	95	42	2.9	8.4	13.2	1
	8	29.7	10	83	26	3.3	10.3	0	0
	9	31.2	11.1	80	26	2.6	10.2	0	0
March	10	30.3	12.5	72	24	4.5	9.6	0	0
	11	29.3	9.8	74	16	2.7	10.1	0	0
	12	33.9	14.4	75	19	3.4	10	2.8	1
	13	38.6	15.9	69	15	3.5	10.3	0	0
April	14	39.3	20.6	41	15	6.1	10	0	0
	15	38.1	14.4	54	9	3.7	10.2	0	0

Source: Department of Physics and Agro-meteorology Farm, College of Agricultural Engineering, JNKVV, Jabalpur

3.1.2 Previous History of the Experimental Field

Soybean and wheat crops were grown in the experimental field during *Kharif* and *Rabi* seasons, respectively since last two years.

3.1.3 Soil and Field Preparation

The soil adjoining to Jabalpur is classified as "vertisol" as per US classification of soil. The soil of the region has medium to the deep depth and black with sandy clay- loam texture and neutral soil reaction. It swells by wetting and shrinks by drying. Therefore, deep and wide cracks develop during the winter season. The experimental field having a gentle slope, proper drainage and uniform were selected. The soil reaction was neutral to mildly alkaline with an average pH of 7.51. The electrical conductivity of soil was 48 ranged between 0.21 to 0.42 dsm^{-1} at 25 ^{0}C which is considered normal. The soil was medium in available nitrogen (252 kg ha^{-1}), medium to high in available phosphorus (164 kg ha^{-1}) and medium in available potassium (351kg ha^{-1}). The soil indicated 47 cm field capacity and 20.5 cm of water point on the volumetric basis.

3.2 Experimental Details

The experimental details of the present investigations are given as under:

Season : Rabi (2016-17)

Design : Factorial RBD

Treatments

1. Genotypes : (a) JG 11 (b) JG 14

2. Foliar application (Water, SA and Nutrient Composition)

T_0 : Rainfed Control (Water spray at 50% Flower)

T_1 : Irrigated Control (Water spray at 50% Flower)

(Irrigation to be applied 7 days before 50% flowering)

T_2 : Rainfed + Salicylic acid (Foliar spray of SA @ 500nmole at 50% flowering and after 15 days)

T_3 : Rainfed +Nutrient composition + Salicylic acid (Foliar spray of SA @ 500nmole + Nutrient at 50% flowering and after 15 days)

T_4 : Irrigated +Nutrient + Salicylic acid (Foliar spray of SA @ 500nmole + Nutrient at 50% flowering and after 15 days)

(Irrigation to be applied 7 days before 50% flowering)

T_5 : Irrigated +Salicylic acid (Foliar spray of SA @ 500nmole at 50% flowering and 15 days)

(Irrigation to be applied 7 days before 50% flowering)

Replications	:	03
Distance between rows	:	30.0 cm
Distance between plots	:	0.6 m
Distance between replication	:	1.0 m
Plot size (Gross plot)	:	3.0 m × 1.2 m (3.6 m^2)
Net plot size	:	0.60 m × 2.50 m (1.50m^2)
Gross area	:	10.20 m × 11.0 m (112.24 m^2)
No. of row per plot	:	04
Fertilizer dose	:	20:40:20 (NPK) kg ha^{-1}
Seed rate	:	75 Kg ha^{-1}

3.3.1.1 Foliar Application of Salicylic Acid (SA) and Nutrients:

(a). Preparation of Salicylic Acid (SA) @ 500nmole:

SA molecular weight is 138.12gmol-1. When the preparation of SA @ 500nmole calculated with here,

$= 138.12 \text{ X}500\text{nmX}10^{-9}$

$= 138120\text{x}500\text{x}10^{-9}$

= 0.06906 mg for1 L of water

For the preparation of 15 L H_20 of hand sprayer used =0.06906X15 =1.035g per 15 L of water.

(b). Preparation of Nutrients Composition: The following constituents are available in pulse magic prepared by ARS Kalburgi Karnataka. Nutrients percentage available in pulse magic below and pH adjuvant synergetic growth enhancer and filler.

Nutrient	Percentage (%)
Nitrogen	10
Phosphorus	40
PGR	20 ppm
Micronutrient	03

Used of Nutrients for Foliar Application: The Ten (10) gm of pulse magic (nutrient composition) + 0.5ml solvent in 1 L of water mix thoroughly and spray. For preparation of 15 L water capacity of hand sprayer use = pulse magic (10x15) =150 g + sticker or solvent (0.5x15) = 7.5 sticker for 15 L of water.

3.3.2 Seed Sowing

Prior to sowing check seed viability and germination test. The seeds were treated with thiram @ 3 g/kg seed. The treated seeds were sown @ 2 kg/ha by hand dibbling at a depth of three to four centimeters.

3.3.3 Intercultural Operations

Hand weeding was done manually after 30 and 60 days of germination in order to minimize crop-weed competition for light, space, moisture, and nutrients.

3.3.4 Harvesting

The final harvesting was carried out when the pods were nearly dry and turned brown. The harvested plants were left in the sun for drying. The harvested material from each net plot was carefully bundled, tagged and brought to the threshing floor separately.

3.3.5 Threshing

Threshing was done by hand with help of stick plot wise and grains were cleaned, dried and weight recorded separately for each net plot. After that analysis of various yield components and yields, traits were recorded.

3.4 Observations Recorded

The observations were sub divided into following groups and recorded during the *rabi* season.

3.4.1 Phenophases

3.4.1.1 Days to flower initiation

3.4.1.2 Days to 50% flowering

3.4.1.3 Days to flower end

3.4.1.4 Days to pod initiation

3.4.1.5 Days to pod end

3.4.1.6 Days to physiological maturity

3.4.2 Growth Analysis and Dry Matter Production

3.4.2.1 Crop Growth Rate (CGR) (Gardner et al.1985)

3.4.2.2 Partition Coefficient (*p*) (Krishnamurthy et al. 2013)

3.4.2.3.1 No. of Nodules plant^{-1}

3.4.2.4 Fresh weight of nodules plant^{-1}(g)

3.4.2.5 Dry weight of nodules plant^{-1}(g)

3.4.2.6 Total dry matter plant^{-1}(g)

3.4.3 Physiological Traits

1. Chlorophyll Content Index (CCI) : Shukla et al. 2007
2. Membrane Stability Index (MSI) : Premachandra et al. (1990).
3. Relative Water Content (RWC %) at 50% Flowering and Pod Filling stage (Barrs and Weatherly, 1962)
4. Photosynthetic rate (Pn) : μmol m^{-2} s^{-1} Infra-red gas analyzer (IRGA)
5. Stomatal conductance (gs) : mol m^{-2} s^{-1} Infra-red gas analyzer (IRGA)
6. Transpiration rate (E) : mmol m^{-2} s^{-1} Infra-red gas analyzer (IRGA)
7. Water Use Efficiency (WUE) : μmol mmol^{-1} Infra-red gas analyzer (IRGA)
8. Carboxylation efficiency (CE) : μmol m^{-2} s^{-1}(μmol m^{-1}) $^{-1}$ Infra-red gas analyzer (IRGA)

3.4.4 Yields and Yield Components

3.4.4.1 Plant height (cm)

3.4.4.2 No. of branches plant^{-1}

3.4.4.3 No. of node plant^{-1}

3.4.4.4 No. of pods plant^{-1}

3.4.4.5 No. of seeds pod^{-1}

3.4.4.6 Hundred seed weight (g)

3.4.4.7 Seed yield (kg ha^{-1})

3.4.4.8 Biological yield (kg ha^{-1})

3.4.4.9 Yield (kg ha^{-1})

3.4.4.10 Harvest index (%)

3.4.5 Biochemical Analysis

3.4.5.1 Nitrogen (%) (AOAC, 1984)

3.4.5.2 Protein (%) (AOAC, 1980)

3.4.5.3 Carbohydrate (%) (Sadasivam and Manickam, 1992)

3.4.5.4 Proline (µmol g^{-1}) (Bates et al. 1973)

3.4.5.5 Fiber & Fat (%) (AOAC, 1980)

3.4.5.5 Mineral content and heavy metals (Sadasivam and Manickam,1992)

The details are given as follows:

3.4.1 Phenophases

The phenophases observations were noted from three selected and tagged plants throughout the growth period through daily visual observations. The under mentioned characters pertaining to the phenology of chickpea genotypes were studied as follows:

3.4.1.1 Days to flower initiation

3.4.1.2 Days to 50% flowering

3.4.1.3 Days to flower end

3.4.1.4 Days to pod initiation

3.4.1.5 Days to pod end

3.4.1.6 Days to physiological maturity

3.4.2 Growth Analysis and Dry Matter Production

3.4.2.1 Crop Growth Rate (CGR) (g cm^{-2} day^{-1})

The hot-air oven dried weights were used for the estimation of crop growth rate (CGR).

CGR = total shoot dry weight at final harvest/growths periods (days)

3.4.2.2 Partition Coefficient (*p*)

Partition coefficient (*p*) or rate of partitioning to estimate the assimilate remobilization rate (sink activity) was calculated by a formula presented by Krishnamurthy et al. (1999).

p = (seed yield / reproductive period in °C day)/ CGR Where,

Reproductive period = ^{0}C day for final harvest – ^{0}C day to reach 50% flowering.

3.4.2.3 No. of Nodules $Plant^{-1}$

The plants were selected randomly from the experimental field and gently carefully uprooted. The root was washed with tap water to remove the adhering soil. The number of nodules per plant was counted in three replicate and the values averaged to give the number of nodules per plant.

3.4.2.4 Fresh Weight (g) of Nodules $Plant^{-1}$

The plants were selected from the experimental trial and gently uprooted. The root was washed with tap water to remove the adhering soil. The number of nodules per plant was counted on the basis of three replicate and the values averaged to give the number of nodules per plant and take fresh weight of nodules with the help of electrical balance.

3.4.2.5 Dry Weight (g) of Nodules $Plant^{-1}$

The plants were selected from the experimental field and gently uprooted. The root was washed with tap water to remove the adhering soil. The number of nodules per plant was counted with three replication and the values

averaged to give the number of nodules per plant and kept in an electrical oven at 100^0c per 1 hrs than 80^0c for 48 hrs for constant nodule dry weight.

3.4.2.5 Total Dry Matter (g)

The plants were removed at flowering and physiological maturity for computation of data. For determining the dry matter accumulation three randomly plants were selected and removed at flowering and physiological maturity stage from the experimental field and kept in electric oven 100^0c for 1 hrs (kill the tissue) after kept at 80^0C for about 36 hrs still constant weights.

3.4.3 Physiological Traits

3.4.3.1 Chlorophyll Content Index (CCI)

The SPAD-502 a hand held chlorophyll meter (Minolta Corporation) was used for rapid and non - destructive estimation of chlorophylls in leaves This instrument uses a silicon photo-iodide to detect transmittance of light emitted by two light emitting diodes through a leaf sample, one with peak emittance at 650nm where absorbance by chlorophylls is high and relatively unaffected by carotene and one with peak emittance at 940nm where absorbance by chlorophyll content index was recorded in upper 3^{rd} 4^{th} and 5^{th} pinnate leaf at flowering and pod filling stage (DAS) .

SPAD value observes in randomly three plants per treatment at flowering and pod filling stages. Chlorophyll content is expressed in terms of Soil Plant Analysis Development (SPAD) units.

3.4.3.2 Membrane Stability Index (MSI)

Membrane stability index (MSI) was estimated according to the method described by Premachandra et al. (1990). For estimation of membrane stability index 100 mg leaf material, in two sets, was taken in test tubes containing 10 ml of double distilled water. One set was heated at 40°C for 30 min in a water bath, and the electrical conductivity of the solution was recorded on a conductivity bridge (C1). The second set was boiled at 100°C on a boiling water bath for

10 min, and its conductivity was measured on a conductivity bridge (C2). Membrane stability index (MSI) was calculated as:

$$MSI = [1 - (C1/C2)] \times 100$$

The following physiological derivative observations were recorded with help of Infra red gas analyzer (IRGA) LiCOR-6400USA.

3.4.3.3 Photosynthetic Rate ($\mu molCo_2\ m^{-2}\ s^{-1}$)

Chickpea leaves photosynthesis rate (Pn) was recorded with help of LICOR-6400 (The USA made) open type infra red gas analyzer (IRGA) instrument. For observation was taken in randomly selected three plants each treatment and express a mean value of Pn.

3.4.3.4 Transpiration Rate (mmol $H_2Om^{-2}\ s^{-1}$)

Transpiration Rate (E) was recorded with help of LICOR-6400 infra red gas analyzer (IRGA). The observation was taken randomly selected plant in each treatment with three replication and finally express a mean value of transpiration (E).

3.4.3.5 Stomatal Conductance ($molH_2O\ m^{-2}\ s^{-1}$)

Stomatal functional units of the epidermis serving the exchange of gases between the intercellular space of the plant and its surrounding. The rate of transpiration can be regulated by stomatal density and regulation of stomatal opening and closing and thus control the Co_2 intake and water from the plant. Stomatal conductance (g_s) was recorded with help of LICOR-6400 infra red gas analyzer (IRGA).

3.4.3.6 Water Use Efficiency ($\mu mol\ mmol^{-1}$)

The water use efficiency was determined by total dry matter production of chickpea plant and losses of water through transpiration or stomata. This physiological WUE was calculated with help of LICOR-6400 Infra Red Gas Analyzer given by (Kannan and Vankataraman, 2010) as follows:

$$WUE = \frac{Pn}{E}$$

Where Pn represents the net photosynthesis and E express transpiration rate.

3.4.3.7 Relative Water Content (%)

Leaf relative water content was estimated by recording the turgid weight of fresh leaf samples by keeping in water for 4 h, followed by drying in hot air oven till constant weight achieved. RWC (%) was calculated by the formula given by Barrs and Weatherlay (1962).

$$RWC = \frac{\text{Fresh Weight - Dry Weight}}{\text{Turgid Weight - Dry Weight}} X\ 100$$

Where fresh weight, dry weight and turgid weight of the leaf samples (4 -mm diameter leaf discs). The turgid weight was determined after floating the leaf discs on distilled water for 24 hrs at room temperature (about 20^0C) under dim light, whereas, dry weight was measured after oven- drying the samples at 65^0C for 24 hrs.

3.4.4 Yields and Yield Components

3.4.4.1 Plant Height (cm)

The height of plant from three randomly selected plants was measured in centimeters from the base of the plant to the tip of the uppermost leaf of plants.

3.4.4.2 No. of Branches Plant^{-1}

A number of branches per plant was counted from three tagged plants.

3.4.4.3 No. of Node Plant^{-1}

The plants were selected from the experimental field and counted node number plant^{-1} branches were arises. The number of node per plant was counted and the values averaged to give the number of node per plant.

3.4.4.4 No. of Pods Plant^{-1}

A number of pods per plant was counted from three tagged plants in the experimental trial.

3.4.4.5 Hundred (100) Seed Weight (g)

The 100 seeds obtained from selected plant separately were weighed and mean weight of seed plant^{-1} was expresses.

3.4.4.6 Biological Yield (kg ha^{-1})

Biological yield is the total yield of the crop including economic yield and the straw yield. The biological yield plant^{-1} was recorded after harvesting.

3.4.4.7 Seed Yield (kg ha^{-1})

The Seed yield (kg h^{-1}) was recorded after threshing, cleaning and drying the grains. It is also known as economical yield.

3.4.4.8 Harvest Index (%)

Harvest index is the ratio of economic yield to the total biological yield expressed in percentage. It represents the efficiency of photosynthetic translocation to economic parts (Synder and Carlson, 1984).

$$HI = \frac{\text{Economic yield}}{\text{Biological yield}} \times 100$$

3.4.5 Biochemical Analysis

Chickpea seed was analyzed for the biochemical constituents at different treatment combination as follows:

3.4.5.1 Seed Proline (µmol g^{-1})

Principle:

Proline estimation is based on the formation of brick red colored proline - ninhydrin complex in acidic medium. This complex is soluble in toluene and thus can be separated from an aqueous phase. This ensures that the reason

interference with other amino acids, which also farmed a blue colored complex with ninhydrin. The toluene soluble brick red colored complex absorbs at 520 nm.

Free proline content in leaves was determined following the method of (Bates et al., 1973). The protocol was based on the formation of red colored form a zone by proline with ninhydrin in acidic medium, which is soluble in organic solvents like toluene.

Requirements

Test tube, test stand, micropipette, Whatman No. 1 filter papers, visible spectrum photometer and chemicals as listed in reagents below.

Reagents

Sulphosalicylic acid (3%): Three gram of sulphosalicylic acid was dissolved in 100 ml of distilled water.

Orthophosphoric Acid (6 N)

Required volume of orthophosphoric acid (38%) was taken and volume was made to 100 ml using distilled water to get 6 N orthophosphoric acid.

Acid Ninhydrin

Ninhydrin (1.25 g) was dissolved in a blend of 30 ml of glacial acetic acid and 20 ml of 6 N orthophosphoric acids.

Procedure

Seed sample (0.5 g) was homogenized in 5 ml of sulphosalicylic acid (3%) using mortar and pestle. The homogenate is filtered through Whatman No. 1 filter paper and a filtrate was collected, which was used for the estimation of protein content. Two ml of extract was taken in the test tube and to it, 2 ml of glacial are added. The reaction mixture was heated in boiling water both at 100^0C for 30 minutes, brick red color develops after cooling the reaction mixture, 6 ml of toluene was added and then transferred to a separating funnel. After through mixing the chromophore containing toluene through mixing the

chromophore containing toluene was separated and its absorbance read at 520 nm in a spectrophotometer against toluene blank. Concentrate of proline was estimated by referring to a standard curve made from known as the concentration of proline.

3.4.5.2 Estimation of Seed Protein and Nitrogen (%)

The protein contents of seeds estimated crop maturity as per Micro - Kjeldahl procedure (AOAC, 1965) as follows:

One (1) g sample was kept in a digestion flask, with a little quantity of catalyst mixture (K_2SO_4 + $CuSO_4$), 10 ml of 96% concentration sulphuric acid was added and kept for complete digestion. Digested sample was distilled. The distilled amount of ammonia was titrated with 0.1 N H_2SO_4.

Nitrogen and protein content was calculated as per following formula:

$$\text{Nitrogen (\%)} = \frac{\text{Normality of } H_2SO_4 \text{ x V of } H_2SO_4 \text{ x } 1.4}{\text{Weight of sample}} X100$$

$$\text{Protein (\%)} = \text{Percent of nitrogen x } 6.25$$

3.4.5.3 Estimation of Total Carbohydrates (%)

Total carbohydrates in the sample were estimated by the hydrolysis method as described in AOAC (1984).

Reagents:

Five (5%) Phenol: Dissolve 50g of redistilled (reagent grade) phenol in water and dilute to one liter. The 96% sulphuric acid (reagent grade).Standard glucose: stock - 100mg in 1(x) ml of water Working Standard 10ml of stock diluted to 100ml with distilled water.

Procedure:

Weigh 100mg of the sample into a boiling tube. The hydrolyze by keeping it in a boiling water bath for 3hr. with 5ml of 2.5N HCL and cool to room temperature. Neutralize it with solid sodium carbonate until the effective science ceases. Make up the volume to 100ml and centrifuge. Pipette out 0.2, 0.6, 0.8

and 1ml of working standard into a series of test tubes. Pipette out 0.1 and 0.2ml of the sample solution in two separate test tubes. Make up the volume in each tube to 1ml with water. Set a blank with 1ml of water. Add 1ml of phenol solution to each tube. Add 5ml of 96% sulphuric acid to each tube and shake well. After 10 min shakes the contents in the tubes and place in a water bath at 25-30^{0}C for 20 min. Read the color at 490nm. Calculate the amount of total carbohydrate present in the sample solution using the standard graph.

Calculate

$$\text{Total carbohydrate in the sample} = \frac{\text{sugar value from the graph (µg)}}{\text{Aliquot sample used (0.1 or 0.2)}} \times \frac{\text{Total volume of extract (100 ml)}}{\text{Weight of sample (100mg)}} \times 100$$

3.4.5.4 Estimation of Fiber and Fat Content (%)

Estimation of fiber and fat with the method of AOAC, (1980).

3.4.5.5 Estimation of Mineral Contents and Heavy Metals from Chickpea Seed.

3.4.5.5.1 Sodium (Na^+) and Potassium (K^+) determination

Equipment

Jenway flame photometer, Accurate balance weighing to 0.0005g, volumetric flasks

Reagents

Sodium Standard – 1000ppm (Part number 025 021), Potassium Standard – 1000ppm (Part number 025 023), Deionised Water.

Procedure:

Aspirate the blank solution and set the zero. Aspirate the standards into the flame photometer. Plot a standard curve of sodium concentration against

intensity. Aspirate the sample solution into the flame and record the reading. Repeat steps 1 to 5 for the determination of potassium.

For Sodium (Na^+)

Sodium was estimated by Flame photometric method of as proposed by Tandon, 1995.

Reagents used

a) Nitric acid (AR grade, 70 %)

b) Perchloric acid (60 %)

Eighty-five (85) ml of perchloric acid was taken and volume was raised to 100 ml by distilled water.

c) Hydrochloric acid (AR grade, 35 %)

Di acid Digestion

Well dried and powdered seed material was washed in 150 ml conical flask. To this 10 ml of concentrated Nitric acid was added and a funnel was placed at the mouth of a flask and left overnight. After pre digestion when Samples were no more visible 10 ml of concentrated nitric acid and 2-3 ml of perchloric acid was added and Samples were digested on a hot plate at 100 ^{0} C in acid proof digestion chamber. The volume of contents was reduced to 2-3 ml by continued heating at the same temperature. After cooling, 10 ml of diluted and colorless HCl was added. Aliquots were filtered through Whatman no 42 filter paper into a 50 ml of volumetric flask. Further dilution was done by taking 2.5 ml of the extract in 25 ml of volumetric flask and volume was made to 25 ml by distilled water.

Sample preparation

Dissolve 5g of the sample in 100.0ml of deionised water. If required, perform serial dilutions of the sample to produce a sample with a sodium and potassium concentrations between 2 and 20ppm.

Stock solution of sodium

1000 ppm solution of sodium was obtained by dissolving 2.541 g of NaCl in 1 liter of de ionized water. 10 ml of the stock solution was diluted to 1200 ml. From this 5, 10, 15and 40 ppm strength solution was prepared.

Estimation of Na^+

For sodium determination, flame photometer was fitted with monochromator and the element was determined by inserting sodium filter. The obtained standard solutions were fed to the flame photometer. Blank was adjusted to zero and 40 ppm adjusted to maximum and a linear graph was prepared from stock solutions. The Sample solutions were also fed to the flame photometer in a similar manner and their reading was noted. Concentrations of the Sample were obtained by referring to the standard curve prepared from the stock solution.

Stock Solution for Potassium (K^+)

From the 1000ppm potassium standards, prepare standards of 20, 15, 10 and 5ppm using deionised water as the diluent. Use deionised water as the blank solution.

Calculation

From the calibration graph, determine the samples' concentration from the recorded reading. If required, multiply the determined concentration by the dilution factor.

3.4.5.5.2. Iron, Manganese and Copper, Zinc

Estimation with help of Atomic absorption spectrophotometer Single- or dual-channel, single- or double beam instrument having a grating monochromator, photomultiplier detector, adjustable slits, a wavelength range of 190 to 800 nm, and provisions for a computer or graphical interface.

Reagents and Standards

Reagent Water - All references to water in the method refer to reagent water unless otherwise specified. Reagent water must be free of interferences. Nitric acid, HNO3 -- Use a spectro grade acid. Prepare a 1:1 dilution with water by adding the concentrated acid to an equal volume of water. If the method blank does not contain target analytes at or above the lowest limit of quantitation, then the acid may be used.

Hydrochloric Acid: Prepare a 1:1 dilution with water by adding the concentrated acid to an equal volume of water. If the method blank does not contain target analytes at or above the lowest limit of quantitation, then the acid may be used.

Fuel and Oxidant - High purity acetylene is generally acceptable. Air may be supplied from a compressed air line, a laboratory compressor, or a cylinder of compressed air and should be clean and dry. Nitrous oxide is also required for certain determinations. A centrifuge filter on the compressed air lines is also recommended to remove particulates.

Stock standard metal solutions – The stock solutions are prepared at concentrations of 1,000 mg of the metal per liter. Commercially available standard solutions may also be used. When using pure metals (especially wire) for standards preparation, the calibration curve enables the standards to be prepared as needed.

Iron - Dissolve 1.000 g of iron wire in 10 mL redistilled HNO3 (conc.) and reagent water and dilute to 1 L with reagent water. Note that iron passivates in conc. HNO3, and therefore some water should be present.

Manganese - Dissolve 1.000 g of manganese metal in 10 mL of redistilled HNO3 (conc.) and dilute to 1 L with reagent water.

Copper - Dissolve 1.000 g of electrolytic copper in 5 mL of redistilled HNO3 (conc.) and dilute to 1 L with reagent water.

Zinc - Dissolve 1.000 g of zinc metal in 10 mL of conc. HNO3 and dilute to 1 L with reagent water.

Zinc –Quantification

Zinc concentration in seed was estimated by a Techtron model AA120 Atomic Absorption Spectrophotometer in di-acid digests prepared by the method described by Piper (1942). Dried chickpea seed powder (0.5) was taken into a 100ml Corning digestion tube. 5ml of HNO_3 and 2ml of $HClO_4$ (70%) was added and kept overnight covered with a watch glass. The sample was digested solution was filtered through an acid –washed filter paper into a 50 ml volumetric flask. The filter paper was washed with water and the filtrate was diluted and the volume was made to 50 ml with deionised water. Because of potential contamination from the reagent used, a reagent blank was prepared excluding the tissue sample. The sample solution was diluted with deionised with deionised water according to need to bring the concentration of element of interest into a suitable range.Standard curve was drawn with the help of zinc sulfate.

The absorption was read at 213.9nm, the most sensitive emission wavelength of Zinc. A nitrous oxide acetylene flame was used. For the standard conditions, the sensitivity was about 0.018µ g^{-1} ml^{-1} Zinc typically gave an absorbance reading of about 0.12 absorbance unit (about 25% absorption).The Zinc content in ppm (parts per million) was calculated as follows:

Element (ppm) = ($\mu g ml^{-1}$ in test solution) (d.f.) (50)

Where, (d.f.) = Dilution factor,

$$\text{Dilution factor} = \frac{\text{Final solution volume (ml)}}{\text{Volume of original sample solution used (ml)}}$$

Besides this, zinc uptake value was also calculated as follows: ppm in dry matter x yield of dry matter (g /pot) = up take of Zn (µg).

Statistical Analysis

Analysis of observations taken on different variables was carried out to know the degree of variation among all the treatments. The data were statistically analyzed through factorial randomized block design with help of Windostat version 9.1 analytical software at the 5% probability level. The result obtained through analysis of variance is given in appendix and the skeleton of analysis of variance table is given below:

Table 3.2 Analysis of variance (ANOVA)

S.No.	Sources of variance (S.V.)	The degree of freedom (d.f.)	Sum of squares (S.S.)	Mean sum of squares (MSS)	Calculated value	Table value 5%
1.	Replications	(r-1)=2				
2.	Genotypes (G)	(g-1) =1				
3.	Treatments (T)	(t-1)=5				
4.	Interaction (G×T)	(G-1)(T-1)= 5				
5.	Error	(r-1)(t-1)= 10				
6.	Total	(rt-1)= 17				

S.E.(m)± = $\sqrt{EMS/2}$

S.E.(d) ± = $\sqrt{2EMS/r}$

C.D. = S.E. (d) x $t_{5\%}$ at error d.f.

Where,

r = number of replications

t = number of treatments

E.M.S. = Error mean square

S.E. (m) = Standard error of treatment mean

S.E. (d) = Standard error of difference

C.D = Critical difference

RESULTS

The present investigation was carried out assess the compatibility of salicylic acid nutrient composition and water spray under late sown condition keeping the objective of investigation in the view a number of observations regarding physio-morphological and biochemical parameter recorded at different stages of crop growth.

4.1 Phenophases of Chickpea Genotype (JG 11 and JG 14)

The experimental finding was recorded different phenophases of chickpea genotype having days to flower initiation, days to 50 % flowering, days to pod initiation days to flower end, days to pod end and days to physiological maturity during the most of the growth stage. Emphasized on genotypes performance, treatment combination and interaction of genotypes with treatment combination in responses salicylic acid (SA) nutrient composition and water spray under late sown condition.

4.1.1 Days to Flower Initiation

JG14 showed early flower initiation (41.89 days) among the genotype varietal deference show statistically at par. However treatment $T_{0,}$ T_2, and T_4 were statistically at par. Although T_0 and T_2 treatment significantly different from T_1 T_3 and T_5 combination.

Genotypes and treatment interaction maximum ranges were JG11 (43.66 days) and minimum (40.33days) in JG14 maximum range (44.33 days) and minimum (40.33 days) DFI showed. (Table 4.1 and Figure 3).

4.1.2 Days to 50% Flowering

JG 14 expressed early 50 % flowering (48.17 days) compared to JG11. However, treatment combination showed the statistically at par or nonsignificant, however maximum days were recorded in JG11 T_3 combination and minimum T_1 (47.17 days).

Interaction combination in JG11 was recorded maximum in longer days (49.67 days) and minimum (47.00 days) However JG14 Interaction combination recorded maximum rang (53.00 days) and minimum (47.00 days) respectively (Table 4.1 and Figure 3).

4.1.3 Days to Pod Initiation

The result showed (Table 4.1 and Figure 3) that among the genotype JG 14 illustrated early pod initiation (62.00 days). However, treatment combination T_2 having longer days for pod initiation (69.17 days). Although the treatment $T_{3,}$ T_4, and T_5 show statistically at par (Table 4.1).

In interaction, JG11 and treatment combinations were recorded maximum pod initiation (68.00 days) and minimum (59.00 days). However, JG14 combination the maximum range showed (70.33 days) and minimum (61.33 days) in T_2 and T_1 combination (Table 4.1 and Figure 3).

4.1.4 Days to Flower End

JG 14 (87.44 days) showed early flower end in comparison to JG 11 (88.61 days) genotype. The study of this trait in treatment combination longer days was recorded in T_3 combination (88.83 days) and minimum in T_0 and T_4 treatment (87.33days) combination respectively. (Table 4.1 and Figure 3)

4.1.5 Days to Pod End

JG14 showed minimum (95.50 days) for pod end in compared to JG11 (96.11 days). In interaction T_2 combination expressed longer days (96.77 days) among the treatment T_2 combination so significantly superior.

In the JG11 interaction of genotype and treatment were recorded maximum range (97.00 days) and minimum (94.66 days). However, JG14 expressed comparable trends and the minimum pod end (95.00 days) respectively. (Table 4.1 and Figure 3)

4.1.6 Days to Physiological Maturity

JG14 showed early physiological maturity assessment to JG11 (100.11 days).In treatment combination maximum days of maturity showed in T_2 and T_3 combination and expressed statistically at par, however, T_1 showed early physiological maturity. In genotype and treatment interaction combination JG11 expressed maximum (101.00 days) and minimum (98.33 days) however JG14 showed the similar trend. (Table 4.1 and Figure 3)

4.2 Growth Analysis and Dry Matter Production

4.2.1 Crop Growth Rate (gcm^{-2} day^{-1})

JG11 and JG14 genotype showed statistically at par. Although treatment combination was maximum crop growth rate (CGR) value expressed in T_0, T_1, T_2 and T_4 combination. However genotype to treatment interaction also expressed maximum CGR value in JG 11 ($0.40gcm^{-2}day^{-1}$) compared from JG14 ($0.19gcm^{-2}day^{-1}$).

The maximum CGR showed T_2 and T_3 combination. JG11 showed a minimum and maximum CGR value (0.207 and $0.40gcm^{-2}day^{-1}$). However, JG14 expressed CGR maximum and minimum showed (0.193 and $0.286gcm^{-2}day^{-1}$) respectively (Table 4.2 and Figure 4).

4.2.2 Partition Coefficient (*p*)

Genotype JG11 expressed statistically at par (nonsignificant). However, treatment combination also showed statistically at par.

Genotype treatment interaction in JG11 maximum partition coefficient value expressed (0.07%) and minimum (0.03%). Nevertheless, JG14 showed maximum value (0.090 %) and minimum (0.03 %) respectively. Genotype treatment interaction JG11 superior partition coefficient expressed (0.07%). However in JG14 was expressed in (0.09 %) the partitioning coefficient (Table 4.2 and Figure 4).

Table 4.1: Effect of foliar application of water salicylic acid nutrient composition on Chickpea phenology under rainfed and irrigated late sown condition

Genotypes	Flower Initiation (Days)	(50%)Flowering (Days)	Pod Initiation (Days)	Flower End (Days)	Pod End (Days)	Physiological Maturity (Days)
Genotypes (G)						
JG11	42.61	50.44	66.39	88.61	96.11	100.11
JG14	41.89	48.17	62.00	87.44	95.50	99.67
SEm+	0.37	1.10	0.98	0.34	0.29	0.28
CD (5%)	1.08	3.23	2.88	1.00	0.86	0.82
Treatment (T)						
T0	44.00	49.00	62.50	87.33	94.83	99.50
T1	40.33	47.17	60.17	87.67	95.33	99.00
T2	43.67	50.00	69.17	88.33	96.67	100.83
T3	41.33	50.17	64.00	88.83	96.00	100.67
T4	42.83	49.67	64.67	87.33	96.17	100.00
T5	41.33	49.83	64.67	88.67	95.83	99.33
SEm+	0.64	1.90	1.70	0.59	0.50	0.48
CD (5%)	1.87	5.60	4.99	1.74	1.50	1.41
Interaction (GXT)						
JG11	**T0**	43.67	49.00	62.67	87.00	94.67	99.67
	T1	40.33	47.33	59.00	86.67	95.33	99.67
	T2	43.67	49.67	68.00	88.33	97.00	100.67
	T3	41.00	47.33	59.67	87.33	95.33	101.00
	T4	42.33	48.67	61.33	86.67	95.33	98.67
	T5	40.33	47.00	61.33	88.67	95.33	98.33
JG14	**T0**	44.33	49.00	62.33	87.67	95.00	99.33
	T1	40.33	47.00	61.33	88.67	95.33	98.33
	T2	43.67	50.33	70.33	88.33	96.33	101.00
	T3	41.67	53.00	68.33	90.33	96.67	100.33
	T4	43.33	50.67	68.00	88.00	97.00	101.33
	T5	42.33	52.67	68.00	88.67	96.33	100.33
	SEm+	0.90	2.40	2.40	0.84	0.72	0.68
	CD (5%)	2.65	7.05	7.05	2.46	2.11	2.00

Table 4.2 : Effect of foliar application of water, salicylic acid and nutrient composition on chickpea genotypes for crop growth rate (CGR) and partitioning coefficient (p) at rainfed and irrigated late sown condition.

Genotypes	CGR (g cm^{-2} day^{-1})		Partition coefficient (P %)
JG11	0.28		0.05
JG14	0.24		0.06
SEm+	0.02		0.01
CD (5%)	0.07		0.02
Treatment (T)			
T0	0.30		0.05
T1	0.28		0.03
T2	0.25		0.05
T3	0.24		0.07
T4	0.26		0.06
T5	0.22		0.07
SEm+	0.04		0.01
CD (5%)	0.12		0.03
Interaction (GXT)			
JG11	**T0**	0.40	0.03
	T1	0.35	0.03
	T2	0.22	0.06
	T3	0.21	0.07
	T4	0.27	0.06
	T5	0.23	0.06
JG14	**T0**	0.19	0.06
	T1	0.20	0.03
	T2	0.29	0.04
	T3	0.28	0.06
	T4	0.25	0.06
	T5	0.21	0.09
	SEm+	0.06	0.01
	CD (5%)	0.17	0.04

4.2.3 Number of Nodules Plant^{-1}

JG11 and JG14 genotype showed statistically at par. However maximum nodules were expressed in T_4, T_5 and T_2 combination.

Genotype and treatment interaction JG11 expressed maximum (12.00) and minimum (7.00) number of nodules plant^{-1}. However, JG14 expressed a maximum number of nodules (21.67) and minimum (9.67) respectively (Table 4.3 and Figure 5).

4.2.4 Fresh Weight (g) of Nodules Plant^{-1}

Genotype showed statistically at par. However in treatment T_3 and T_4 expressed superior combination. Genotype treatment interaction expressed statistically at par. JG11 showed maximum fresh weight (0.55 g) and minimum (0.20 g). However, JG14 was recorded maximum (1.05 g) and minimum (0.33 g) nodule fresh weight plant^{-1} respectively (Table 4.3 and Figure 5).

4.2.5 Dry Weight (g) of Nodules Plant^{-1}

JG11 and JG14 were showed statistically at par. Although nodules dry weight were maximum JG14 (0.29g). A treatment combination dry weight of nodules plant^{-1} expressed higher in T_4 (0.29 g) on the other hand JG 11 maximum (0.35 g) and minimum (1.00 g). However, JG14 was recorded maximum (0.46 g) and minimum (0.41 g) respectively (Table 4.3 and Figure 5).

4.2.6 Total Dry Matter Accumulation at Flowering and Maturity (g)

JG14 showed statistically significant total dry matter accumulation in plant^{-1} at flowering stage. However in maturity stage expressed statically at par. At flowering stage, accumulation was higher in JG14 (14.86 g). However, at maturity stage dry matter accumulation was maximum value express in JG11 (27.44 g) and treatment T_5 combination at flowering and maturity stage expressed maximum in T_2 (31.17 g) combination.

Table 4.3: Effect of foliar application of water, salicylic acid and nutrient composition on chickpea genotypes on nodules traits at flowering stage under rainfed and irrigated late sown condition.

Genotypes		No. of Nodules	Nodules F.W (g)	Nodules D.W (g)
JG11		9.33	0.35	0.20
JG14		12.78	0.56	0.29
SEm+		2.03	0.13	0.07
CD (5%)		5.96	0.37	0.19
		Treatment (T)		
T0		9.17	0.33	0.28
T1		10.17	0.40	0.16
T2		11.50	0.33	0.28
T3		9.33	0.54	0.21
T4		14.67	0.63	0.29
T5		11.50	0.50	0.23
SEm+		3.52	0.22	0.11
CD (5%)		10.32	0.65	0.34
		Interaction (GXT)		
JG11	**T0**	7.00	0.20	0.35
	T1	10.00	0.35	0.12
	T2	12.00	0.34	0.14
	T3	9.00	0.55	0.27
	T4	7.67	0.20	0.11
	T5	10.33	0.45	0.20
JG14	**T0**	11.33	0.46	0.22
	T1	10.33	0.45	0.20
	T2	11.00	0.33	0.42
	T3	9.67	0.54	0.14
	T4	21.67	1.05	0.46
	T5	12.67	0.55	0.26
	SEm+	4.97	0.31	0.16
	CD (5%)	14.59	0.92	0.47

Genotype treatment interaction table JG11 T_3 combination showed superior dry matter accumulation (15.83 g) at flowering stage although at maturity stage T_0 and T_2 combination expressed superior dry matter accumulation plant^{-1}. JG11 maximum dry matter accumulation value (15.82 g) and minimum (8.22 g) at flowering stage although JG14 maximum dry matter accumulation (18.40 g) and minimum (11.21 g) at flowering stage. At maturity stage total dry matter accumulation in JG11 maximum (40.00 g) and minimum (19.33 g) and JG14 maximum expressed (28.33 g) and minimum (20.66 g) respectively (Table 4.4 and Figure 6).

4.3 Physiological Traits

4.3.1 Chlorophyll Content Index (CCI) at Flowering and Podfilling Stage

JG14 showed maximum value (59.05 SPAD) at flowering stage. However, JG11 expressed maximum CCI value (71.06 SPAD). At flowering stage, genotypes expressed CCI value statistically significant. Though maturity stage expressed statistically at par.

The treatment combination T_2 showed maximum CCI (60.48 SPAD) at flowering stage and T_3 expressed (72.63 SPAD) higher value compare to among the treatment.

Genotype treatment interaction JG11 expressed maximum (55.33 SPAD) and minimum (53.43 SPAD) respectively. JG14 expressed maximum (66.33 SPAD) and minimum (54.60 SPAD). At maturity stage JG11 genotype treatment interaction maximum value expressed (73.86 SPAD) and minimum (68.70 SPAD). Although JG14 expressed maximum (72.96 SPAD) and minimum (68.50 SPAD) value (Table 4.5 and Figure 7).

Table 4.4: Responses to foliar application of water, salicylic acid and nutrient composition on chickpea genotypes on total dry matter accumulation (TDMA) plant^{-1} at flowering and maturity stage under rainfed and irrigated late sown condition.

Genotypes		Total Dry Matter Accumulation Plant^{-1} at Flowering (g)	Total Dry Matter Accumulation Plant at Maturity (g)
JG11		11.31	27.44
JG14		14.86	24.33
SEm+		0.85	1.15
CD (5%)		2.49	3.37
Treatment (T)			
T0		12.91	30.33
T1		11.55	23.83
T2		12.15	31.17
T3		13.85	23.00
T4		13.32	22.33
T5		14.73	24.67
SEm+		1.47	1.99
CD (5%)		4.30	5.83
Interaction (GXT)			
JG11	**T0**	10.80	40.00
	T1	11.38	19.33
	T2	9.92	34.67
	T3	15.83	20.67
	T4	8.23	21.67
	T5	11.71	28.33
JG14	**T0**	15.03	20.67
	T1	11.71	28.33
	T2	14.38	27.67
	T3	11.88	25.33
	T4	18.40	23.00
	T5	17.74	21.00
	SEm+	2.08	2.81
	CD (5%)	6.09	8.25

4.3.2 Membranes Stability Index (MSI)

JG11 genotype was express significantly differing from JG14. However, the maximum MSI value expressed in T_1 combination and minimum MSI was observed in T_2 combination (26.07 %).

Genotype treatment interaction the maximum MSI showed (38.57%) and minimum showed (30.17%) in JG11. However JG14 maximum MSI showed (31.37%) and minimum (21.97%) minimum MSI recorded T_2 combination (21.97%) in JG14 genotype (Table 4.5 and Figure 7).

4.3.3 Relative Water Content (RWC %) at Flowering and Pod Filling Stage

JG11 showed maximum water retention capacity in leaves tissue weigh against from JG14 at flowering and pod filling stage but genotype variation expressed statistically at par or nonsignificant.

Treatment combination maximum superior value expressed in (58.88%) combination at flowering and T_0 (51.37%) expressed at pod filling.

Genotype treatment interaction JG11 showed maximum RWC (63.73%) and minimum RWC (39.93 %) and JG14 showed maximum (58.57%) and minimum (45.60 %) at flowering stage. At pod filling, JG 14 expressed (55.87%) maximum and minimum (46.10%). Although JG14 was expressed higher RWC (52.33%) and minimum (42.00%). Nevertheless JG11 at flowering stage T_1 interaction combination retain maximum water in leaves tissue (63.73 %) and JG14 expressed T_0 (58.57%) at flowering. At maturity maximum RWC recorded T_2 combination (55.87%) and JG14 retain water in leaves tissue (52.33 %) respectively (Table 4.6 and Figure 8).

Table 4.5: Effect of foliar application of water, salicylic acid and nutrient composition on chickpea genotypes leaves in chlorophyll content index (CCI) at flowering and pod filling stage and membrane stability index (MSI) at pod filling stage under rainfed and irrigated late sown condition.

Genotypes		CCI at Flowering (SPAD)	CCI at Pod filling (SPAD)	MSI (%)
JG11		54.24	71.06	34.13
JG14		59.05	70.58	26.94
SEm+		1.46	0.93	1.61
CD (5%)		4.27	2.73	4.72
		Treatment (T)		
T0		55.40	71.18	33.65
T1		54.02	70.33	34.90
T2		60.48	71.82	26.07
T3		56.70	72.63	29.88
T4		57.47	68.70	28.78
T5		55.82	70.23	29.92
SEm+		2.52	1.61	2.78
CD (5%)		7.40	4.73	8.17
		Interaction (GXT)		
JG11	**T0**	53.47	73.87	38.57
	T1	53.43	71.40	38.43
	T2	54.33	70.80	30.17
	T3	55.33	72.30	31.80
	T4	54.30	68.70	34.43
	T5	54.60	69.27	31.37
JG14	**T0**	57.33	68.50	28.73
	T1	54.60	69.27	31.37
	T2	66.63	72.83	21.97
	T3	58.07	72.97	27.97
	T4	60.63	68.70	23.13
	T5	57.03	71.20	28.47
	SEm+	3.57	2.28	3.94
	CD (5%)	10.47	6.69	11.55

Table 4.6: Effect of foliar application of water, salicylic acid and nutrient composition on chickpea leaves in relative water content (RWC) at flowering and pod filling stage under rainfed and irrigated late sown condition.

Genotypes		RWC (%) at Flowering	RWC (%) at Pod Filling
JG11		53.17	50.47
JG14		52.27	48.33
SEm+		1.82	1.33
CD (5%)		5.34	3.91
Treatment (T)			
T0		54.45	51.37
T1		58.88	49.28
T2		50.50	49.08
T3		44.10	48.48
T4		52.38	47.63
T5		55.98	50.55
SEm+		3.16	2.31
CD (5%)		9.26	6.77
Interaction (GXT)			
JG11	**T0**	50.33	50.43
	T1	63.73	49.80
	T2	55.40	55.87
	T3	39.93	46.10
	T4	55.57	51.83
	T5	54.03	48.77
JG14	**T0**	58.57	52.30
	T1	54.03	48.77
	T2	45.60	42.30
	T3	48.27	50.87
	T4	49.20	43.43
	T5	57.93	52.33
	SEm+	4.46	3.27
	CD (5%)	13.09	9.58

4.3.4 Photosynthetic Rate (μmol Co_2 $m^{-2}s^{-1}$)

Photosynthetic rate (P_n) was maximum in JG14 (25.86) and showed statistically at par. In treatment combination, P_n recorded superior in T_3 (26.13) combination.

Genotype and treatment combination JG14 was recorded maximum photosynthetic rate (26.70) and minimum (24.25) at pod filling stage. In JG11 T_3 combination expressed superior photosynthetic rate among the genotype treatment interaction combination (Table 4.7 and Figure 9).

4.3.5 Stomatal Conductance (mol $H_2om^{-2}s^{-1}$)

JG 11 showed maximum stomatal conductance (g_s) (0.37). However, treatment T_0, T_2, T_3, and T_4 were expressed statistically at par. However T_1 treatment expressed significant differences among other treatment.

Genotype and treatment interaction JG11 maximum value showed (0.42 and minimum (0.28) showed at pod filling stage (Table 4.7 and figure 9).

4.3.6 Transpiration Rate (m mol H_20 $m^{-2}s^{-1}$)

Transpiration rate expressed maximum JG11 (11.70) and expressed statistically significant comparison from JG14. Treatment combination T_4 and T_5 combination express superior transpiration rate (11.58) and (12.35) respectively.

Genotype treatment interaction JG11 expressed maximum transpiration rate (13.49) and minimum (9.71). JG14 was illustrated maximum transpiration (12.70) and minimum (8.9) at pod filling stage (Table 4.7 and Figure 9).

Table 4.7: Effect of foliar application of water, salicylic acid and nutrient composition on chickpea leaves in photosynthetic rate (Pn), stomatal conductance (gs) and transpiration rate (E) at pod filling stage under rainfed and irrigated late sown condition.

Genotypes		Photosynthetic Rate (μ mol Co_2 m^{-2} s^{-1})	Stomatal Conductance (mol H_2O m^{-2} s^{-1})	Transpiration Rate (m mol H_2O m^{-2} s^{-1})
JG11		25.39	0.37	11.70
JG14		25.56	0.35	10.95
SEm+		0.21	0.01	0.20
CD (5%)		0.61	0.03	0.58
		Treatment (T)		
T0		25.83	0.39	11.01
T1		24.89	0.31	11.22
T2		25.75	0.37	10.88
T3		26.13	0.38	10.91
T4		25.14	0.37	11.58
T5		25.14	0.33	12.35
SEm+		0.36	0.02	0.34
CD (5%)		1.05	0.05	1.00
		Interaction (GXT)		
JG11	**T0**	25.51	0.38	9.71
	T1	25.18	0.35	10.43
	T2	27.25	0.42	13.47
	T3	26.25	0.42	13.49
	T4	23.57	0.35	11.09
	T5	24.59	0.28	12.01
JG14	**T0**	26.15	0.39	12.31
	T1	24.59	0.28	12.01
	T2	24.25	0.32	8.29
	T3	26.00	0.33	8.32
	T4	26.70	0.40	12.07
	T5	25.68	0.37	12.70
	SEm+	0.51	0.02	0.48
	CD (5%)	1.49	0.07	1.41

4.3.7 Intrinsic and Instantaneous Water Use Efficiency (μmol $mmol^{-1}$)

Intrinsic and instant water use showed a maximum in JG14 instant water use efficiency was expressed non- significant among the genotype. Nevertheless, JG14 has expressed significance difference in JG11.

Treatment combination T_1 illustrated superior combination (80.93). Among the genotype, instantaneous water use efficiency expressed maximum in (2.54) in T_3 combination.

Genotype treatment interaction intrinsic water use efficiency JG11 showed maximum (89.31) and minimum (62.81) and JG14 expressed maximum (89.31) and minimum (66.93) respectively. However instantaneous water use efficiency was recorded maximum (2.42) and minimum (1.95) in JG11. JG14 showed instantaneous WUE maximum (3.13) and minimum (2.02). Intrinsic WUE JG11 T_5 combination was an express superior value (89.31) among the genotype. However JG14 T_1 (89.31) combination expressed similar value (Table 4.8 and Figure 10).

4.3.8 Carboxylation Efficiency [μmol m^{-2} s^{-1}(μmol m^{-1})-1]

JG11 and JG14 expressed statistically at par. However, treatment combination expressed T_5 (0.098) superior carboxylation efficiency. Nevertheless, genotype treatment interaction JG11 maximum carboxylation efficiency (0. 105) minimum (0.088) and JG14 showed maximum carboxylation efficiency (0.103) and minimum (0.080) respectively (Table 4.8 and Figure 10).

Table 4.8: Effect of foliar application of water, salicylic acid and nutrient composition on chickpea leaves intrinsic and instantaneous water use efficiency (WUE) and carboxylation efficiency (CE) at pod filling stage under rainfed and irrigated late sown condition.

Genotypes		Intrinsic WUE (μmol mmol^{-1})	Instantaneous WUE (μmol mmol^{-1})	C E μmol m^{-2} s^{-1}(μmol m^{-1}) $^{-1}$
JG11		71.43	2.17	0.094
JG14		74.68	2.42	0.094
SEm+		2.26	0.04	0.002
CD (5%)		6.63	0.12	0.007
		Treatment (T)		
T0		67.34	2.27	0.095
T1		80.93	2.24	0.096
T2		70.59	2.50	0.093
T3		70.80	2.54	0.088
T4		69.60	2.20	0.096
T5		79.07	2.04	0.098
SEm+		3.92	0.07	0.004
CD (5%)		11.49	0.21	0.013
		Interaction (GXT)		
JG11	**T0**	67.75	2.42	0.089
	T1	72.55	2.42	0.094
	T2	65.53	2.03	0.105
	T3	62.81	1.95	0.092
	T4	70.63	2.16	0.088
	T5	89.31	2.05	0.097
JG14	**T0**	66.93	2.13	0.101
	T1	89.31	2.05	0.097
	T2	75.64	2.97	0.080
	T3	78.79	3.13	0.085
	T4	68.57	2.24	0.103
	T5	68.82	2.02	0.098
	SEm+	5.54	0.10	0.006
	CD (5%)	16.25	0.30	0.018

4.4 Yield and Yield Components

4.4.1 Plant Height (cm) at Flowering and Maturity

JG14 was increased height at flowering (49.78 cm) at maturity (55.17 cm). However, genotype showed non- significant difference.

Treatment combination T_5, T_3, T_4, and T_1 expressed statistically at par. However, T_3 and T_5 show significant difference among the treatment at flowering stage. However at maturity stage T_5 (55.83 cm) expressed superior value among treatment.

The interaction genotype with treatment combination JG11 showed maximum value (51.00 cm) and minimum (44.00 cm). Although JG14 showed maximum (55.00 cm) and minimum (42.66 cm). At maturity stage, JG14 were expressed maximum height (56.67 cm) and minimum (52.33 cm) and JG14 was recorded maximum height (58.67 cm) and minimum (51.00 cm) (Table 4.9 and Figure 11).

4.4.2 Number of Node and Total Number of Branches Plant^{-1}

In a JG14 number of node plant^{-1} (23.78) and a total number of branches (15.44) plant^{-1} were illustrated higher comparison from JG11 (Table 4.9 and Figure 11).

In treatment combination, maximum number of a node expressed T_2 combination from among the treatment. However, the total number of branches plant^{-1} illustrated maximum in T_4 (18.50) combination.

Genotype and treatment interaction number of node plants^{-1} were expressed higher in JG14. Although T_4 (26.33) combination was express higher no of a node and a total number of branches plant^{-1} from among the genotype and treatment interaction. A total number of branches plants^{-1} maximum expressed in JG14 T_4 (19.33) combination and minimum JG11 T_2 and T_5 (11.33) combination (Table 4.9 and Figure 11).

Table 4.9: Effect of foliar application of water, salicylic acid and nutrient composition on chickpea height at flowering, maturity, the total number of branches Plant^{-1} and number of node plant^{-1} at maturity stage under rainfed and irrigated late sown condition.

Genotypes		Height (cm) at Flowering	Height(cm) at Maturity	Total Number of Branches Plant^{-1}	No. of node plant^{-1}
JG11		48.50	54.56	14.11	20.44
JG14		49.78	55.17	15.44	23.78
SEm+		0.86	1.09	0.60	5.00
CD (5%)		2.52	3.19	1.76	1.45
		Treatment (T)			
T0		47.17	54.50	15.83	20.83
T1		49.33	53.50	13.67	20.50
T2		43.50	55.67	13.33	23.50
T3		52.00	52.50	15.67	23.00
T4		50.67	57.17	18.50	22.00
T5		52.17	55.83	11.67	22.83
SEm+		1.49	1.88	1.04	1.50
CD (5%)		4.37	5.52	3.05	2.51
		Interaction (GXT)			
JG11	**T0**	47.67	54.00	13.67	19.00
	T1	49.33	52.33	16.00	20.33
	T2	44.33	56.67	11.33	22.33
	T3	51.00	54.00	14.67	22.00
	T4	49.33	55.67	17.67	17.67
	T5	49.33	54.67	11.33	21.33
JG14	**T0**	46.67	55.00	18.00	22.67
	T1	49.33	54.67	11.33	20.67
	T2	42.67	54.67	15.33	24.67
	T3	53.00	51.00	16.67	24.00
	T4	52.00	58.67	19.33	26.33
	T5	55.00	57.00	12.00	24.33
	SEm+	2.11	2.66	1.47	1.74
	CD (5%)	6.18	7.80	4.32	0.27

4.4.3 Number of Pods Plant^{-1}

JG11 showed a higher number of the pod (57.33) and significantly differ from JG14. However, treatment T_1 combination expressed a higher number of pod plant^{-1} (62.33).

The treatment T_2 significantly superior combination from among the treatment T1, T_2, T_5, T_0, and T_4 showed statistically at par. However T1 significantly difference from the T_3 combination.

In the interaction of genotype to treatment combination, the JG11 maximum number of a pod (70.67) and minimum (34.67) were expressed. However, JG14 was recorded the total number of pod plants^{-1} maximum (54.33) and minimum (34.00) (Table 4.10 and Figure 12).

4.4.4 Seed Weight Plant^{-1} and Hundred (100) Seed Weight (g)

JG11 were recorded higher seed weight (14.78 g) and 100 seed weight (23.78 g) weigh against from JG14 both traits expressed statistically at par.

In treatment T_0 gain higher seed weight compares from among the treatment. Although hundred (100) seed weight showed higher in T_5 combination. Nevertheless, treatment combination expressed statistically at par.

Genotype and treatment interaction in seed weight plant^{-1} T_0 and T_2 combination expressed similar value (17.33) in JG11. However JG14 T_1 combination expressed higher seed weight plant^{-1} (16.67). JG11 was recorded maximum (17.33) and minimum (11.33) seed weight plant^{-1}. However, JG14 articulated maximum (16.67) and minimum (12.00) seed weight plant^{-1}. Although JG11 showed maximum (24.33) and minimum (22.66) hundred (100) seed weight. However, JG14 was recorded maximum (25.00) and minimum (17.66) hundred (100) seed weight (Table 4.10 and Figure 12).

Table 4.10: Effect of foliar application of water, salicylic acid and nutrient composition on chickpea genotypes a total number of pod plant^{-1}, seed weight plant^{-1} and hundred seed weight under rainfed and irrigated late sown condition.

Genotypes		Total Number of Pod Plant^{-1}	Seed Weight (g) Plant^{-1}	Hundred (100) Seed Weight (g)
JG11		57.33	14.78	23.78
JG14		48.11	13.78	23.11
SEm+		3.49	0.88	1.00
CD (5%)		10.25	2.59	2.94
		Treatment (T)		
T0		49.67	15.50	24.17
T1		62.33	14.50	24.00
T2		58.67	15.17	23.67
T3		44.17	14.33	20.17
T4		48.00	11.67	24.17
T5		53.50	14.50	24.50
SEm+		6.05	1.53	1.73
CD (5%)		17.75	4.49	5.09
		Interaction (GXT)		
JG11	**T0**	52.00	17.33	23.67
	T1	70.33	12.33	24.00
	T2	70.67	17.33	24.33
	T3	34.67	13.67	22.67
	T4	62.00	11.33	24.00
	T5	54.33	16.67	24.00
JG14	**T0**	47.33	13.67	24.67
	T1	54.33	16.67	24.00
	T2	46.67	13.00	23.00
	T3	53.67	15.00	21.67
	T4	34.00	12.00	24.33
	T5	52.67	12.33	25.00
	SEm+	8.56	2.16	2.45
	CD (5%)	25.11	6.35	7.19

4.4.5 Biological Yield (kg ha^{-1})

JG14 showed higher biological yield (5373.30 kg/ha.) as a comparison from JG11 although genotype expressed non-significant difference.

In treatment combination, T_0 expressed maximum biological yield (5623.61) from among the treatment.

Genotype and treatment interaction the maximum biological yield was recorded in JG11 T_4 (5647.22 kg/ha.) and JG14 T_3 (6150.00). Although JG11 expressed maximum biological yield (5647.22 kg/ha.) and minimum (3297.22). However, JG14 maximum biological yield was recorded (6150.00) and minimum (3982.40 kg/ha.) (Table 4.11 Figure 13).

4.4.6 Seed Yield (kg ha^{-1})

JG14 showed significantly higher seed yield comparison from JG11. Although JG14 was recorded superior seed yield (1765.90 kg/ha.) in comparison to JG11.

Treatment combination T_0, T_2, T_4, and T_5 showed statistically at par but T_1 and T_3 were expressed significantly difference from T_0 combination.

Genotype and treatment interaction JG11 were recorded superior seed yield in T_0 and T_4 and T_1 combination. However, JG14 showed superior seed yield in T_2 and T_5 combination. Although JG11 expressed maximum seed yield (1874.99) and minimum (1061.11) and JG14 maximum seed yield (2135.19) and minimum (1248.15) respectively (Table 4.11 and Figure 13).

4.4.7 Harvest Index (%)

JG14 showed superior harvesting index (34.58%) comparison from JG11. In genotype expressed non- significant difference among the genotype.

Treatment combination superior expressed T_5 (38.87%) combination and minimum T_3 combination (30.67%).

Table 4.11: Effect of foliar application of water, salicylic acid and nutrient composition on biological yield, seed yield and harvest index (HI) under rainfed and irrigated late sown chickpea genotypes.

Genotypes		Biological Yield ($kgha^{-1}$)	Seed Yield ($kgha^{-1}$)	Harvest Index (%)
JG11		4837.04	1454.01	31.18
JG14		5373.30	1765.90	34.58
SEm+		272.00	97.33	2.19
CD (5%)		797.77	285.45	6.43
		Treatment (T)		
T0		5623.61	1910.65	34.15
T1		4785.19	1412.04	31.35
T2		5484.72	1727.78	31.25
T3		4723.61	1359.26	30.67
T4		5445.37	1697.22	31.00
T5		4568.52	1552.78	38.87
SEm+		471.13	168.58	3.80
CD (5%)		1381.77	494.42	11.14
		Interaction (GXT)		
JG11	**T0**	5525.93	1875.00	34.13
	T1	4415.74	1575.93	37.44
	T2	4981.48	1320.37	26.82
	T3	3297.22	1061.11	34.50
	T4	5647.22	1643.52	28.93
	T5	5154.63	1248.15	25.26
JG14	**T0**	5721.29	1946.30	34.17
	T1	5154.63	1248.15	25.26
	T2	5987.96	2135.19	35.68
	T3	6150.00	1657.41	26.84
	T4	5243.52	1750.93	33.07
	T5	3982.41	1857.41	52.47
	SEm+	666.28	238.40	5.37
	CD (5%)	1954.12	699.21	15.74

Genotype and treatment interaction in JG11 showed maximum (37.44%) and minimum (25.26%) and JG14 expressed maximum (52.47%) and minimum (25.26%) harvesting index respectively (Table 4.11 and Figure 13).

4.5 Biochemical Analysis of JG11 and JG14 Chickpea Seed

4.5.1 Nitrogen (%)

JG14 showed higher nitrogen (3.76%) compare from JG11. The genotype expressed statistically at par.

In treatment combination maximum value expressed T_1 combination (3.81) among the other treatment.

Genotype and treatment Interaction the superior value expressed in JG14 T_1 combination (3.89%). However, JG11 also expressed superior T_1 combination with genotype and treatment interaction. However maximum and minimum value was expressed (3.89%) and (3.46%) respectively (Table 4.12 and Figure 14).

4.5.2 Protein (%)

Protein content in JG14 (23.52%) was expressed superior and significant differences from JG11.

The treatment combination T_1 (23.83%) was superior to the treatment. Treatment was showed statistically at par.

Genotype treatment interaction in JG14 T_1 combination showed higher protein (24.37%) comparison from among the genotype with treatment interaction. JG11T_3 combination was illustrated minimum protein content (20.97%) (Table 4.12 and Figure 14).

4.5.3 Carbohydrate (%)

The carbohydrate content was higher in JG11 (54.49%) comparison from JG14. Although genotypic ally expressed statistically at par.

Treatment combination T_3 (58.78%) expressed superior carbohydrate level among the treatment.

Genotype and treatment interaction carbohydrate was maximum (58.97%) and minimum (51.85%) in JG11 genotype. However, JG14 genotype showed maximum carbohydrate (58.60%) and minimum (51.72%). Nevertheless, JG14 T_0 combination was recorded (58.96%) carbohydrate comparison from other among the genotype with treatment interaction (Table 4.12 and Figure 14).

4.5.4 Proline (μmolg^{-1})

JG14 were expressed higher proline content comparison from JG11. Although genotypic ally showed statistically at par.

In treatment, T_2 combination was higher proline content (0.905) in chickpea seed among the other treatment.

Genotype and treatment interaction JG14 T_2 combination were illustrated higher proline content (0.947) in seed comparison from other genotype and treatment interaction (Table 4.13 and Figure 15).

4.5.5 Fiber and Fat (%)

JG14 showed higher fiber content (17.00%) comparison from JG11. Although genotype variation showed statistically at par. In fat content was higher in JG11 (11.59%) compare from JG14. Nevertheless, JG 11 showed a significant difference from JG14.

In treatment combination, T_5 was illustrated higher fiber content (19.10%) in chickpea seed. However, T_3, T_5, T_1, and T_4 showed significantly at par. In fat content was recorded higher in T_1 (13.00%) among the treatment. T_1, T_5, T_4, T_0.

Genotype and treatment interaction in JG11 expressed maximum fiber (18.70%) and minimum (14.29%). Although JG14 showed maximum (19.50%) and minimum (14.55%). In JG14 fat content were recorded maximum (11.00%) and minimum (8.00%). Although JG11 T_1 combination was recorded maximum fat content (15.00%) and minimum showed in T_2 combination (9.00%) respectively (Table 4.13 and Figure 15).

Table 4.12: Effect of foliar application of water, salicylic acid and nutrient composition on Chickpea genotypes level of nitrogen, protein and carbohydrate per cent under rainfed and irrigated late sown condition.

Genotypes		Nitrogen (%)	Protein (%)	Carbohydrate (%)
JG11		3.57	22.31	54.49
JG14		3.76	23.52	54.31
SEm+		0.28	1.80	1.17
CD (5%)		0.26	1.60	3.44
		Treatment (T)		
T0		3.76	23.47	53.41
T1		3.81	23.83	53.61
T2		3.74	23.40	53.57
T3		3.61	22.55	58.78
T4		3.55	22.17	53.88
T5		3.53	22.07	53.15
SEm+		0.12	0.91	2.03
CD (5%)		0.44	2.78	5.95
		Interaction (GXT)		
JG11	**T0**	3.66	22.90	55.10
	T1	3.73	23.30	55.37
	T2	3.65	22.83	52.00
	T3	3.36	20.97	58.96
	T4	3.56	22.23	53.65
	T5	3.46	21.63	51.85
JG14	**T0**	3.85	24.03	51.72
	T1	3.89	24.37	51.85
	T2	3.83	23.97	55.14
	T3	3.86	24.13	58.60
	T4	3.53	22.10	54.11
	T5	3.60	22.50	54.44
	SEm+	10.00	0.65	2.87
	CD (5%)	0.63	3.93	8.42

Table 4.13: Effect of foliar application of water, salicylic acid and nutrient composition on chickpea genotypes on level of proline, fiber and fat under rainfed and irrigated late sown condition.

Genotypes		Proline ($\mu molg^{-1}$)	Fiber (%)	Fat (%)
JG11		0.819	16.88	11.39
JG14		0.879	17.00	9.44
SEm+		0.09	0.92	0.83
CD (5%)		0.11	2.69	2.43
		Treatment (T)		
T0		0.835	15.85	10.17
T1		0.87	17.40	13.00
T2		0.905	14.42	8.50
T3		0.878	19.10	9.00
T4		0.775	16.90	10.83
T5		0.83	17.94	11.00
SEm+		0.06	1.59	1.44
CD (5%)		0.191	4.65	4.21
		Interaction (GXT)		
JG11	**T0**	0.813	16.04	11.33
	T1	0.847	17.14	15.00
	T2	0.863	14.30	9.00
	T3	0.863	18.70	9.67
	T4	0.747	17.42	12.33
	T5	0.78	17.66	11.00
JG14	**T0**	0.857	15.66	9.00
	T1	0.893	17.66	11.00
	T2	0.947	14.55	8.00
	T3	0.893	19.50	8.33
	T4	0.803	16.38	9.33
	T5	0.88	18.22	11.00
	SEm+	0.02	2.24	2.03
	CD (5%)	0.27	6.58	5.96

4.5.6 Potassium (mg100g^{-1})

JG14 showed higher potassium content (1222.07) comparison from JG11. Although genotype variation showed significant differences.

In treatment T_5 (1213.72) combination was expressed higher among the other treatment. However, T_5, T_2, T_3, and T_2 showed statistically at par.

Genotype and treatment interaction JG14 expressed T_2 (1307.47) combination higher potassium content weigh against from among interaction. The JG11 was illustrated minimum T_0 (1006.20) and maximum T_5 (1223.67) combination in potassium content of the seed. Although T_5 expressed significant differences from the T_0 and T_4 combination (Table 4.14 and Figure 16).

4.5.7 Calcium (mg100g^{-1})

JG14 expressed higher calcium content (188.82) measure up to from JG11. Although genotype variation expressed significantly difference.

In treatment T_3 (183.52) showed superior and higher content among the other treatment although treatment combination showed statistically at par.

Genotype and treatment interaction JG14 was recorded higher calcium content in T_2 (210.30) combination from genotype with treatment interaction. JG11 expressed minimum T_2 (136.97) and maximum (165.17) calcium content in chickpea seed (Table 4.14 and Figure 16).

4.5.8 Sodium (mg100g^{-1})

Maximum sodium content was recorded in JG14 (12.66) and genotypic ally showed statistically at par.

Treatment combination T_2 and T_3 were showed statistically nonsignificant. However, T_0, T_1, T_4, and T_5 were illustrated significantly different from the T_2 combination.

Genotype and treatment interaction JG11 was recorded maximum (22.43) and minimum (20.28) sodium content. However, JG14 maximum

Table 4.14: Effect of foliar application of water, salicylic acid and nutrient composition on potassium, calcium, and sodium in per 100g of seed under rainfed and irrigated late sown condition of chickpea genotypes.

Genotypes		Potassium ($mg100g^{-1}$)	Calcium ($mg100g^{-1}$)	Sodium ($mg100g^{-1}$)
JG11		1105.67	148.75	21.35
JG14		1222.07	188.82	21.68
SEm+		17.05	5.04	0.17
CD (5%)		50.00	14.78	0.50
		Treatment (T)		
T0		1112.08	161.62	21.55
T1		1142.47	167.45	21.05
T2		1201.07	173.63	22.52
T3		1198.45	183.52	21.68
T4		1115.45	161.92	21.25
T5		1213.72	164.58	21.05
SEm+		29.53	8.73	0.29
CD (5%)		86.60	25.60	0.86
		Interaction (GXT)		
JG11	**T0**	1006.20	142.90	21.70
	T1	1093.37	155.47	20.83
	T2	1094.67	136.97	22.43
	T3	1090.20	165.17	21.23
	T4	1125.93	140.20	21.00
	T5	1223.67	151.80	20.90
JG14	**T0**	1217.97	180.33	21.40
	T1	1191.57	179.43	21.27
	T2	1307.47	210.30	22.60
	T3	1306.70	201.87	22.13
	T4	1104.97	183.63	21.50
	T5	1203.77	177.37	21.20
	SEm+	41.76	12.35	0.41
	CD (5%)	122.48	36.21	1.22

Content (22.60) and minimum (21.20) showed respectively (Table 4.14 and Figure 16).

4.5.9 Copper (mg100g^{-1})

JG14 was recorded higher copper content measure up to from JG11 and showed statistically at par.

The treatment T_0 and T_3 combination were expressed significantly differ from T_1, T_2, T_4 and T_5 combination respectively.

Genotype and treatment interaction JG11 was recorded maximum cupper content (1.33) and minimum (0.93). However, JG14 showed maximum copper content (1.43) and minimum (0.96) respectively (Table.15 and Figure 17).

4.5.10 Zinc (mg100g^{-1})

Zinc content was recorded higher in JG14 and showed statistically significant differences from JG11.

Treatment combination JG14 (4.97) was illustrated superior among the other treatment.

Genotype and treatment interaction JG11 was recorded maximum (4.83) and minimum (3.13) zinc content in seed. However, JG14 maximum (5.10) and minimum (3.4) were recorded zinc content in chickpea seed (Table 4.15 and Figure 17).

4.5.11 Iron (mg100g^{-1})

JG 14 showed higher iron content (6.16) comparison from JG11 and genotypic ally showed statistically significant.

Treatment combination T_1, T_2, T_3, T_4, and T_5 showed statistically at par. However, T_3 and T_4 showed significantly differ from T_0, T_1, T_2 and T_5 combination.

Genotype and treatment interaction JG11 showed maximum (5.70) and minimum (4.83) iron content. However, JG14 expressed in maximum (6.70) and

minimum (5.46) iron content in seed. The overall maximum iron content was recorded in JG14 T3 (6.70) combination among the genotype with treatment interaction (Table 4.15 and Figure 17).

4.5.12 Manganese (mg100g^{-1})

JG 14 was recorded higher (3.64) manganese content and showed statistically significant difference from JG11.

Treatment T_5 combination was illustrated superior manganese content from among other treatments.

Genotype and treatment interactions were recorded maximum (3.83) and minimum (2.93) in JG11. Nevertheless, JG14 showed maximum (4.07) and minimum (3.33) manganese content in chickpea seed (Table 4.15 and Figure 17).

Table 4.15 : Effect of foliar application of water, salicylic acid and nutrient composition on chickpea in the content of copper, zinc, iron, and manganese in per 100g of seed under rainfed and irrigated late sown condition.

Genotypes		Copper ($mg100g^{-1}$)	Zinc ($mg100g^{-1}$)	Iron ($mg100g^{-1}$)	Manganese ($mg100g^{-1}$)
JG11		1.15	3.85	5.34	3.50
JG14		1.17	4.18	6.16	3.64
SEm+		0.07	0.13	0.17	0.13
CD (5%)		0.21	0.38	0.49	0.39
		Treatment (T)			
T0		1.35	3.42	5.15	3.13
T1		0.95	4.03	5.60	3.52
T2		1.05	3.77	5.90	3.73
T3		1.32	4.00	6.20	3.65
T4		1.18	4.97	6.02	3.62
T5		1.12	3.92	5.63	3.77
SEm+		0.12	0.22	0.29	0.23
CD (5%)		0.36	0.65	0.85	0.67
		Interaction (GXT)			
JG11	**T0**	1.27	3.40	4.83	2.93
	T1	0.93	4.00	5.37	3.63
	T2	0.93	3.13	5.20	3.40
	T3	1.27	4.13	5.70	3.40
	T4	1.33	4.83	5.37	3.80
	T5	1.17	3.60	5.60	3.83
JG14	**T0**	1.43	3.43	5.47	3.33
	T1	0.97	4.07	5.83	3.40
	T2	1.17	4.40	6.60	4.07
	T3	1.37	3.87	6.70	3.90
	T4	1.03	5.10	6.67	3.43
	T5	1.07	4.23	5.67	3.70
	SEm+	0.17	0.31	0.41	0.32
	CD (5%)	0.51	0.92	1.20	0.95

DISCUSSION

The global chickpea (*Cicer arietinum* L.) is a secondly grown pulse crop an internationally with a total production of 14.2 million tons from an area of 14.8 million ha and a productivity of 0.96 t ha^{-1}. The major growing countries including India, Australia, Pakistan, Turkey, Myanmar, Ethiopia, Iran, Mexico, Canada, and the United States. India, the largest chickpea producing country, accounts for about 68% of the global production.

These improved pulse varieties will be of critical importance, especially for low-input agricultural production systems. Pulses also help mitigate climate change by reducing dependency on synthetic fertilizers by Russel, (2015). Important legume crop suffers major yield losses by terminal heat stress and terminal drought stress (DS). Are major abiotic factors in chickpea growing stages. Therefore need stronger root system in drought an important trait for yields but this understanding remains controversial. To understand precisely the root traits contribution towards yield, according to Purushothaman et al. 2017, proposed to be the best selection strategy, for an efficient water use and an enhanced terminal drought tolerance in chickpea. Abiotic stresses problem overcome the stress by foliar application SA, Nutrient composition and water therefore formulated experiment on present investigation focused on “Response of foliar application of water salicylic acid of chickpea genotypes and nutrient on physiology growth and productivity under rainfed and irrigated late sown condition*”* Where moisture is inadequate for achieving the crop yield potential, selecting genotypes for wide adaptation and high stability across variable environments is a useful strategy, which ensures the production of an economic yield under variable soil moisture conditions. Responses to genotypic behavior on different water levels (Rainfed and irrigated) for their seed yield and another Morpho- physiological traits changes as water level increased or decreases as specific stages. JG11 and JG14 responses with treatment combination along with or without irrigation (rainfed) along with exposed water at 7^{th} days before 50% flowering. This can be attributed to irrigated condition, which resulted in

disproportionate vegetative growth, causing poor flower setting, prolong flower setting days, increase inter -nodal length, biomass and grain yield reduction were noticed. This was reflected in the reduction of the harvest index values as well as on smaller pods and seeds produced when soil moisture increased. The experimental finding expressed similar result reported by Saxena and Yadav, (1976)

Salicylic acid showed significant responses in biochemical, physiological and molecular mechanism under abiotic stress tolerant plant similar finding by Khan et al. 2015. The dry matter accumulation and seed yield also influenced by the foliar application of SA, Nutrient composition and water spraying similar result to find out by (Pandey et al. 2016). With this background, the present investigation was carried out and the results obtained are discussed in the following subheads.

5.1 Phenophases of Chickpea Genotypes

5.2 Growth Analysis and Dry Matter Production

5.3 Physiological Traits

5.4 Yields and Yield Components

5.5 Biochemical Analysis

5.1 Phenophases of Chickpea Genotypes

A phenol phases can be defined as an observable stage or phase in the annual life cycle of a plant that can be defined by a start and end point. The occurrence of a phenological event can be pinpointed to a single data and time.

5.1.1 Days to Flower Initiation (DFI)

The Foliar application of water salicylic acid and nutrient composition on chickpea phenology expressed in JG14 was bear early flower initiation (41.89 days) among the genotype, however, treatment combination was statistically at par. Although genotypes and treatment interaction maximum ranges were JG11 (43.66 days) and minimum (40.33 days) and JG14 maximum range

(44.33 days) and minimum (40.33 days) DFI (Table 4.1 and Figure 3). The similar finding showed days to first flowering in chickpea genotypes by (Patel and Hemantranjan, 2012). The early flower initiation provides the plants to have the longer reproductive period which may enhance the economic output provided the seed development occurs early and pod filling rate was most favorable. Photo-thermal unit and relative temperature depression indicated that involvement of gene action and possibilities of effective selection for improvement of these traits reported by Kumar et al. (2017).

5.1.2 Days to 50% Flowering (DFF)

The present investigation on the foliar application on JG 14 expressed early 50 % flowering (48.17 days). However, treatment combination showed the statistically at par or not significant, however maximum days were recorded in JG11 T_3 combination. In the present of nutrient and SA responses extend the flower retention capacity in JG11. Interaction combination in JG11 was recorded maximum in longer days (49.67 days) and minimum (47.00 days) However JG14 recorded maximum rang (53.00 days) (Table 4.1 and Figure 3). However under stress in chickpea, reproductive success under salt stress has been associated with the production of more tertiary branches and flowers, (Kotula et al. 2015).

5.1.3 Days to Pod Initiation (DPI)

JG 14 illustrated early pod initiation (62.00days). However, treatment combination T_2 having longer days for pod initiation (69.17 days). In interaction, JG11 and treatment combinations were recorded maximum pod initiation (68.00 days) and minimum (59.00 days). However, JG14 combination the maximum range showed (70.33days) and minimum (61.33 days) in T_2 and T_1 combination (Table 4.1 and Figure 3). SA and nutrient component and water spraying produced an increasing trend of DPI rate. Although increased grain yields under abiotic stress. The similar result finds out by (Khan et al. 2016).

5.1.4 Days to Flower End (DFE)

JG 14 (87.44 days) showed early flower end. The study of this trait in treatment combination longer days was recorded in T_3 combination (88.83 days) and minimum in T_0 and T_4 treatment (87.33days) combination (Table 4.1 and Figure 3). Nutrient and SA combination were expressed prolong days and retention of the flower. The time to the first flower was significantly shortened under mild temperature stress (MTS) in the chickpea genotypes, flower abortion increased showed similar result by Bahuguna et al. (2012).

5.1.5 Days to Pod End (DPE)

JG14 showed minimum period (95.50 days) for pod end in compared to JG11 (96.11 days). In interaction T_2 combination expressed longer days (96.77 days) among the treatment T_2 combination so significantly superior. In the JG11 interaction of genotype and treatment were recorded maximum range (97.00 days) and minimum (94.66 days). However, JG14 expressed comparable trends and the minimum pod end (95.00 days) respectively (Table 4.1 and Figure 3). The first pod was significantly shortened under mild temperature stress (MTS) in both the chickpea genotypes, while pod set and pod growth rate decreased. Moreover, slow pod growth rate in the MTS treatment decreased seed number, seed size and seed weight plant^{-1} reported by (Bahuguna et al. 2012).

5.1.6 Days to Physiological Maturity (DPM)

JG14 showed early physiological maturity assessment to JG11 (100.11 days).In treatment combination maximum days of maturity showed in T_2 and T_3 combination and expressed statistically at par, however, T_1 showed early physiological maturity. In genotype and treatment interaction combination JG11 expressed maximum (101.00 days) and minimum (98.33 days) however JG14 showed the similar trend. (Table 4.1 and Figure 3).The Dry matter partitioning was determined from the dry mass of individual plant parts as a percentage of total plant dry mass at physiological maturity. Under high temperature by more

dry matter partitioning towards pods instead of temperature induced partitioning towards vegetative plant parts reported by Rai et al. (2016).

5.2 Growth Analysis and Dry Matter Production

5.2.1 Crop Growth Rate (gcm^{-2} day^{-1})

In present investigation crop growth rate in JG 11 showed statistically at par with JG 14.However genotype to treatment interaction expressed maximum GCR value in JG 11 (0.40 $gcm^{-2}day^{-1}$) compared from JG14 (0.19 $gcm^{-2}day^{-1}$). The maximum GCR showed T_2 and T_3 combination. However JG14 expressed CGR maximum and minimum showed (0.193 and 0.286 gcm^{-2} day^{-1}) respectively (Table 4.2 and Figure 4) However SA and nutrient component have provided strengthening and internal mechanism to protect and developed systemic acquired resistant chickpea plant in compared to without used of SA and nutrient component similar pattern for CGR in genotypic differences were noticed by Pandey et al. (2016).

5.2.2 Partition Coefficient (*p*)

JG11 expressed statistically at par with JG14. Genotype treatment interaction in JG11 maximum partition coefficient value expressed (0.07 %) and minimum (0.03%). Nevertheless, JG14 showed maximum value (0.090 %) and minimum (0.03 %) respectively (Table 4.2 and Figure 4). Salicylic acid sprayed as individual and in combination at vegetative and flowering stages revealed that combined applications of 2 % DAP+100 ppm salicylic acid+0.05 % sodium molybdate increased the yield attributes (partitioning coefficient 49.18 %) per plant in green gram similar pattern find out by (Kuttimani and Velayutham, 2011). In the portioning coefficient was distinguishing genotypic difference showed by finding Pandey et al. (2016).

5.2.3 Number of Nodules $Plant^{-1}$

JG11 and JG14 genotype showed statistically at par. However maximum nodules were expressed in T_4, T_5 and T_2 combination. Genotype and treatment interaction JG11 expressed maximum (12.00) and minimum (7.00) number of

nodules plant^{-1}. However, JG14 expressed a maximum number of nodules (21.67) and minimum (9.67) respectively (Table 4.3 and Figure 5). The legume-rhizobium symbiosis, rhizobia form nodules on the roots of legume hosts and fix dinitrogen (N2) into ammonium (NH4 +) and other chemically active forms of nitrogen according to Galloway et al. (2013).

5.2.4 Fresh Weight of Nodules Plant^{-1} (g)

Genotype showed statistically at par. Genotype treatment interaction expressed statistically at par. JG11 showed maximum fresh weight (0.55 g) and minimum (0.20 g). However, JG14 was recorded maximum (1.05 g) and minimum (0.33 g) nodule fresh weight plant^{-1} respectively (Table 4.3 and Figure 5). According to Regus et al. (2017). Deposition intensity was tightly correlated with nitrogen concentration in soils. The growth benefits of rhizobial nodulation were dramatically reduced by even modest levels of mineral nitrogen.

5.2.5 Dry Weight of Nodules Plant^{-1} (g)

JG11 and JG14 were showed statistically at par. Although nodules dry weight were maximum JG14 (0.29g). The treatment combination dry weight of nodules plant^{-1} expressed higher in T_4 (0.29 g) on the other hand JG 11 maximum (0.35 g) and minimum (1.00 g). However, JG14 was recorded maximum (0.46 g) and minimum (0.41 g) respectively (Table 4.3 and Figure 5).The similar finding showed by the foliar application of salicylic acid (SA), used an increase of nodule dry mass and leg hemoglobin content was recorded in chickpea plants (Hayat et al. 2012).

5.2.6 Total Dry Matter Accumulation at Flowering and Maturity (g)

JG14 showed statistically significant total dry matter accumulation in plant^{-1} at flowering stage. However in maturity stage expressed statically at par. At flowering stage, accumulation was higher in JG14 (14.86 g). However, at maturity stage dry matter accumulation was maximum value express in JG11 (27.44 g) and treatment T_5 combination at flowering and maturity stage expressed maximum in T_2 (31.17 g) combination. Genotype treatment

interaction table JG11 T_3 combination showed superior dry matter accumulation (15.83 g) at flowering stage although at maturity stage T_0 and T_2 combination expressed superior dry matter accumulation plant^{-1}. (Table 4.4 and Figure 6). According to Rai et al. (2016). Dry matter partitioning was determined from the reported that dry mass of individual plant parts as a percentage of total plant dry mass at physiological maturity. The biomass partitioning was more towards vegetative plant parts attributing enhanced biomass.

5.3 Physiological Traits

5.3.1 Chlorophyll Content Index (CCI) at Flowering and Podfilling Stage

JG14 showed maximum value (59.05 SPAD) at flowering stage. However, JG11 expressed maximum CCI value (71.06 SPAD). At flowering stage, genotypes expressed CCI value statistically significant. Though pod filling stage expressed statistically at par. The treatment combination T_2 showed maximum CCI (60.48 SPAD) at flowering stage and T_3 expressed (72.63 SPAD) higher value compare to among the treatment. Genotype treatment interaction JG11 expressed maximum (55.33 SPAD) and minimum (53.43 SPAD) respectively. JG14 expressed maximum (66.33 SPAD) and minimum (54.60 SPAD). At pod filling stage JG11 genotype treatment interaction maximum value expressed (73.86 SPAD) and minimum (68.70 SPAD). Although JG14 expressed maximum (72.96 SPAD) and minimum (68.50 SPAD) value (Table 4.5 and Figure 7) Due to more accumulation of starch at pod filling stage showed higher SPAD value at pod filling stage and foliar application of SA and nutrient enhanced the CCI similar result reported by (Trankner et al. 2017).

5.3.2 Membranes Stability Index (MSI)

JG11 genotype was express significantly differing from JG14. However, the maximum MSI value expressed in T_1 combination and minimum MSI was observed in T_2 combination (26.07 %). Genotype treatment interaction the maximum MSI showed (38.57%) and minimum showed (30.17%) in JG11. However, JG14 maximum MSI showed (31.37%) and minimum (21.97%)

minimum MSI has recorded T_2 combination (21.97%) in JG14 genotype (Table 4.5 and Figure 7). The membrane stability was drastically reduced under imposed water deficit stress. However foliar application of SA and Nutrient component during rainfed maintained higher MSI values over the water deficit stress similar result report by Vineeth et al. (2017).

5.3.3 Relative Water Content (RWC %) at Flowering and Pod Filling Stage

JG11 showed maximum water retention capacity in leaves tissue weigh against from JG14 at flowering and pod filling stage but genotype variation expressed statistically at par or nonsignificant. Treatment combination maximum superior value expressed in (58.88%) combination at flowering and T_0 (51.37%) expressed at pod filling. Genotype treatment interaction JG11 showed maximum RWC (63.73%) and minimum RWC (39.93 %) and JG14 showed maximum (58.57%) and minimum (45.60 %) at flowering stage. At pod filling, JG 14 expressed (55.87%) maximum and minimum (46.10%). Although JG14 was expressed higher RWC (52.33%). Nevertheless JG11 at flowering stage T_1 interaction combination retain maximum water in leaves tissue (63.73 %) and JG14 expressed T_0 (58.57%) at flowering. At maturity maximum RWC has recorded T_2 combination (55.87%) and JG14 retain water in leaves tissue (52.33 %) respectively (Table 4.6 and Figure 8). Foliar application of SA and nutrient enhanced the water retention capacity in mesophyll leaf tissue during water deficit stress maintained higher RWC values over the water deficit stress control. Maximum RWC was estimated with the application of SA and nutrient combination (Figure 8) Similar results on RWC [%] were also reported with the application of bioregulators maintained the integrity of mesophyll tissue and chloroplast structure thereby protected the chickpea plants from the detrimental effects of water deficit stress by Vineeth et al. (2017).

5.3.4 Net Photosynthetic Rate (μmol Co_2 $m^{-2}s^{-1}$)

Photosynthetic rate (P_n) was maximum in JG14 (25.86) and showed statistically at par. In treatment combination, P_n has recorded superior in T_3 (26.13) combination. Genotype and treatment combination JG14 was recorded

maximum photosynthetic rate (26.70) and minimum (24.25) at pod filling stage. In JG11 T_3 combination expressed superior photosynthetic rate among the genotype treatment interaction combination (Table 4.7 and Figure 9). According to Khan et al. 2016 reported that photosynthesis declined in response to sucrose infusion. However maximum photosynthetic assimilation in SA and nutrient component under rainfed foliar application. Photosynthetic rate (Pn). However, bioregulators application maintained higher Pn under water deficit stress. Under imposed water stress, compact palisade layers of the mesophyll tissue were disrupted and cell size of the mesophyll cells displayed drastic reduction. Chloroplast, under water stress, displayed a number of grana with losing type of thylakoid, the large increase in osmiophilic granules, reduction in a number of starch granules and overall disruption of the thylakoid membrane similar finding reported by Vineeth et al. (2017).

5.3.5 Stomatal Conductance (mol $H_2om^{-2}s^{-1}$)

JG 11 showed maximum stomatal conductance (g_s) (0.37). However, treatment T_0, T_2, T_3, and T_4 were expressed statistically at par. However T_1 treatment expressed significant differences among other treatment. Genotype and treatment interaction JG11 maximum value showed (0.42 and minimum (0.28) showed at pod filling stage (Table 4.7 and figure 9).The stomatal conductance which is a component of photosynthesis exhibited the positive association with photosynthetic rate (Pn) and Total Dry Matter (TDM) while it had no relationship with grain yield (Reynolds et al. (1994).the similar result finds out by Marques DJ et al. (2016).

5.3.6 Transpiration Rate (m mol H_20 $m^{-2}s^{-1}$)

Transpiration rate expressed maximum JG11 (11.70) and expressed statistically significant from JG14.Treatment combination T_4 and T_5 combination express higher transpiration rate (11.58) and (12.35) respectively. Genotype treatment interaction JG11 expressed maximum transpiration rate (13.49) and minimum (9.71). JG14 was illustrated maximum transpiration (12.70) and minimum (8.90) at pod filling stage (Table 4.7 and Figure 9). The transpiration

rate expresses at the lower level and higher depends on the genotypic variations. Nutrient component and SA application only genotypic significant effect and stage specific condition. However nutrient deficiency showed less transpiration (E) similar result find out by Marques et al. (2016).

5.3.7 Intrinsic and Instantaneous Water Use Efficiency (μmol $mmol^{-1}$)

Intrinsic and instant water use showed the maximum in JG14 instant water use efficiency was expressed non- significant among the genotype. Nevertheless, JG14 has expressed significance difference in JG11. Treatment combination T_1 illustrated superior combination (80.93). Among the genotype, instantaneous water use efficiency expressed maximum in (2.54) in T_3 combination. Genotype treatment interaction intrinsic water use efficiency JG11 showed maximum (89.31) and minimum (62.81) and JG14 expressed maximum (89.31) and minimum (66.93) respectively. However instantaneous water use efficiency was recorded maximum (2.42) and minimum (1.95) in JG11. In Genotype JG14 showed instantaneous WUE maximum (3.13) and minimum (2.02). Intrinsic WUE JG11 T_5 combination was an express superior value (89.31) among the genotype. However JG14 T_1 (89.31) combination expressed similar value (Table 4.8 and Figure 10).however the foliar application of 10^{-5} M of salicylic acid was significantly increase of Water Use Efficiency 86.8%, 92.7% in chickpea (Alyemeni et al. 2014). Nevertheless, the transcriptional reprograming that occurs during the plant defense response against abiotic stress was reported to be modulated by SA, where the transcription of different sets of defense genes can be controlled in a spatiotemporal manner via SA-mediated mechanisms (Herrera-Vásquez et al. 2015).

5.3.8 Carboxylation Efficiency [μmol m^{-2} s^{-1}(μmol m^{-1})-1]

JG11 and JG14 expressed statistically at par. However, treatment combination was expressed T_5 (0.098) superior carboxylation efficiency. Nevertheless, genotype treatment interaction JG11 maximum carboxylation efficiency (0. 105) minimum (0.088) and JG14 showed maximum carboxylation efficiency (0.103) and minimum (0.080) respectively (Table 4.8 and Figure 10).

The ratio of net photosynthesis rate to intercellular Co_2 concentration is term carboxylation Efficiency (CE). SA and nutrient availability also influenced the CE rate. Although genotypically was express non-significant. The similar result showed by Meena et al. (2015).

5.4 Yield and Yield Components

5.4.1 Plant Height (cm) at Flowering and Maturity

JG14 was increased height at flowering (49.78 cm) at maturity (55.17 cm). However, genotype showed non- significant difference. However, T_3 and T_5 showed significant difference among the treatment at flowering stage. However at maturity stage T_5 (55.83 cm) expressed superior value among treatment. The interaction genotype with treatment combination JG11 showed maximum value (51.00 cm) and minimum (44.00 cm). Although JG14 showed maximum (55.00 cm) and minimum (42.66 cm). At maturity stage, JG14 were expressed maximum height (56.67 cm) and minimum (52.33 cm) and JG14 was recorded maximum height (58.67 cm) and minimum (51.00 cm) (Table 4.9 and Figure 11).SA and nutrient helpful for plant height in chickpea irrigated condition height increased. Although some hormones activity and metabolites changes. Plant height was genotype devolvement and the stronger selection was observed when crosses were made between stiff stalk and tropical germplasm. GA active were elevated with an increased Laval. Increased GA promotes BR and they together lead to increased plant height reported by Hu et al. (2017).

5.4.2 Number of Node and Total Number of Branches Plant^{-1}

In the JG14 number of node plant^{-1} (23.78) and a total number of branches (15.44) plant^{-1} (Table 4.9 and Figure 11). In treatment combination, maximum number of the node expressed T_2 combination from among the treatment. However the total number of branches plant^{-1} illustrated maximum in T_4 (18.50) combination. Genotype and treatment interaction number of node plants^{-1} were expressed higher in JG14. Although T_4 (26.33) combination was express higher no of the node and a total number of branches plant^{-1} from among the genotype and treatment interaction. A total number of branches

plants^{-1} maximum expressed in JG14 T_4 (19.33) combination and minimum JG11 T_2 and T_5 (11.33) combination (Table 4.9 and Figure 11).The number of nodes increased in the foliar application of SA and nutrients and water, however internodal length was enlarged compare without irrigated chickpea genotypes.Although each node bears branches and number of branches were increased and only genotypic variation expressed. Similar observation reported by (Das. 2017)

5.4.3 Number of Pods Plant^{-1}

JG11 showed the higher number of the pod (57.33) and significantly differ from JG14. However, treatment T_1 combination expressed a higher number of pod plant^{-1} (62.33). The treatment T_2 significantly superior. However, T1 significantly difference from the T_3 combination. In the interaction of genotype to treatment combination, the JG11 maximum number of the pod (70.67) and minimum (34.67) were expressed. However, JG14 was recorded the total number of pod plants^{-1} maximum (54.33) and minimum (34.00) (Table 4.10 and Figure 12). Rainfed and irrigated were reduced number pod and increased number of empty pod per plant similar result find out by Pang et al.(2016).The foliar application of SA, nutrients, and water under the rainfed number of pod bearing was enhanced. Nevertheless, the reproductive period was showed enlarge in rainfed condition. However in irrigation condition plant express delay and few flowering came and a number of fewer pods occurs. However, application of SA and nutrient ameliorate the flower abortion rate and retain maximum flower and flower converted in the pod. Nutrient uptake is also helpful for the pod to retain in plant similar result quoted by Das (2017).

5.4.4 Seed Weight Plant^{-1} and Hundred (100) Seed Weight (g)

JG11 were recorded higher seed weight (14.78 g) and 100 seed weight (23.78 g) weigh against from JG14 both traits expressed statistically at par. In treatment T_0 gain higher seed weight compares from among the treatment. Although hundred (100) seed weight showed higher in T_5 combination. Nevertheless, treatment combination expressed statistically at par. JG11 was

recorded maximum (17.33) and minimum (11.33) seed weight plant^{-1}. However, JG14 articulated maximum (16.67) and minimum (12.00) seed weight plant^{-1}. Although JG11 showed maximum (24.33) and minimum (22.66) hundred (100) seed weight. However, JG14 was recorded maximum (25.00) and minimum (17.66) hundred (100) seed weight (Table 4.10 and Figure 12). The foliar application of SA and nutrient component increased seed weight and hundred seed weight. Although nutrient mobilization also the important availability of sugar translocation at the time of seed formation and pod filling stage. Which is enhances the rate of accumulation, when the foliar application direct leaf absorbed nutrient through diffusion and utilized by plant similar result find out by (Verma et al. 2017 and Das 2017).

5.4.5 Biological Yield (kg ha^{-1})

Plant biomass was significantly increased through foliar application of SA in well watered and rainfed condition reported by Farjam et al. (2014).

JG14 showed higher biological yield (5373.30) as the comparison from JG11 although genotype expressed non-significant difference. In treatment combination, T_0 expressed maximum biological yield (5623.61) from among the treatment. Genotype and treatment interaction the maximum biological yield was recorded in JG11 T_4 (5647.22) and JG14 T_3 (6150.00). Although JG11 expressed maximum biological yield (5647.22) and minimum (3297.22). However, JG14 maximum biological yield was recorded (6150.00) and minimum (3982.40) (Table 4.11 Figure 13). The foliar application of SA and nutrient composition and water were enhanced the chlorophyll content and Rubisco protein and SA presence delay senescence in leaves. However, enhanced photosynthetic assimilation rate and development of more biomass similar result reported by Tränkner et al. (2016).

5.4.5 Seed Yield (kg ha^{-1})

JG14 expressed significant response on seed yield plant-1 under drought (8.71%) by the priming of salicylic acid (SA) with a foliar spray of 500nm SA in drought reported by Verma et al. (2017).

In the present investigation, JG14 showed significantly higher seed yield comparison from JG11. Although JG14 was recorded superior seed yield (1765.90) in comparison from JG11. Genotype and treatment interaction JG11 were recorded superior seed yield in T_0 and T_4 and T_1 combination. However, JG14 showed superior seed yield in T_2 and T_5 combination. Although JG11 expressed maximum seed yield (1874.99) and minimum (1061.11) and JG14 maximum seed yield (2135.19) and minimum (1248.15) respectively (Table 4.11 and Figure 13). Nevertheless application of SA and nutrient component increased seed size and nutrient, which is responsible for accumulation of sucrose from source (leaves) to sink (seed) in presence of SA. Chickpea is rainfed crop, foliar application of SA and nutrient component produced abundant amount of osmolyte in plant cytosol and that osmolyte helpful for producing energy (form of ATP). This is directly or indirectly participate sucrose translocation, however, abiotic stress state grain yield was reduced similar result reported by Pang et al. (2016).

5.4.6 Harvest Index (%)

JG14 showed superior harvest index (34.58%) comparison from JG11. In genotype expressed non- significant difference among the genotype. Treatment combination superior expressed T_5 (38.87%) combination and minimum T_3 combination (30.67%). Genotype and treatment interaction in JG11 showed maximum (37.44%) and minimum (25.26%) and JG14 expressed maximum (52.47%) and minimum (25.26%) harvesting index respectively (Table 4.11 and Figure 13). At the foliar application of SA treatment combination showed higher HI (%) also similar result reported by Purushothaman et al. (2017).

5.5 Biochemical Analysis of JG11 and JG14 Chickpea Seed

5.5.1 Nitrogen (%)

JG14 showed higher nitrogen (3.76%) compare from JG11. The genotype expressed statistically at par. In treatment combination maximum value expressed T_1 combination (3.81) among the other treatment. Genotype and treatment Interaction the superior value expressed in JG14 T_1 combination

(3.89%). However, JG11 also expressed superior T_1 combination with genotype and treatment interaction. However maximum and minimum value was expressed (3.89%) and (3.46%) respectively (Table 4.12 and Figure 14). The genotypic differences occur only but in seed size helpful for nutrient treatment similar finding reported by Verma et al. (2017).

5.5.2 Protein (%)

Protein content in JG14 (23.52%) was expressed superior and significantly differences from JG11. Genotype treatment interaction in JG14 T_1 combination showed higher protein (24.37%) comparison from among the genotype with treatment interaction. The jg11 T_3 combination was illustrated minimum protein content (20.97%) (Table 4.12 and Figure 14). Protein is the important constituent of chickpea seed but here only showed genotypic variation. However, the treatment effects expressed vary from SA and nutrient component in chickpea seed when the nitrogen content directly indicates the protein level. Verma et al. (2017) reported that the protein percent was increased in genotype JG11 (25.42%) in Salicylic acid primed seed + Foliar spray of 500nm salicylic acid at 15 days interval combination and significantly dominated over JG14. However, in the present experiment have show JG14 have high protein content because SA and Nutrient composition may be due helpful for the positive effect for the increasing protein content under late sown high temperature. Nevertheless, JG14 has high-temperature tolerant genotypes.

5.5.3 Carbohydrate (%)

The carbohydrate content was higher in JG11 (54.49%) comparison from JG14. Although genotypically expressed statistically at par. Treatment combination T_3 (58.78%) expressed superior carbohydrate level among the treatment. Genotype and treatment interaction carbohydrate was maximum (58.97%) and minimum (51.85%) in JG11 genotype. However, JG14 genotype showed maximum carbohydrate (58.60%) and minimum (51.72%). Nevertheless, JG14 T_0 combination was recorded (58.96%) carbohydrate

comparison from other among the genotype with treatment interaction (Table 4.12 and Figure 14). Carbohydrate (%) was higher in JG 11 when the foliar application of SA and nutrient composition and water. SA and Nutrient composition may be enhancing carbohydrate and maintaining the homeostasis in the cell system. Foliar application JG11 have expressed higher carbohydrate similar result reported by Verma et al. (2017).

5.5.4 Proline ($\mu molg^{-1}$)

JG14 were expressed higher proline content comparison from JG11. Although genotypically showed statistically at par. In treatment, T_2 combination was higher proline content (0.905) in chickpea seed among the other treatment. Genotype and treatment interaction JG14 T_2 combination were illustrated higher proline content (0.947) in seed comparison from other genotype and treatment interaction (Table 4.13 and Figure 15). Chickpea proline content was expressed not- significant differences. However proline content was low in JG11 but JG14 showed the higher value. Because the JG14 has recommended for late sown and high-temperature tolerant genotype. JG14 may be having strong scavenging system or osmolyte formation. Proline is an also osmolyte that maintains the homeostasis inside the cytosol. Similar observation trends reported by Verma et al. (2017).

5.5.5 Fiber and Fat (%)

JG14 showed higher fiber content (17.00%) comparison from JG11.Although genotype variation showed statistically at par. In fat content was higher in JG11 (11.59%) compare from JG14. Nevertheless, JG 11 showed significantly difference from JG14. In treatment combination, T_5 was illustrated higher fiber content (19.10%) in chickpea seed. In fat content was recorded higher in T_1 (13.00%) among the treatment. Genotype and treatment interaction in JG11 has expressed maximum fiber (18.70%) and minimum (14.29%). Although JG14 was showed maximum (19.50%) and minimum (14.55%). In JG14 fat content were recorded maximum (11.00%) and minimum (8.00%). Although JG11 T_1 combination was recorded maximum fat content (15.00%)

and minimum showed in T_2 combination (9.00%) respectively (Table 4.13 and Figure 15). The application of SA and nutrient composition fat content was slightly higher in JG11. However, in JG14 has shown slightly high fiber content and low fat may be an application of nutrient composition the level of fat increases in chickpea genotypes similar observation result reported by Bellaloui, (2011).

5.5.6 Potassium (mg100g^{-1})

JG14 showed higher potassium content (1222.07) comparison from JG11. Although genotype variation showed significant differences. In treatment T_5 (1213.72) combination was expressed higher among the other treatment. Genotype and treatment interaction JG14 expressed T_2 (1307.47) combination higher potassium content weigh against from among interaction. The JG11 was illustrated minimum T_0 (1006.20) and maximum T_5 (1223.67) combination in potassium content of the seed. (Table 4.14 and Figure 16). SA and nutrient composition positive responses showed. Further research is needed to investigate the role of K+ and its uptake, efflux, translocation in seed similar result reported by Atieno et al. (2017).

5.5.7 Calcium (mg100g^{-1})

JG14 expressed higher calcium content (188.82) measure up to from JG11. Although genotype variation expressed significantly difference. In treatment T_3 (183.52) showed superior and higher content among the other treatment although treatment combination showed statistically at par. Genotype and treatment interaction JG14 was recorded higher calcium content in T_2 (210.30) combination from genotype with treatment interaction. JG11 expressed minimum T_2 (136.97) and maximum (165.17) calcium content in chickpea seed (Table 4.14 and Figure 16). Calcium is a necessary plant nutrient that originates in igneous rocks. It is also a component of minerals such as dolomite, calcite, apatite, anorthite, and amphiboles that occur in sedimentary and metamorphic rocks. In soils of humid climates, these minerals are intemperate; additionally, part of the calcium is lost to leaching, and the rest is either adsorbed to soil

colloids or trapped in biomass. Under high pH conditions, calcium can become insoluble. Plant requirements for calcium are not very high, mainly because soils that contain low levels of calcium are very acidic. The important macronutrient of Ca++play role in a plant in a formation of a middle lamina, along with seed coat strengthen. The foliar application of SA and nutrients may be providing strengthen seed of chickpea. The similar result reported by Bevilaqua et al. (2012) and Verma et al. (2017).

5.5.8 Sodium (mg100g^{-1})

Maximum sodium content was recorded in JG14 (12.66) and genotypic ally showed statistically at par. Treatment combination T_2 and T_3 were showed statistically nonsignificant. Genotype and treatment interaction JG11 was recorded maximum (22.43) and minimum (20.28) sodium content. However, JG14 maximum content (22.60) and minimum (21.20) showed respectively (Table 4.14 and Figure 16).Previously studies the negative correlation showed by Sodium (Na+). The moderate negative correlation between Na+ accumulation in seed yield similar finding observed by Pushpavalli (2015).

5.5.9 Copper (mg100g^{-1})

JG14 was recorded higher copper content measure up to from JG11 and showed statistically at par. Genotype and treatment interaction JG11 was recorded maximum cupper content (1.33) and minimum (0.93). However, JG14 showed maximum copper content (1.43) and minimum (0.96) respectively (Table.15 and Figure 17). According to Khan et al. (2015). As the present of Cu-mediated stimulation of ethylene synthesis has been finding out the of the increase of 1-aminocyclopropane-1-carboxylic acid (ACC) synthase (ACS) activity, one of the enzymes involved in the ethylene synthesis pathway Plants tend to adjust or induce adaptation or tolerance mechanisms to overcome stress conditions. Foliar application of SA and nutrients to develop stress tolerance, plants trigger a network of hormonal cross talk and signaling, among which ethylene production and signaling processes optimum concentration may be helpful for storage resilience of seed.

5.5.10 Zinc (mg100g^{-1})

Zinc content was recorded higher in JG14 and showed statistically significant differences from JG11. Treatment combination JG14 (4.97) was illustrated superior among the other treatment. Genotype and treatment interaction JG11 was recorded maximum (4.83) and minimum (3.13) zinc content in seed. However, JG14 maximum (5.10) and minimum (3.4) were recorded zinc content in chickpea seed (Table 4.15 and Figure 17).Zinc has an important micro-nutrients and required minute quantity to the plant as well as seed health. Zinc is also the key role in the formation of tryptophan and hormone Indole Acetic acid (IAA) and enzyme carbonic anhydrase and alcohol dehydrogenase and carbonic anhydrase. The minute quantity of zinc helpful for overcome abiotic stresses (Formation of antioxidant Zn-SOD enzyme). The abiotic stress plasma membrane or seed membrane is ruptured by excess production of NADPH oxidase enzyme and produces the superoxide radical (O^{-}_{2}), in the presence of zinc ameliorate the effect the formation superoxide radical and formed of the Zn-SOD enzyme. The foliar application of SA and Nutrients may be provided strengthen to seed and sugar translocation result reported by Pandey et al. (2017).

5.5.11 Iron (mg100g^{-1})

JG 14 showed higher iron content (6.16) comparison from JG11 and genotypic ally showed statistically significant. Genotype and treatment interaction JG11 showed maximum (5.70) and minimum (4.83) iron content. However, JG14 expressed in maximum (6.70) and minimum (5.46) iron content in seed. The overall maximum iron content was recorded in JG14 T3 (6.70) combination among the genotype with treatment interaction (Table 4.15 and Figure 17). Connorton et al. 2017 reported that in the grains, *TaVIT1* and *TaVIT2* are both expressed in the aleurone, correlating with high levels of iron in this tissue which is removed from white flours during the milling process. In contrast, expression of *TaVIT1* and *TaVIT2* is very low in the starchy endosperm, the tissue from which white flour is extracted. While the pulses may

be helpful for to facilitate this type of gene also enhanced the concentration of Fe in chickpea seed with foliar application of SA and Nutrients.

5.5.12 Manganese (mg100g^{-1})

JG 14 was recorded higher (3.64) manganese content and showed statistically significant difference from JG11. Treatment T_5 combination was illustrated superior manganese content from among other treatments. Genotype and treatment interactions were recorded maximum (3.83) and minimum (2.93) in JG11. Nevertheless, JG14 showed maximum (4.07) and minimum (3.33) manganese content in chickpea seed (Table 4.15 and Figure 17). The Mn is important key role in photolysis of water during PSII pigment and in the presence breakdown of water, and It is also possible that wheat and barley differ in iron and manganese transport efficiency from roots to shoots, thus affecting the total amount of iron and manganese that is (re)mobilized to the grain reported by Connorton et al. (2017).

SUMMARY, CONCLUSIONS, AND SUGGESTION FOR FURTHER WORK

6.1 Summary

A field experiment was conducted during *Rabi*, 2016-17 at Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur to study the "Response of Foliar Application of Water, Salicylic Acid and Nutrients on Physiology of Chickpea Genotypes Growth and Productivity under Rainfed and Irrigated Late Sown Condition"

Climate change and weather variability and temperature instability viz., low and high temperature (Late sowed) is an important factor creating abiotic stresses. Especially high temperature in late sown condition, chickpea crops phase's problem, therefore an urgent need for formulated experiment on the present investigation.

The experiment was laid out in a factorial randomized block design (FRBD) with two genotypes and six (06) treatments in three replications. The treatments water and salicylic acid (500nm) and nutrients foliar application with two varieties (JG11 and JG14).The experimental findings showed from the present investigation are summarized in this chapter.

The chickpea phenology were recorded through visual observations under rainfed and irrigated late sown condition. The growth analysis and dry matter production to analyze the dry matter production and partitioning efficiencies were carried out at maturity. The foliar application of water, salicylic acid and nutrient composition on chickpea genotypes analyses the crop growth rate (CGR) and partitioning coefficient (p) were recorded till maturity in all the treatments and interactions. The nodules traits (Viz. Number of the nodule, nodule fresh weight, and dry weight), observations were recorded at flowering stage in rainfed and irrigated condition. The highlight on total dry matter accumulation at flowering and maturity (g) stage along with the various physiological traits viz., chlorophyll content index (SPAD - 502 plus) and relative

water content (RWC %) at flowering and maturity stage and membrane stability index (MSI) at pod filling stage were recorded in chickpea leaves. The gaseous and derivative observation viz., photosynthetic rate (μmol Co_2 $m^{-2}s^{-1}$), stomatal conductance (mol $H_2om^{-2}s^{-1}$), transpiration rate (m mol H_20 $m^{-2}s^{-1}$), intrinsic and instantaneous, water use efficiency (μmol $mmol^{-1}$) and carboxylation efficiency [μmol m^{-2} s^{-1}(μmol m^{-1})-1] were recorded with help of infra red gas analyzer (IRGA) LiCOR 6400 USA in all the treatments and interactions combination.

The observations were recorded on yield and its components viz., chickpea height (cm) at flowering and maturity, total number of branches $plant^{-1}$ and number of node $plant^{-1}$ at maturity stage, total number of pod $plant^{-1}$, seed weight $plant^{-1}$ and hundred seed weight and biological yield, seed yield ($kgha^{-1}$) and HI (%).

For the biochemical estimation of nitrogen, protein, and carbohydrate per cent along with proline, fiber and fat were estimated from mature seed. The mineral nutrients and heavy metal viz., potassium, calcium, sodium, copper, zinc, iron and manganese in per 100g of seed were estimated from the JG11 and JG14 seeds.

The experimental finding of the chickpea phonological concerned indicated variable response in different phenophases of chickpea genotype having days to flower initiation, days to 50 % flowering, days to pod initiation days to flower end, days to pod end and days to physiological maturity during the most of the growth stage. JG14 showed early flower initiation (41.89 days) among the genotype varietal deference. Genotypes and treatment interaction maximum ranges were JG11 (43.66 days) and minimum (40.33days). (Table 4.1 and Figure 3) . JG 14 expressed early 50 % flowering (48.17 days) compared to JG11. Interaction combination in JG11 was recorded maximum in longer days (49.67 days) and minimum (47.00 days) However, JG14 Interaction combination recorded maximum rang (53.00 days) and minimum (47.00 days) respectively. Days to pod initiation (DPI)**,** Result showed (Table 4.1 and Figure 3) that among the genotype JG 14 illustrated early pod initiation (62.00 days).

However, JG14 combination the maximum range showed (70.33 days) and minimum (61.33 days) in T_2 and T_1 combination (Table 4.1 and Figure 3). Days to Flower End (DFE) JG 14 (87.44 days) showed early DFE. The study of this trait in treatment combination longer days (Figure 3). Days to Pod End (DPE) in JG14 showed minimum (95.50 days) for pod end.

In JG11 interactions of genotype with treatment were recorded maximum range (97.00 days) and minimum (94.66 days). However, JG14 expressed comparable trends and the minimum pod end (95.00 days) respectively. Days to physiological maturity (DPM) in JG14 showed early physiological maturity assessment.In genotype and treatment interaction combination JG11 expressed maximum (101.00 days) and minimum (98.33 days) (Table 4.1 and Figure 3).

At the Crop Growth Rate (gcm^{-2} day^{-1}) genotype to treatment interaction expressed maximum CGR value in JG 11 ($0.40gcm^{-2}day^{-1}$).The maximum CGR JG11 showed the minimum and maximum CGR value (0.207 and $0.40gcm^{-2}day^{-1}$). However, JG14 expressed CGR maximum and minimum showed (0.193 and $0.286gcm^{-2}day^{-1}$) respectively. The Partition Coefficient (*p*) in JG11 expressed statistically at par (nonsignificant). JG11 maximum partition coefficient value expressed (0.07%) and minimum (0.03%). Nevertheless, JG14 showed maximum value (0.090 %) and minimum (0.03 %) respectively (Table 4.2 and Figure 4). At full bloom (Flowering) stage number of the nodule, Fresh weight and dry weight (g) of nodule plant-1 were expressed JG11 maximum (12.00) and minimum (7.00) number of nodules $plant^{-1}$. However, JG14 expressed a maximum number of nodules (21.67) and minimum (9.67). JG11 showed maximum fresh weight (0.55 g) and minimum (0.20 g). However, JG14 was recorded maximum (1.05 g) and minimum (0.33 g) nodule fresh weight $plant^{-1}$. Although nodules dry weight were maximum JG14 (0.29g) on the other hand JG 11 maximum (0.35 g) and minimum (1.00 g). However, JG14 was recorded maximum (0.46 g) and minimum (0.41 g) respectively (Table 4.3 and Figure 5). At flowering stage total dry matter accumulation was higher in JG14

(14.86 g). However at maturity stage maximum value expressed JG11 (27.44 g).

Genotype treatment interaction JG11 T_3 combination showed superior dry matter accumulation (15.83 g) at flowering stage. JG11 maximum dry matter accumulation value (15.82 g) and minimum (8.22 g) at flowering stage although JG14 maximum dry matter accumulation (18.40 g) and minimum (11.21 g) at flowering stage. At maturity stage total dry matter accumulation in JG11 maximum (40.00 g) and minimum (19.33 g) and JG14 maximum expressed (28.33 g) and minimum (20.66 g) respectively (Table 4.4 and Figure 6). Various Physiological Traits viz., Chlorophyll Content Index (CCI) JG14 showed maximum value (59.05 SPAD) at flowering stage. However, JG11 expressed maximum CCI value (71.06 SPAD) at pod filling stage. At flowering stage, genotypes expressed CCI value statistically significant. Though maturity stage expressed statistically at par.

Genotype treatment interaction JG11 expressed maximum (55.33 SPAD) and minimum (53.43 SPAD) respectively. JG14 expressed maximum (66.33 SPAD) and minimum (54.60 SPAD) at flowering stage. At maturity stage JG11 genotype treatment interaction maximum value expressed (73.86 SPAD) and minimum (68.70 SPAD). Although JG14 expressed maximum (72.96 SPAD) and minimum (68.50 SPAD) value. Chickpea leaves membranes stability index (MSI) were expressed in JG11 significantly differing from JG14. Genotype treatment interaction the maximum MSI showed (38.57%) and minimum showed (30.17%) in JG11. However, JG14 maximum MSI showed (31.37%) and minimum (21.97%) minimum MSI recorded T_2 combination (21.97%) in JG14 genotype (Table 4.5 and Figure 7). In leaves, relative water content (RWC %) JG11 showed maximum water retention capacity in leaves tissue weigh against from JG14 at flowering and pod filling. Genotype treatment interaction JG11 showed maximum RWC (63.73%) and minimum RWC (39.93 %) and JG14 showed maximum (58.57%) and minimum (45.60 %) at flowering stage. At pod filling, JG 14 expressed (55.87%) maximum and minimum (46.10%). Although JG14 was expressed higher RWC (52.33%) and minimum

(42.00%). Nevertheless, JG11 at flowering stage T_1 interaction combination retain maximum water in leaves tissue (63.73 %) (Table 4.6 and Figure 8). The gaseous observation photosynthetic rate (μmol Co_2 $m^{-2}s^{-1}$) was maximum in JG14 (25.86) and showed statistically at par. Genotype with treatment combination JG14 was recorded maximum photosynthetic rate (26.70) and minimum (24.25) at pod filling stage (Table 4.7 and Figure 9). The Stomatal Conductance (mol $H_2om^{-2}s^{-1}$) JG 11 showed maximum stomatal conductance (g_s) (0.37). Genotype and treatment interaction JG11 maximum value showed (0.42 and minimum (0.28) showed at pod filling stage (Table 4.7 and figure 9). The leaves transpiration Rate (m mol H_20 $m^{-2}s^{-1}$) expressed maximum JG11 (11.70). Genotype treatment interaction JG11 expressed maximum transpiration rate (13.49) and minimum (9.71). JG14 was illustrated maximum transpiration (12.70) and minimum (8.9) at pod filling stage (Table 4.7 and Figure 9). Intrinsic and instantaneous Water Use Efficiency (μmol $mmol^{-1}$) showed a maximum in JG14 instant water use efficiency was expressed non-significant among the genotype. Nevertheless, JG14 has expressed significance difference in JG11.

Genotype treatment interaction intrinsic water use efficiency JG11 showed maximum (89.31) and minimum (62.81) and JG14 expressed maximum (89.31) and minimum (66.93) respectively. However instantaneous water use efficiency was recorded maximum (2.42) and minimum (1.95) in JG11. JG14 showed instantaneous WUE maximum (3.13) and minimum (2.02). Intrinsic WUE JG11 T_5 combination was an express superior value (89.31) among the genotype. The carboxylation efficiency [μmol m^{-2} s^{-1}(μmol m^{-1})-1] were recorded JG11 maximum carboxylation efficiency (0.105) minimum (0.088) and JG14 showed maximum carboxylation efficiency (0.103) and minimum (0.080) respectively (Table 4.8 and Figure 10).

The yield and its components traits viz., chickpea height (cm) at flowering and maturity stage JG14 was increased height at flowering (49.78 cm) at maturity (55.17 cm).The genotype with treatment interaction JG11 showed

maximum value (51.00 cm) and minimum (44.00 cm). Although JG14 showed maximum (55.00 cm) and minimum (42.66 cm). At maturity stage, JG14 were expressed maximum height (56.67 cm) and minimum (52.33 cm) and JG14 was recorded maximum height (58.67 cm) and minimum (51.00 cm). The number of node and a total number of branches plant^{-1} expressed a JG14 number of node plant^{-1} (23.78) and a total number of branches (15.44) plant^{-1} were illustrated higher. Genotype and treatment interaction number of node plants^{-1} were expressed higher in JG14. Although T_4 (26.33) combination was express higher no of the node and a total number of branches plant^{-1} from among the genotype and treatment interaction. A total number of branches plants^{-1} maximum expressed in JG14 T_4 (19.33) combination (Table 4.9 and Figure 11). A number of Pods Plant^{-1} showed in JG11 higher number of a pod (57.33) and significantly differ from JG14. However, treatment T_1 combination expressed the higher number of pod plant^{-1} (62.33). In the interaction of genotype to treatment combination, the JG11 maximum number of the pod (70.67) and minimum (34.67) were expressed. However, JG14 was recorded the total number of pod plants^{-1} maximum (54.33) and minimum (34.00). Seed weight plant^{-1} and hundred (100) seed weight (g) were recorded in JG11 higher seed weight (14.78 g) and 100 seed weight (23.78 g) weigh against from JG14.

Genotype and treatment interaction JG11 was recorded maximum (17.33) and minimum (11.33) seed weight plant^{-1}. However, JG14 articulated maximum (16.67) and minimum (12.00) seed weight plant^{-1}. Although hundred (100) seed weight showed maximum (24.33) and minimum (22.66) in JG11.However, JG14 was recorded maximum (25.00) and minimum (17.66) hundred (100) seed weight (Table 4.10 and Figure 12). Biological yield (kg ha^{-1}) showed higher in JG14 (5373.30).Genotype and treatment interaction the maximum biological yield was recorded in JG11 T_4 (5647.22) and JG14 T_3 (6150.00). Although JG11 expressed maximum biological yield (5647.22) and minimum(3297.22). However, JG14 maximum biological yield was recorded (6150.00) and minimum (3982.40). Seed yield (kg ha^{-1}) JG14 showed

significantly higher seed yield comparison from JG11. Although JG14 was recorded superior seed yield (1765.90) in comparison to JG11.

Genotype and treatment interaction JG11 expressed maximum seed yield (1874.99) and minimum (1061.11) and JG14 maximum seed yield (2135.19) and minimum (1248.15) respectively. JG14 showed superior harvesting index (34.58%), and T_5 (38.87%) combination and minimum T_3 combination (30.67%).Genotype and treatment interaction in JG11 showed maximum (37.44%) and minimum (25.26%). However, JG14 expressed maximum (52.47%) and minimum (25.26%) harvesting index respectively (Table 4.11 and Figure 13). Nevertheless the foliar application of water, salicylic acid, and nutrients. Biochemical estimation of chickpea seed expressed Nitrogen (%) content JG14 showed higher nitrogen (3.76%) compare from JG11. In treatment combination maximum value expressed T_1 combination (3.81) among the other treatment. Genotype and treatment Interaction the superior value expressed in JG14 T_1 combination (3.89%). However, JG11 maximum and minimum value were expressed (3.89%) and (3.46%) respectively (Table 4.12 and Figure 14). Protein content in JG14 (23.52%) was expressed superior and significant differences from JG11. The JG14 T_1 combination showed higher protein (24.37%) comparison from among the genotype with treatment interaction. JG11T_3 combination was illustrated minimum protein content (20.97%) (Table 4.12 and Figure 14). The carbohydrate content was higher in JG11 (54.49%). Treatment combination T_3 (58.78%) expressed superior carbohydrate level among the treatment. Genotype and treatment interaction carbohydrate was maximum (58.97%) and minimum (51.85%) in JG11 genotype. However, JG14 genotype showed maximum carbohydrate (58.60%) and minimum (51.72%). Nevertheless, JG14 T_0 combination was recorded (58.96%) carbohydrate comparison from other among the genotype with treatment interaction (Table 4.12 and Figure 14).

JG14 were expressed higher proline content although genotypic ally showed statistically at par. In treatment, T_2 combination was higher proline

content (0.905) in chickpea seed among the other treatment. Genotype and treatment interaction JG14 T_2 combination were illustrated higher proline content (0.947) in seed genotype with treatment interaction (Table 4.13 and Figure 15). However, JG14 showed higher fiber content (17.00%) comparison from JG11. In fat content was higher in JG11 (11.59%). Nevertheless, JG 11 showed significantly difference from JG14.In treatment combination T_5 was illustrated higher fiber content (19.10%) in chickpea seed. Genotype and treatment interaction in JG11 has expressed maximum fiber (18.70%) and minimum (14.29%). Although JG14 showed maximum (19.50%) and minimum (14.55%) fiber. In JG14 fat content were recorded maximum (11.00%) and minimum (8.00%). Although JG11 T_1 combination was recorded maximum fat content (15.00%) and minimum showed in T_2 combination (9.00%) respectively (Table 4.13 and Figure 15). The estimation of biochemical nutrients from chickpea seeds the level of the nutrient in the $mg100g^{-1}$ basis of macro, micro and heavy metal present in JG11 and JG14. Potassium ($mg100g^{-1}$) content JG14 expressed higher potassium content (1222.07) comparison from JG11.In treatment T_5 (1213.72) combination was expressed higher among the other treatment. Genotype and treatment interaction JG14 expressed T_2 (1307.47) combination higher potassium content weigh against from among interaction.(Table 4.14 and Figure 16). However, calcium ($mg100g^{-1}$) in JG14 expressed higher calcium content (188.82) measure up to from JG11. Although genotype variation expressed significantly difference. In treatment T_3 (183.52) showed superior and higher content among the other treatment although treatment combination showed statistically at par.

JG14 was recorded higher calcium content in T_2 (210.30) combination from genotype with treatment interaction. JG11 expressed minimum T_2 (136.97) and maximum (165.17) calcium content in chickpea seed. Although maximum sodium content was recorded in JG14 (12.66) and genotypic ally showed statistically at par. Genotype and treatment interaction JG11 was recorded maximum (22.43) and minimum (20.28) sodium content. However, JG14 maximum content (22.60) and minimum (21.20) showed respectively (Table

4.14 and Figure 16). However, in a seed of JG14 was recorded higher copper ($mg100g^{-1}$) measure up to from JG11 and showed statistically at par. Genotype and treatment interaction JG11 was recorded maximum cupper content (1.33) and minimum (0.93). However, JG14 showed maximum copper content (1.43) and minimum (0.96) respectively. The zinc ($mg100g^{-1}$) content was recorded higher in JG14 and showed statistically significant differences from JG11. Treatment combination JG14 (4.97) was illustrated superior among the other treatment. Genotype and treatment interaction JG11 was recorded maximum (4.83) and minimum (3.13) zinc content in seed. However, JG14 maximum (5.10) and minimum (3.4) were recorded zinc content in chickpea seed respectively. JG 14 showed higher iron ($mg100g^{-1}$) content (6.16) comparison from JG11 and genotypic ally showed statistically significant. Genotype and treatment interaction JG11 showed maximum (5.70) and minimum (4.83) iron content. However, JG14 expressed in maximum (6.70) and minimum (5.46) iron content in seed. The overall maximum iron content was recorded in JG14 T3 (6.70) combination among the genotype with treatment interaction. JG 14 was recorded higher manganese ($mg100g^{-1}$) content (3.64) and showed statistically significant difference from JG11. Treatment T_5 combination was illustrated superior manganese content from among other treatments. Genotype and treatment interactions were recorded maximum (3.83) and minimum (2.93) in JG11. Nevertheless, JG14 showed maximum (4.07) and minimum (3.33) manganese content in chickpea seed (Table 4.15 and Figure 17).

6.2 Conclusions:

Present investigation emphasized on chickpea genotypes growth and productivity under rainfed and irrigated late sown condition expressed, the genotypic variation along with available irrigation in specific stages, SA, and nutrients. JG14 expressed higher seed yield and biological yield with rainfed and SA presence in late sown.However, JG11 expresses negative responses under late sown. The foliar application of water, SA and nutrients are responsible for proper partitioning of the source and sink relation along with the

proliferation of nutrients easily available to plant and translocation through the help of phloem from the shoot to root along with soil nutrient under temperature stress (late sown). Nevertheless the JG 14 expressed significant responses under late sown with the application of salicylic acid (SA).

Suggestion for further work:-

1) The investigations are required to be conducted with more precise foliar application of SA and nutrients concentration.
2) Further studies root behavior on chickpea genotype with foliar application of water, SA, and nutrients.
3) Study needed about the improvement of nutrient uptake efficiency under late sown condition, with vesicular arbuscular mycorrhiza (VAM) use for the stele strengthen or vascular tissue.

BIBLIOGRAPHY

Aliloo AA, Khorsandy H and Mustafavi SH. 2015. Response of chickpea (*Cicer arietinum* L.) cultivars to nitrogen applications at vegetative and reproductive stages. Cercetari Agronomice in Moldova. 45(4): 49-55.

Alyemeni MN, Hayat Q, Wijaya L and Hayat S. 2014. Effect of salicylic acid on the growth, photosynthetic efficiency and enzyme activities of leguminous plant under cadmium stress. Notulae Botanicae Horti Agrobotanici, 42(2):440-445.

Anonymous. 2016. Project Coordinators Report AICRP on Chickpea in Indian Institute of Pulses Research Kanpur. in: Proceeding Annual Group Meet on Chickpea 29 - 31 August 2016, Agricultural research station, (ARS) Kalaburgi Karnataka, India. pp.25-29.

AOAC 1980. Official method of analysis of the association of official Agriculture Chemist, 10th edition Washington D.C.ISBN: 3-9521414-0-2.

Atieno J, Li Y, Langridge P, Dowling K, Brien C, Berger B, Varshney RK and Sutton T. 2017 .Exploring genetic variation for salinity tolerance in chickpea using image-based phenotyping. Scientific Reports 7: 1300. DOI: 10. 1038/s41598-017-01211-7.

Bahuguna RN, Shah D, Jha J, Pandey SK, Khetarpal S, Anand A And Pal M. 2012. Effect of mild temperature stress on reproduction dynamics and yield of chickpea (*cicer arietinum* l.) Indian Journalof Plant Physiology 17(1): pp. 1-8.

Bellaloui N. 2011. Effect of Water Stress and Foliar Boron Application on Seed Protein, Oil, Fatty Acids, and Nitrogen Metabolism in Soybean American Journal of Plant Sciences2, 692-701 doi: 10. 4236/ajps. 2011. 25084.

Bevilaqua GAP, Filho S, and Possenti JC. 2002. Aplicação foliar de cálcio e boro e componentes de rendimento e qualidade de sementes de soja [Boron and Calcium Leaf Application and Yield Components and Physiological Quality of Soybean Seeds]. Ciência Rural, 32, 31-34. http://dx.doi.org/10.1590/S0103-84782002000100006.

Barrs HD and Weatherly PE. 1962. A re-examination of relative turgidity technique for estimating water deficits in leaves. Australian Journal of Biological Science 15: 413- 428.

Boukraâ D, Belabid L, Benabdelli K and Bennabi F. 2015. Implication of salicylic acid in chickpea growth to salt resistance Adv. Environ. Biol., 9(27): 270-277.

Brijnandan, Jamwal BS, Sharma BC, Kumar A and Gupta V. 2014. Seed priming and foliar nutrition studies on growth, yield and quality of chickpea under subtropical kandi areas of hills of shivalik foothills of Jammu region. International Journal of Basic and Applied Agricultural Research. Vol. 12 (2): 184-187.

Connorton MJ, Jones R E, Ramiro IR, Susan, Tait F, Uauy C and Balk J 2017. Vacuolar Iron Transporter TaVIT2 transports Fe and Mn and is effective

for biofortification. Plant Physiology Preview. Published by www.plantphysiol.org .DOI:10.1104/pp.17.00672.

Chen Y, Ghanem ME, Siddique KHM. 2017. Characterising root trait variability in chickpea (*Cicer arietinum* L.) germplasm. Journal of Experimental Botany 68, 1987–1999.

DAS SK. 2017. Effect of phosphorus and sulphur on yield attributes, yield, nodulation and nutrient uptake of green gram [*Vigna radiate* (L.) wilczek]. Legume Research, 40 (1): 138-143. DOI:10.18805/lr.v0iOF.9385.

Farjam S, Siosemardeh A, Kazemi Arbat H, Yarnia M and Rokhzadi A. 2014. Response of chickpea (*Cicer arietinum* L.) to exogenous salicylic acid and ascorbic acid under vegetative and reproductive drought stress conditions. Journal of Applied Botany and Food Quality 87, 80 – 86.

Galloway JN, Leach AM, Bleeker A and Erisman JW. 2013 Achronology of human understanding of the nitrogen cycle. Philos Trans R Soc B Biol Sci 368(1621).

Gardner FP, Pearce RB and Mitchell RL. 1985. Physiology of crop plants. The Iowa State University Press, Ames, 327.

Hayat Q, Hayat S, Alyemeni MN and Ahmad A. 2012. Salicylic acid mediated changes in growth, photosynthesis, nitrogen metabolism and antioxidant defense system in (*Cicer arietinum* L.) Plant Soil Environmental 58 (9): 417–423.

Hayat S, Hayat Q, Alyemeni MN, Ahmad A. 2014. Cumulative effects of proline and salicylic acid on the cadmium-induced changes in *Cicer arietinum* L. Fresenius Environmental Bulletin. 23(2):330-340.

Heidari A, Shekari F, Saba J and Shahidi G. 2015. The effect of seed priming with salicylic acid on growth and grain yield of pinto bean under nitrogen levels. International Journal of Biosciences Vol. 6 (1) 298-307.

Hu S, Wang C, Sanchez DL, Lipka AL, Liu P, Yin Y, Blanco M and Lubbertedt T. 2017. Gibberellins promote brassinosteroiods active and both increased Heterosis for plant height in maize. Frontiers in Plant Science,dio: 10.3389/fpls 01039.

Jukanti, AK, Gaur PM, Gowda CLL, and Chibbar RN. 2012. Nutritional quality and health benefits of chickpea (Cicer arietinum L.): a review Brit J Nutr 108,S11–S26.

Kalarani MK, Thangaraj M, Sivakumar R and Mallika V. 2002. Effect of salicylic acid on tomato (*Lycopercicon esculentum*) productivity. Crop Research 23:486-492.

Khan MlR, Mehar F, Tasir SP, Naser AA and Khan NA. 2015. Salicylicacid induced abiotic stress tolerance and under lyingmechan is ms in plants published: doi: 10.3389/fpls.2015.00462.

Khan HA, Siddique KHM and Colmer TD. 2016. Vegetative and reproductive growth of salt stressed chickpea are carbon-limited: sucrose infusion at the reproductive stage improves salt tolerance. Journal of Experimental Botany. 1-11.

Kotula L, Khan HA, Quealy J, Turner NC, Vadez V, Siddique KHM, Clode PL and Colmer TD. 2015. Salt sensitivity in chickpea (*Cicer arietinum* L.): ions in reproductive tissues and yield components in contrasting genotypes. Plant, Cell & Environment 38: 1565–1577.

Krishnamurthy L, Kashiwagi J, Gaur PM, Upadhyaya HD, Varshney RK and Tobita S. 2013. Traits of relevavance to improve yield under terminal drought in the chickpea (*Cicer arietinum* L.) Field Crop Research 145: 88–95.

Kumar C, Mishra SB, Nilanjaya and Singh CM. 2017. Investigating morpho-physiological traits and agro-meteorological indices in green gram [*Vigna radiata* (L.) Wilczek] for terminal heat tolerance. Legume Research, 40 (2):271-276. DOI: 10.18805/lr.v0i0.7588.

Kumari S, Sehgal A, Kumar J, Kumar S, Singh S, Kadambot H, Siddique M, and Nayyar H. 2017. Identification of high-temperature tolerant lentil (Lens culinaris Medik.) genotypes through leaf and pollen traits. Frontiers in Plant Science 8:744-771 doi: 10.3389/fpls.2017.00744.

Kuttimani R and Velayutham A. 2011.Foliar application of nutrients enhances the yield attributes and nutrient uptake of green gram. Agricultural Research Communication Center 31(3): 202–205.

Marques DJ, Silva EC, Ferreira MM, Paglis CM, Souza TC, Maluf WR, Maciel GM, Ferreira ED and Lobato AKS 2016. Differential responses of root system and gas exchange in contrasting tomato genotypes under phosphorus starvation. Australian Journal of Crop Science 10(1):101-110.

Mate SK, Deshmukh SN, Bharud DV, RW. 2013. Light use efficiency and its influence on physiological parameters in chickpea genotypes. Annals of Plant Physiolog 27(1/2):63-68.

Mena KC, Rao S, Gontia AS, Upadhyaya A and Rao SK. 2015. Physiology performance of pigeon pea. Indian Journal of Plant Physiology doi 10.1007/s40502-015-01467.

Miura K, Tada Y. 2014. Regulation of water, salinity, and cold stress responses by salicylic acid.Front Plant Science 5:4.

Pak Mehr A, Rastgoo M, Shekari F, Saba J, Vazayefi M and Zangani A. 2011. Effect of Salicylic acid priming on yield and yield components of cowpea (*Vigna unguiculata* L.) under water deficit at reproductive stage. Iranian Journal of Pulses Research 2(1): 53-64.

Pandey SK, Pandey S, Upadhyay A, Upadhyaya SD, Rani A, Bhowmick AK and Samaiya RK. 2016 .Assimilate remobiligation of grain yield behavior of chickpea genotypes under increasing temperature. Symposium on physiological approaches to enhance productivity in pulses under changing climate aprl 30th pp101-104.

Pandey SK, Upadhyay SD, Dar ZM, Hemantaranjan A and Srivastava JP. 2017. Effect of electrolyte leakage activity on mungbean leaf under induced salinity and zinc levels. International Journal of Current Research 9 (6): 5248-52440.

Pang J, Turner NC, Khan T, Du YL, Xiong JL, Colmer TD, Devilla R, Stefanova K and Siddique KHM. 2016. Response of chickpea (*Cicer arietinum* L.) to terminal drought: leaf stomatal conductance, pod abscisic acid concentration, and seed set. Journal of Experimental Botany 1-13.

Pang J, Turner NC, Khan T, Du Y-L, Xiong J-L, Colmer TD, Devilla R, Stefanova K, Siddique KHM. 2017. Response of chickpea (*Cicer arietinum* L.) to terminal drought: leaf stomatal conductance, pod abscisic acid concentration, and seed set. Journal of Experimental Botany 68, 1973–1985.

Patel PK and Hemantranjan A. 2012. Salicylic acid induces alternation in dry matter partitioning, antioxidant defence system and yield in chickpea (*Cicer arientinum* L.) under drought stress. Asian Journal of Crop Science 4 (3): 86-102.

Patel PK, Hemantaranjan A, Sarma BK and Singh R. 2013. Growth and antioxidant system under drought stress in Chickpea (*Cicer arietinum* L.) as sustained by salicylic acid. Journal. Stress Physiological. Biochemisty 7: 130-144.

Pittaway JK, Robertson IK and Ball MJ. 2008. Chickpeas may influence fatty acid and fiber intake in an ad libitum diet, leading to small improvements in serum lipid profile and glycemic control. Journal Am Diet Assoc 108: 1009–1013.

Purushothaman R, Krishnamurthy L, Upadhyaya HD, Vadez V, and Varshney RK. 2017. Root traits confer grain yield advantages under terminal drought in chickpea (Cicer arietinum L.) Field Crops Research 201: 146–161.

Pushpavalli, R. 2015. Higher flower and seed number leads to higher yield under water stress conditions imposed during reproduction in chickpea. Functional Plant Biology 42, 162–174, doi:10. 1071/FP14135Rao SR.

Rai P, Chaturvedi AK, Shah D and Pal M. 2016. Impact of elevated CO2 on high temperature induced effects in grain yield of chickpea (*Cicer arietinum*). Indian Journal of Agricultural Sciences 86 (3): 414–7.

Rajabi L, Sajedi NA and Roshandel M. 2013. Response of yield and yield component of dry land chickpea to salicylic acid and superabsorbent polimer. Journal of Crop Production Research. Vol. 4 (4): 343-353.

Rao SR, Qayyum A, Razzaq A, Ahmad M, Mahmood I and Sher A. 2012. Role of foliar application of salicylic acid and l-tryptophan in drought tolerance of maize. The Journal of Animal & Plant Sciences 22(3):768-772.

Regus JU, Wendlandt CE, Bantay RM, Gano-Cohen KA, Gleason NJ, Hollowell AC, Neil MRO, Shahin KK. And Sachs JL. 2017. Nitrogen deposition decreases the benefits of symbiosis in a native legume. Plant and Soil 414: 159–170. DOI 10.1007/s11104-016-3114-8.

Reynolds MP, Balota M, Delgado MIB, Amani I and Fischer RA. 1994. Physiological and morphological traits associated with spring wheat yield under not irrigated condition. Australian Journal Plant Physiology 21: 717-730.

Russel N. 2015. Beans that can beat the heat. Accessed 29 February 2016.

Sarde BH, Wagh RS, Deshmukh DV. 2011. Morphophysiological evaluation and dry matter distribution in chickpea (*Cicer arietinum* L.) germplasm. Annals of Plant Physiology 25(2):182-187.

Saxena MC and Yadav DS. 1976. Some Agronomic Consideration of Pigeonpeas and Chickpeas. In Proceeding of the International Workshop on Grain Legumes. ICRISAT, Hyderabad, India 31-62.

Saxena NP, 1990. ‘‘Status of Chickpea in the medeterranean basin. In: Present Status and Future Prospects of Chickpea Crop Production and Improvement in the Mediterranean Countries. Seminar Zaragoza (Spain)’’ Options Mediterraneans (CIHEAM) S” Rie A, 9:17- 27.

Serraj R and Sinclair TR. 2002. Osmolyte accumulation: can it really help increase crop yield under drought conditions. Plant Cell Environment. 25: 333-341.

Shekari F. 2014. Seed priming with salicylic acid affected chickpea performance under rainfed condition. World Academy of Science, Engineering and Technology Agricultural and Biosystems Engineering Vol(1): 2.

Subbaro GV, Johnson C, Slinkard AE, Nagaeswara RC, Saxena NP and Chauhan YS. 1995. Strategies for Improving Drought Resistance in grain Legumes. Plant Science14 (6): 469-523.

Shukla KC, Singh OP and Samaiya RK. 2007. Effect of foliar spray of plant growth regulators and nutrient complex on productivity of soybean var. JS. 7981. Crop Research. 13 (1): 213 – 215.

Tandon HLS. (1995). Estimation of sodium and potassium. Methods of analysis of soils, plants, water and fertilisers. FDCO, New Delhi, pp. 62-63.

Tosh SM and Yadav S. 2010. Dietary fibres in pulse seeds and fractions Characterization, functional attributes, and applications. Food Research International 43:450-460.

Tränkner M, Jákli B, Tavakol E, Geilfus CM, Cakmak I, Dittert K and Senbayram M. 2016. Magnesium deficiency decreases biomass water-use efficiency and increases leaf water-use efficiency and oxidative stress in barley plants. Plant and Soil 406:409–423. DOI 10.1007/s11104-016-2886-1.

Vaisnad S and Talebi R. 2015. Salicylic acid-enhanced morphological and physiological responses in chickpea (*Cicer arietinum*) under water deficit stressEnvironmental and Experimental Biology 13: 109–115.

Varshney RK, Hiremath P J, Lekha P, Kashiwagi J, Balaji j, Deokar A And Vadez A V. 2009. A comprehensive resourse of drought and salinity responsive ESTs for gene discovery and marker development in chickpea (*Cicer arietinum L.*). BMC Genomics, 10:52.

Verma SO, Pandey SK, Upadhyay A, Upadhyaya SD and Gontia AS 2017. Biochemical changes in chickpea seed by priming and foliar application of salicylic acid and water under drought and excessive moisture stress. International Journal of Chemical Studies 5(3): 797-801.

Vineeth TV, Kumar P and Singh J .2017. Bioregulators protected the leaf anatomy and photosynthetic machinery underwater deficit stress in chickpea

(*Cicer arietinum* L.) Legume Research, 40 (2) : 250-256. DOI: 10.18805 / lr. v0i OF.4479.

Zandonadi CHS, Albuquerque CJB and Freitas RS. 2016. Chlorophyll index (spad) and macronutrients relation and productive performance of sorghum hybrid in different growth stage. Australian Journal of Crop Science 10(4): 546-555.

APPENDICES

Phenophases

Mean sum of square							
Source of variance	**DF**	**Days to flower initiation**	**Days to 50% flowering**	**Days to pod initiation**	**Days to flower end**	**Days to pod end**	**Days to physiological maturity**
Replication	2	6.75	43.86	73.53	11.19	11.86	0.03
Var. (A)	1	4.69	46.69	173.36	12.25	3.36	1.78
Treat. (B)	5	12.92	7.56	53.16	2.69	2.49	3.31
Inter. (AXB)	5	0.83	11.29	17.83	2.11	1.16	3.71
Error	22	2.45	21.86	17.38	2.10	1.55	1.39

Growth analysis and dry matter production

Mean sum of square								
Source of variance	**DF**	**CGR (g cm^{-1} day^{-1})**	**Partition coefficient (*p*)**	**No. of nudules**	**Fresh wt of nodules (g)**	**Dry wt of nodules**	**TDM at Flowering (g)**	**TDM at Maturity (g)**
Replication	2	0.00434	0.00151	106.78	0.35	0.25	6.77	88.19
Var. (A)	1	0.01562	0.00014	106.78	0.42	0.07	113.20	87.11
Treat. (B)	5	0.00428	0.00135	24.91	0.09	0.02	7.94	89.18
Inter. (AXB)	5	0.01903	0.00072	45.18	0.16	0.06	35.36	156.91
Error	22	0.00990	0.00058	74.23	0.29	0.08	12.92	23.71

Physiological traits

Mean sum of square												
Source of variance	**DF**	**CCI at flower**	**CCI at pod filling**	**MSI (%)**	**RWC (%) at Flowering**	**RWC (%) at Pod Filling**	**Pn**	**gs**	**E**	**Intrinsic WUE**	**Instantaneous WUE**	**C E**
Replication	2	51.7	32.25	95.71	100.33	60.50	2.77	0.00137	5.97	111.58	0.177	0.0003
Var. (A)	1	207.8	2.05	465.12	7.29	40.96	0.26	0.00253	5.06	94.90	0.575	0.0000
Treat. (B)	5	29.4	11.39	63.12	157.17	11.12	1.44	0.00551	1.93	184.71	0.217	0.0000
Inter. (AXB)	5	24.7	12.09	16.3	113.47	80.19	6.18	0.00949	18.27	299.96	0.639	0.0003
Error	22	38.2	15.59	46.51	59.75	31.99	0.77	0.00160	0.68	92.05	0.031	0.0001

Yields and yield components

Mean sum of square											
Source of variance	**DF**	**Height at Flowering**	**Height At Maturity**	**No. of Branches**	**No. of node plant^{-1}**	**No. of Pod Plant^{-1}**	**Seed Wt (g) Plant^{-1}**	**Hundred Seed Wt (g)**	**Biological Yield (kgha^{-1})**	**Seed Yield (kgha^{-1})**	**Harvest Index (%)**
Replication	2	137.03	56.69	25.53	19.69	28.53	5.36	19.44	12816362.7	708189.63	92.33
Var. (A)	1	14.69	3.36	16.00	100.00	765.44	9.00	4.00	2588226.86	875437.80	103.93
Treat. (B)	5	66.49	17.36	34.51	8.98	279.78	11.04	15.91	1277456.80	260642.54	61.01
Inter. (AXB)	5	11.16	9.49	15.93	12.13	447.38	19.80	7.87	2864126.68	279336.79	291.98
Error	22	13.33	21.23	6.50	4.39	219.86	14.05	18.05	1331778.98	170510.21	86.47

Biochemical analysis

Mean sum of square							
Source of variance	**DF**	**Nitrogen**	**Protein**	**Carbohydrate**	**Proline**	**Fiber**	**Fat**
Replication	2	0.08	3.09	46.54	0.039	3.97	46.58
Var. (A)	1	0.32	13.08	0.28	0.032	0.13	34.02
Treat. (B)	5	0.09	3.36	27.98	0.013	16.09	15.51
Inter. (AXB)	5	0.04	1.74	12.15	0.001	0.72	3.16
Error	22	0.14	5.38	24.70	0.025	15.09	12.37

Mean sum of square								
Source of variance	**DF**	**Potassium**	**Calcium**	**Sodium**	**Copper**	**Zinc**	**Iron**	**Manganese**
Replication	2	2847.59	616.03	2.89	0.55	0.56	0.86	0.74
Var. (A)	1	121940.60	14452.04	1.00	0.00	1.00	5.92	0.17
Treat. (B)	5	12658.21	430.22	1.84	0.14	1.60	0.83	0.32
Inter. (AXB)	5	19855.89	481.72	0.23	0.05	0.44	0.39	0.28
Error	22	5231.61	457.27	0.51	0.09	0.29	0.50	0.31

CURRICULAM VITAE

Name of the author **- Rahul Raghuwanshi**
Place – Vill + Post **- Pindraikala,**
Dist. **- Chhindwara 480001 (MP)**
Date of Birth **- 16th April 1991**

The author of this thesis Mr. Rahul Raghuwanshi, S/o Shri Bodh Singh and Sau. Kantee was born on 16th April 1991 at Chhindwara (MP). He has joined the following institutions and successfully completed the degree of M.Sc. (Ag.) during the year 2016-17 with 7.00 OGPA with 10 point scale.

S. No.	Institutions
1	JNKVV, Jabalpur (MP)
2	RVSKVV, Mandsaur (MP)
3	Higher Secondary School, M.P. Board (MP)
4	High School, M.P Board (MP)

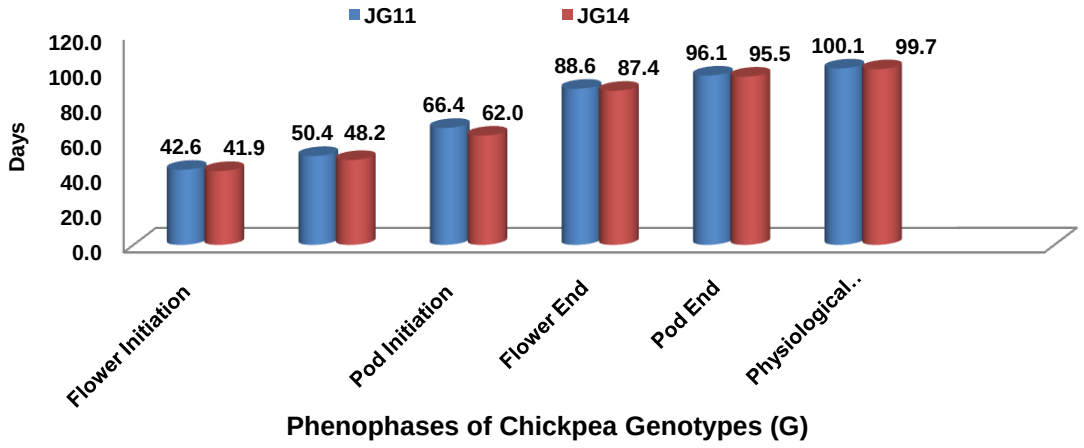
He has got the following degrees,

S. No.	Degrees granted	University/Board	Year
1	M.Sc. (Ag.)	JNKVV, Jabalpur, (MP)	2017
2	B.Sc. (Hort.)	RVSKVV, Gwalior, (MP)	2015
3	12th	S.M.S.H.S.S, Chhindwara, (MP)	2009
4	10th	Shri ram high school Chand, (MP)	2007

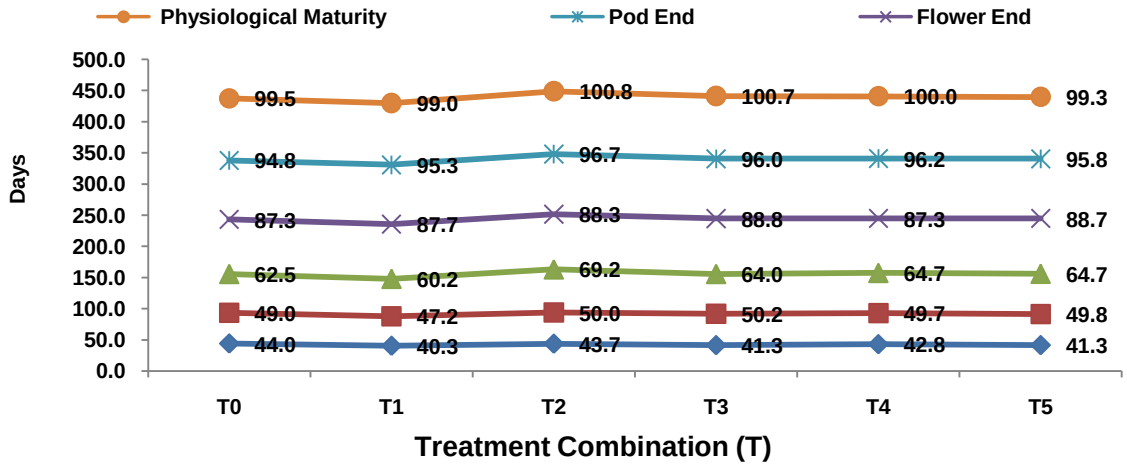
He has following scientific interests-
Scientific interests
Research Works on "Adaptation of physiological and biochemical strategies for identification of climate-resilient chickpea genotypes under unpredictable environment**"**

He has gained the following award

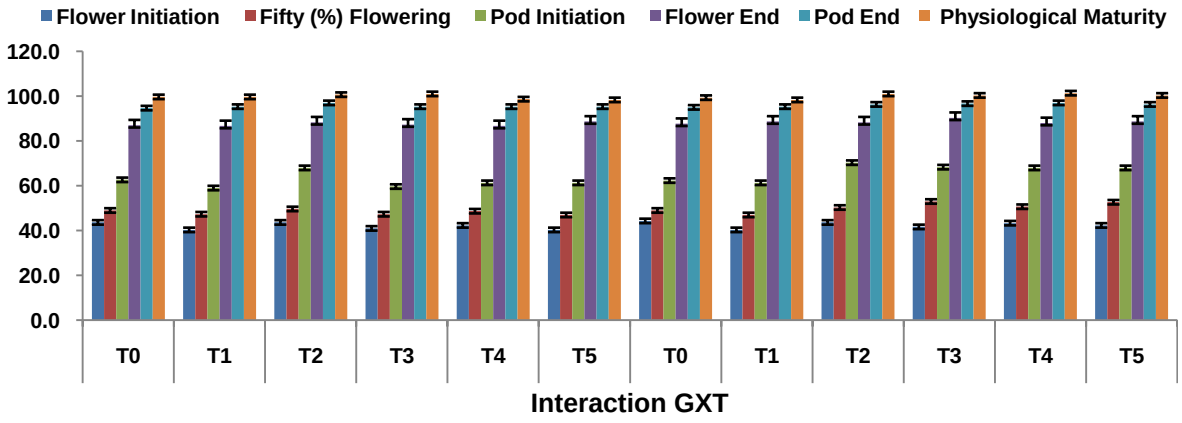
For the partial fulfilment of the master's degree programmes he was allotted a research problem on **"Response of Foliar Application of Water Salicylic Acid and Nutrient on Physiology of Chickpea Genotypes Growth and Productivity under Rainfed and Irrigated Late Sown Condition"** which was successfully conducted by him and being submitted in the form of the thesis.



(a)

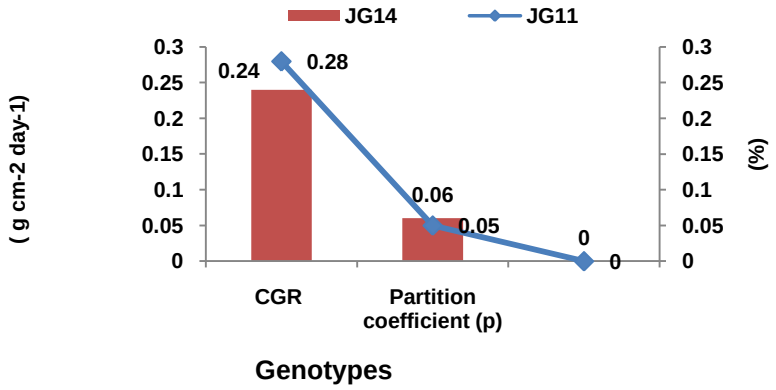


(b)

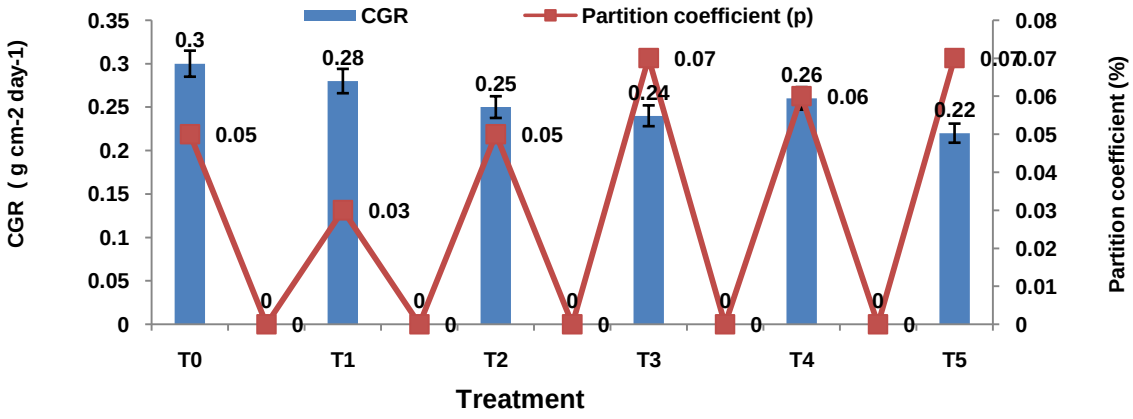


(c)

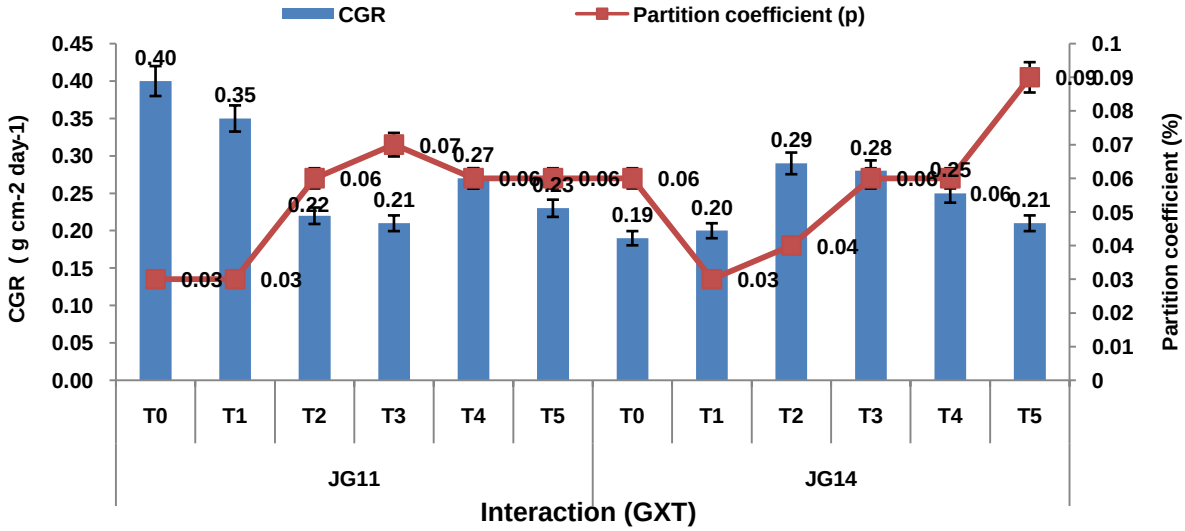
Figure No. 3: Responses of foliar application of water salicylic acid nutrient composition on Chickpea phenology.



(a)

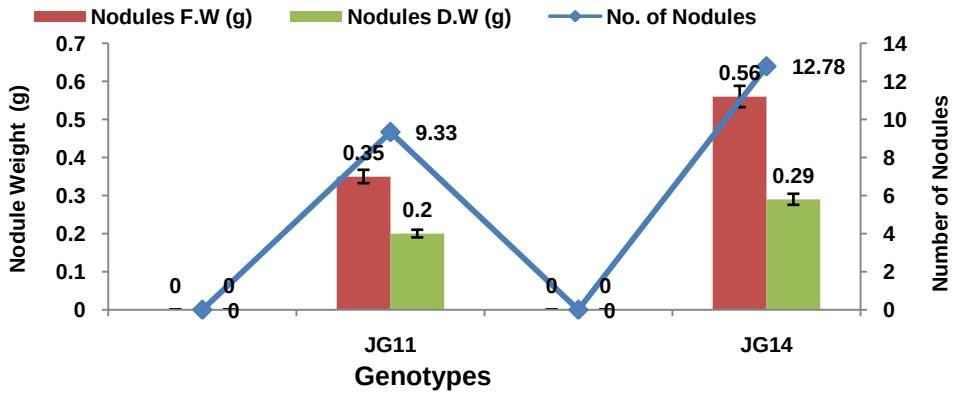


(b)

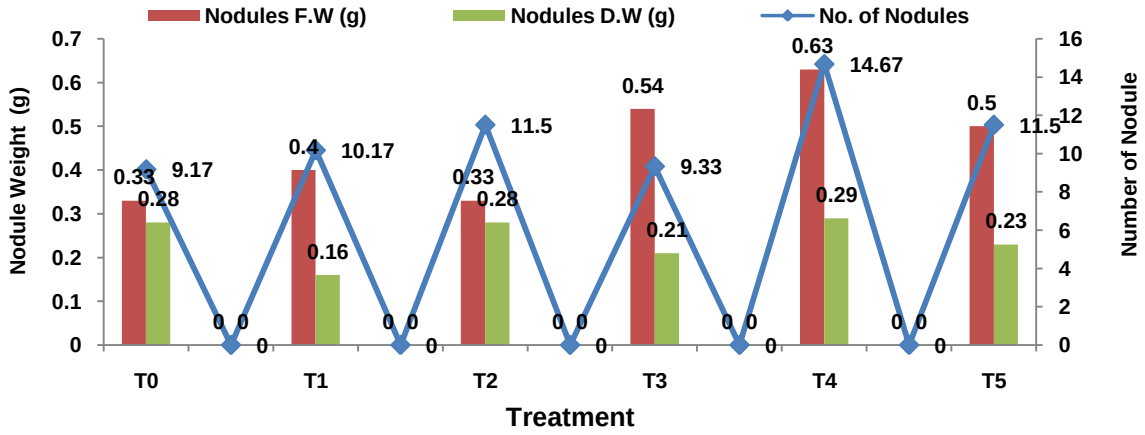


(c)

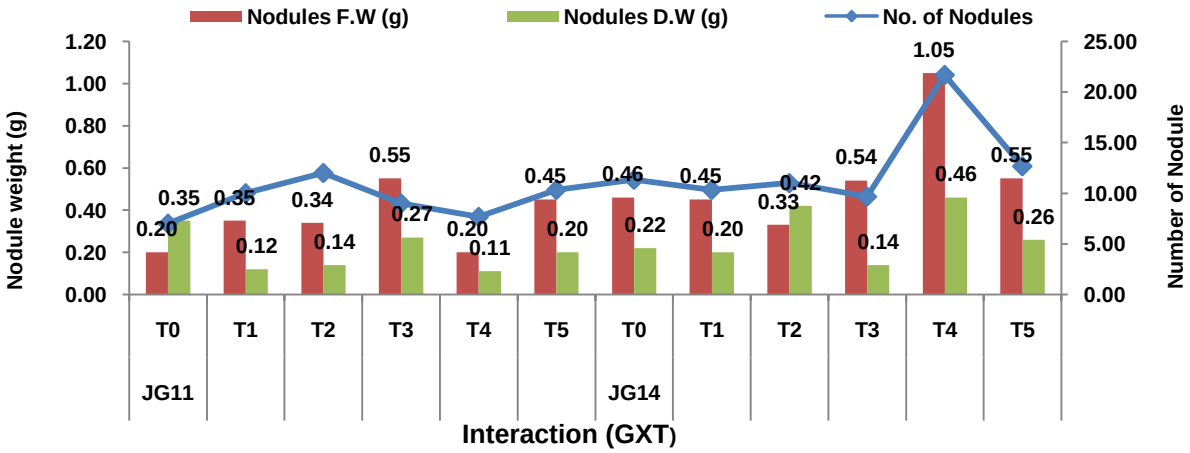
Figure No. 4: Effect of foliar application of water salicylic acid nutrient composition on crop growth rate (CGR) and partitioning coefficient (p) of chickpea genotypes.



(a)

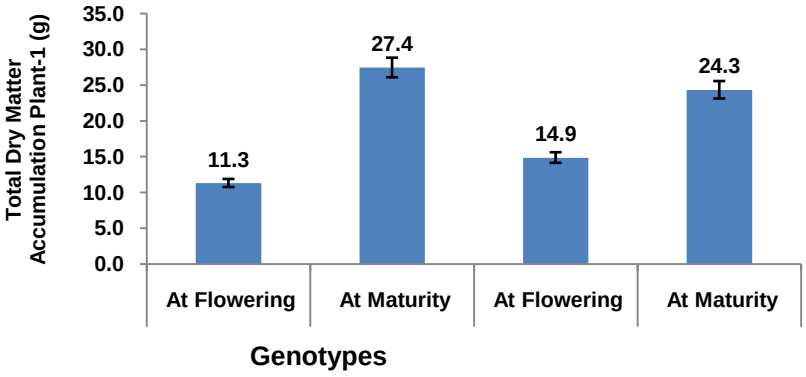


(b)

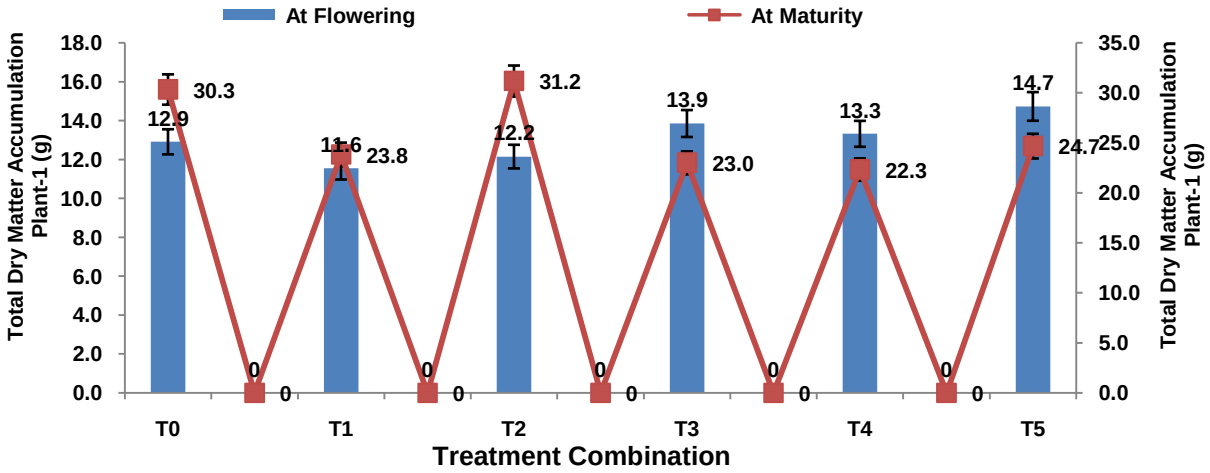


(c)

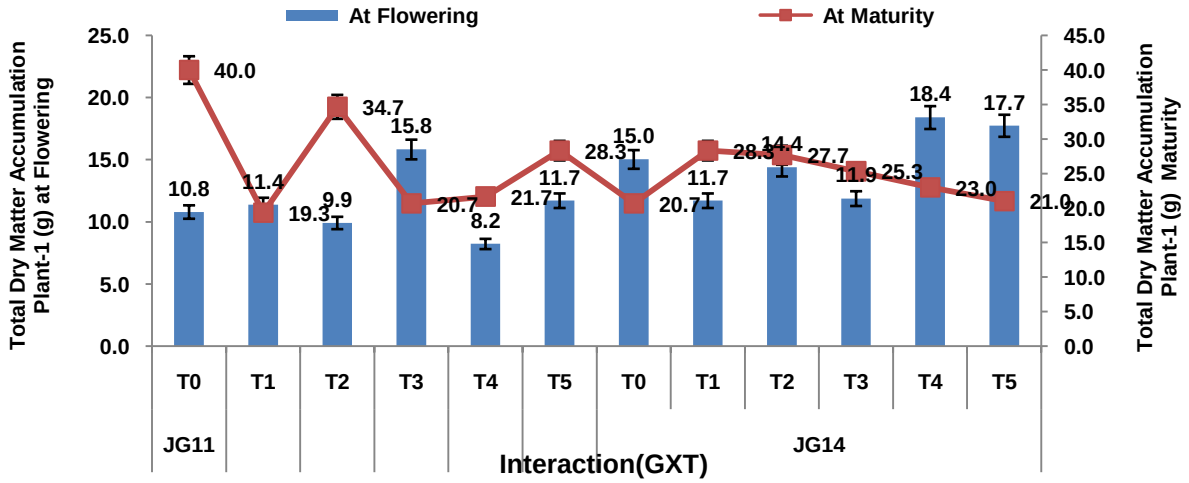
Figure No. 5: Effect of foliar application of water salicylic acid and nutrient composition on nodules fresh weight, nodules dry weight and number of nodule plant^{-1} of chickpea genotypes.



(a)

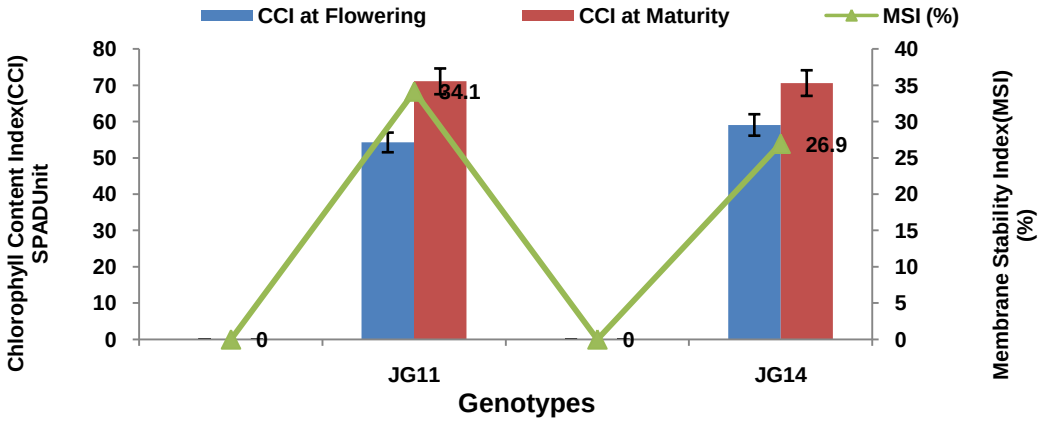


(b)

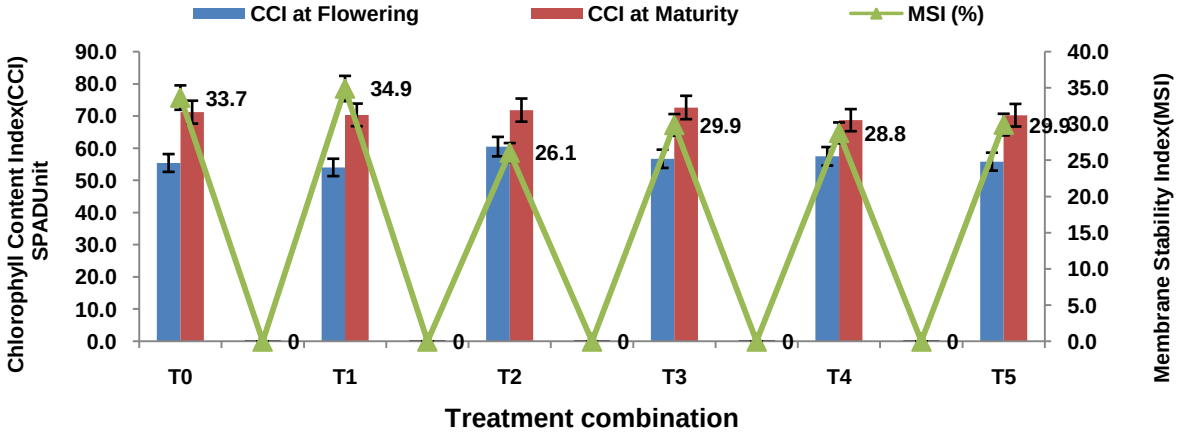


(c)

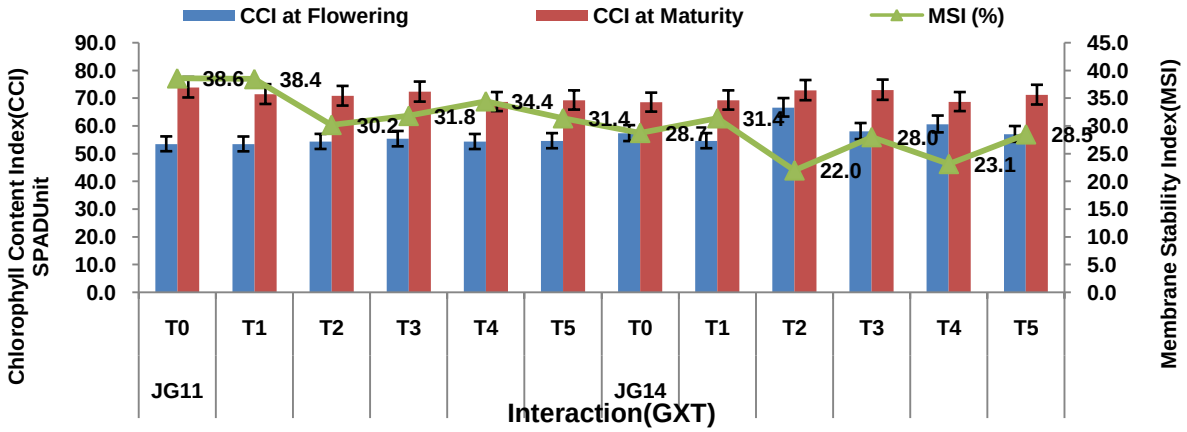
Figure No. 6: Effect of foliar application of water salicylic acid and nutrient composition on chickpea genotypes in total dry matter accumulation plant^{-1} at flowering and maturity stage.



(a)

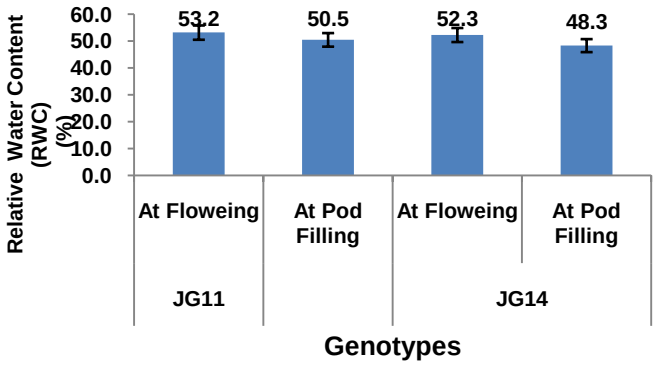


(b)

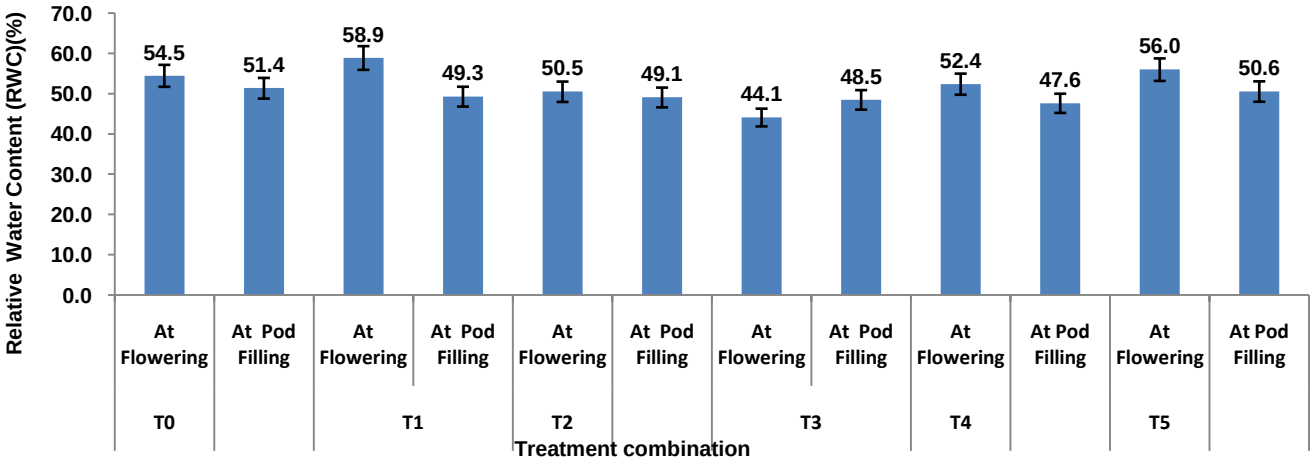


(c)

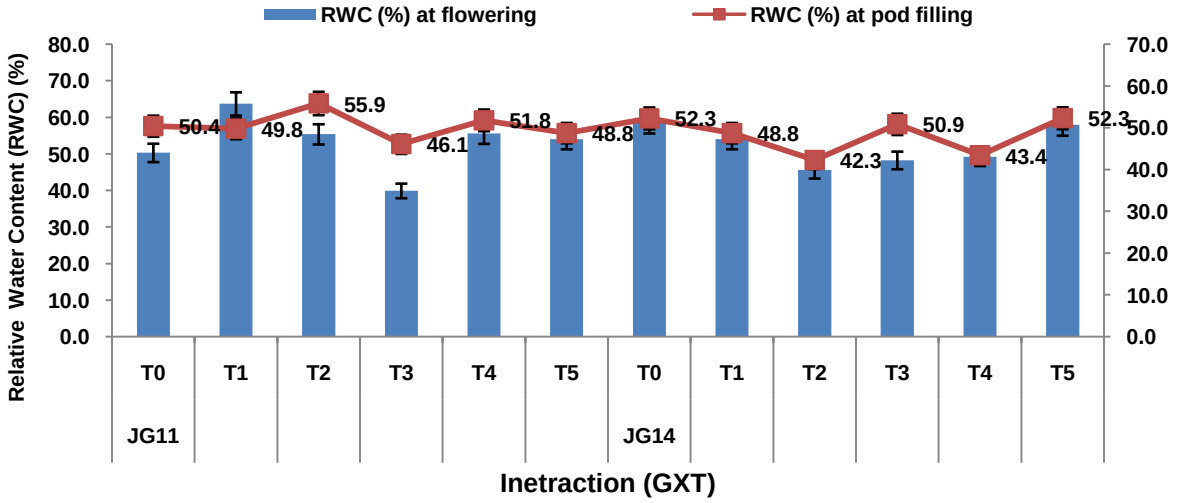
Figure No. 7: Effect of foliar application of water, salicylic acid and nutrient composition on chickpea genotypes chlorophyll content index (CCI) at flowering and pod filling stage and Membranes stability index (MSI) at pod filling stage.



(a)

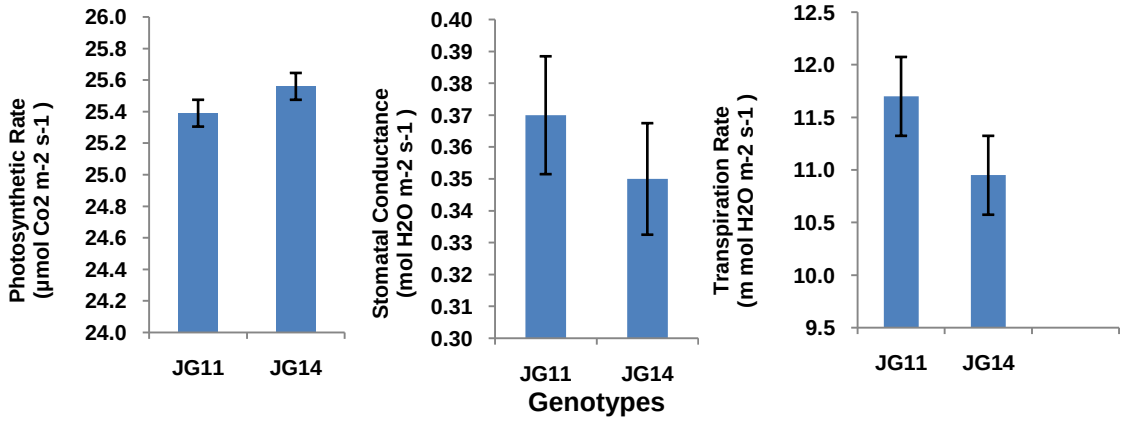


(b)

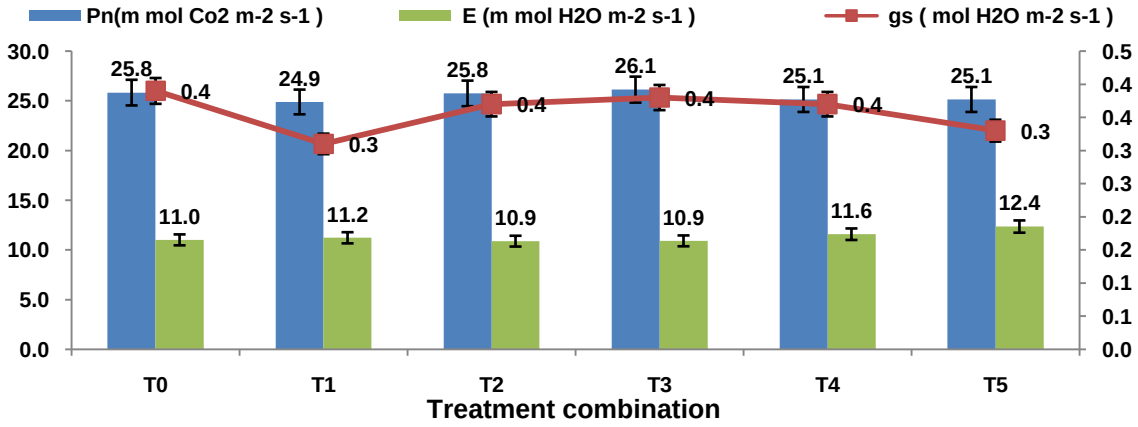


(c)

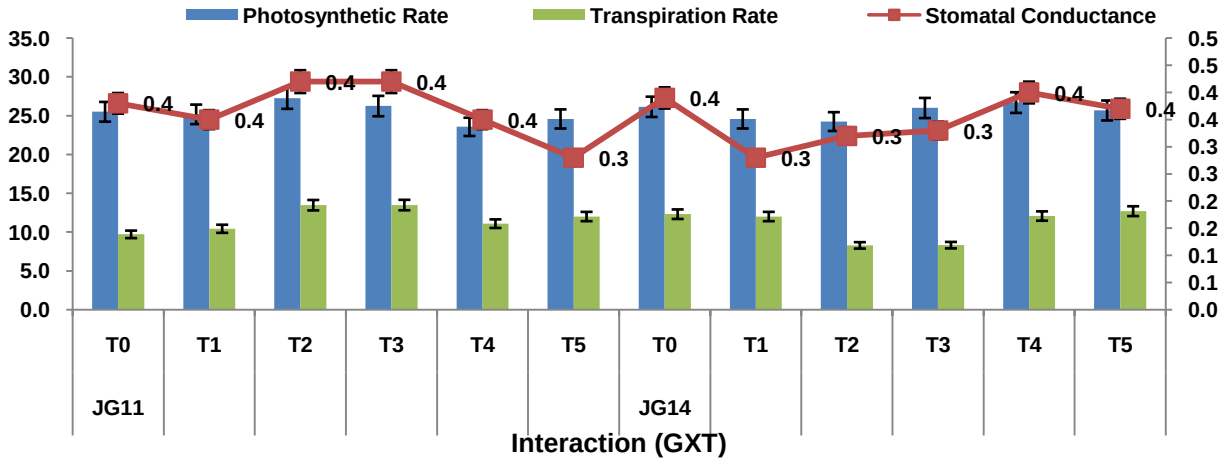
Figure No. 8: Effect of foliar application of water, salicylic acid and nutrient composition on leaves relative water content (RWC) at flowering and pod filling stage in chickpea genotypes.



(a)

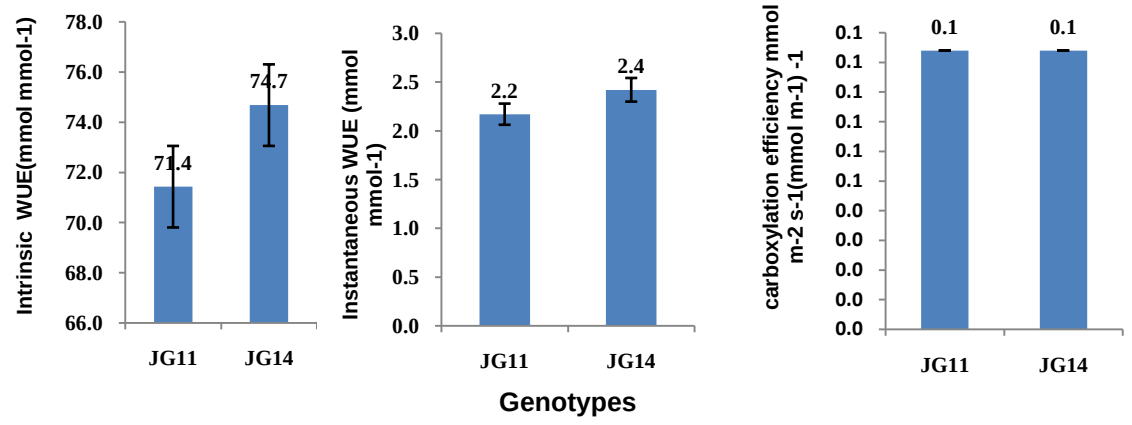


(b)

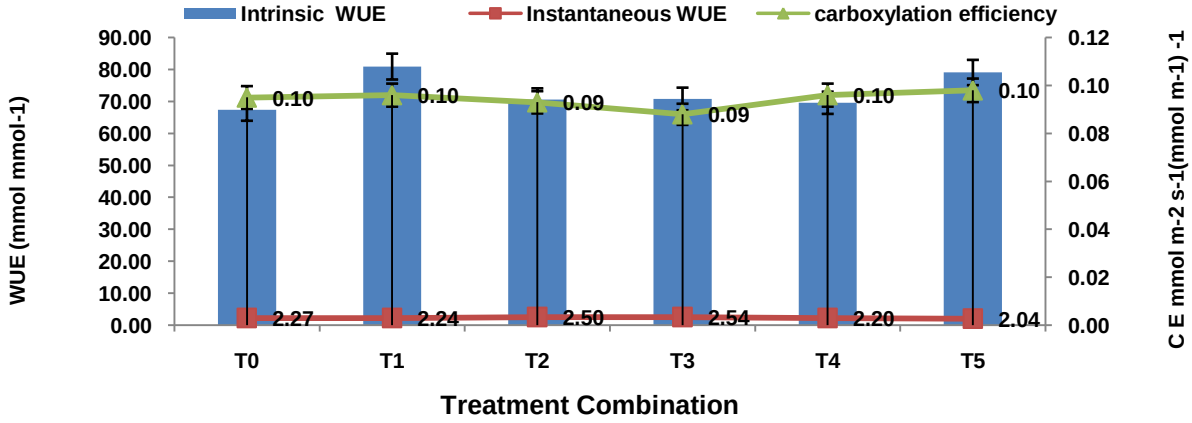


(c)

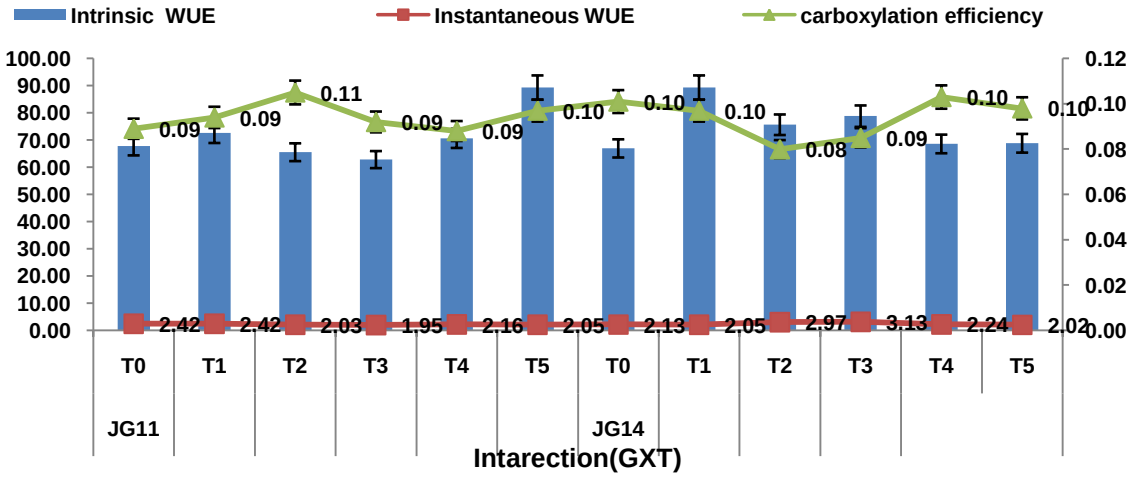
Figure No. 9: Effect of foliar application of water, salicylic acid and nutrient composition on photosynthesis (Pn), transpiration (E) and stomatal conductance (gs) of chickpea genotypes.



(a)

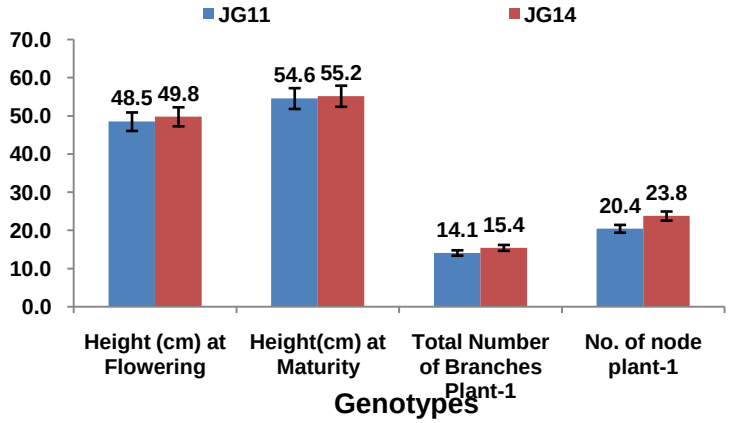


(b)

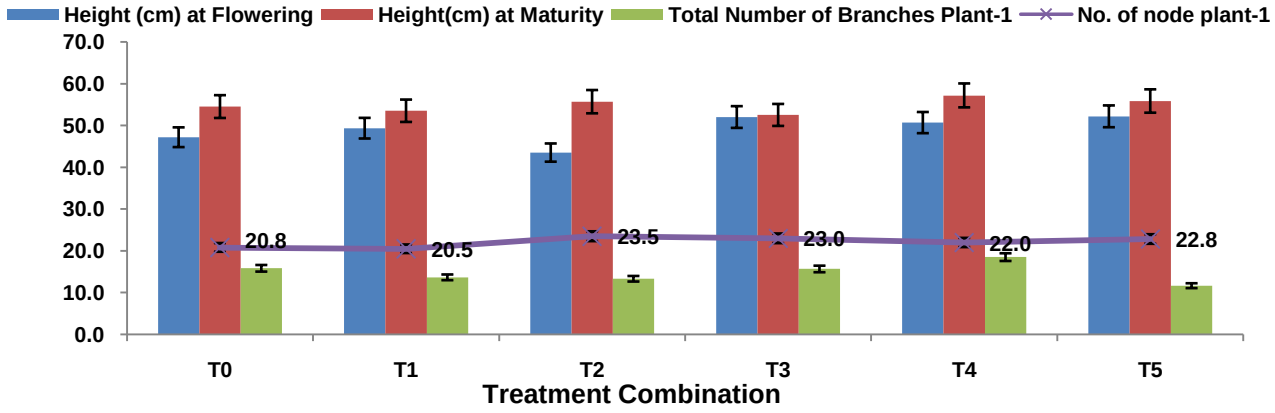


(c)

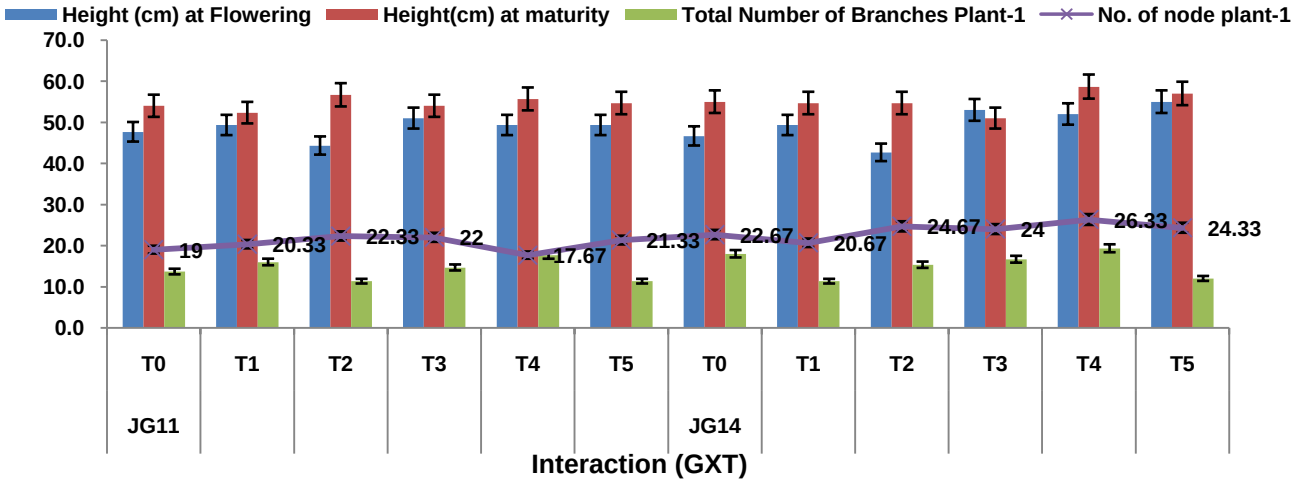
Figure No. 10: Effect of foliar application of water, salicylic acid and nutrient composition on intrinsic and instantaneous WUE and carboxylation efficiency (CE) of chickpea genotypes.



(a)

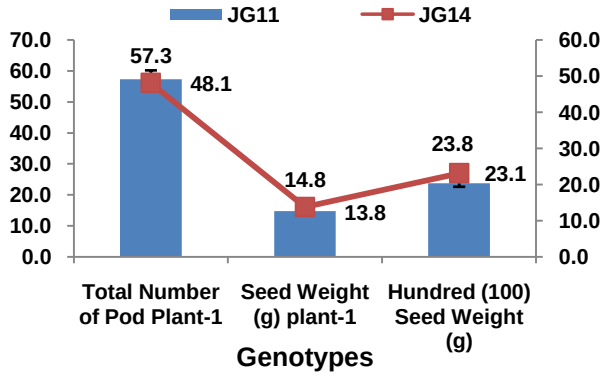


(b)

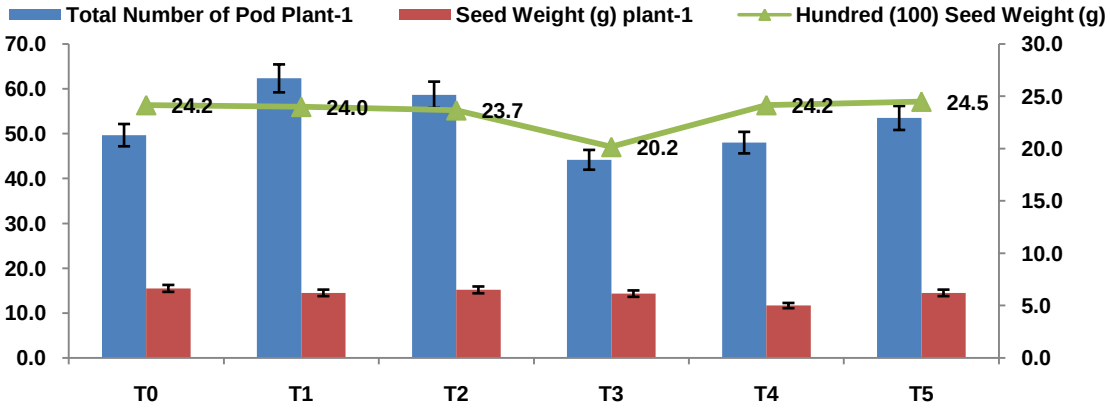


(c)

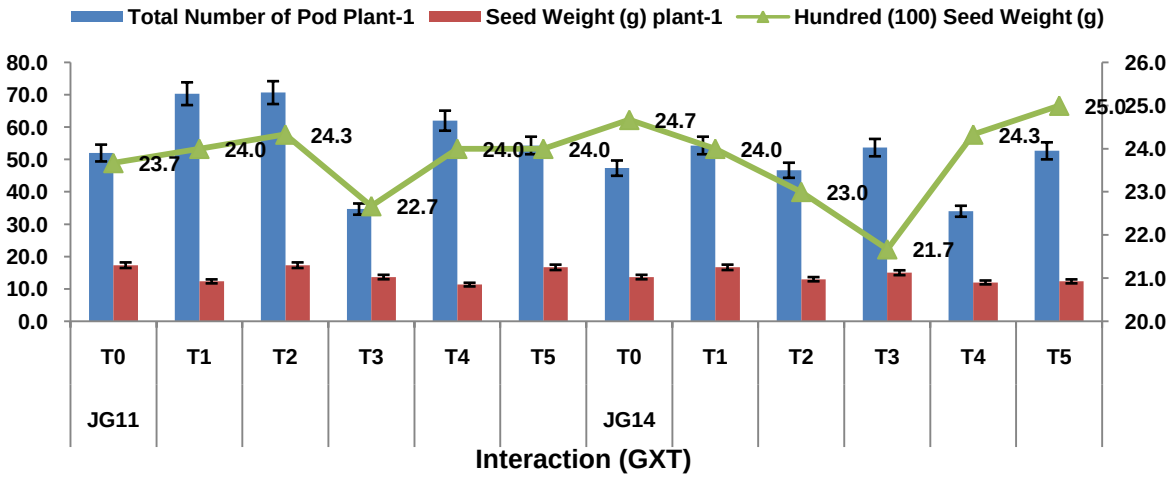
Figure No. 11: Effect of foliar application of water, salicylic acid and nutrient composition on height at flowering and maturity, total number of branches and number of node of chickpea genotypes.



(a)

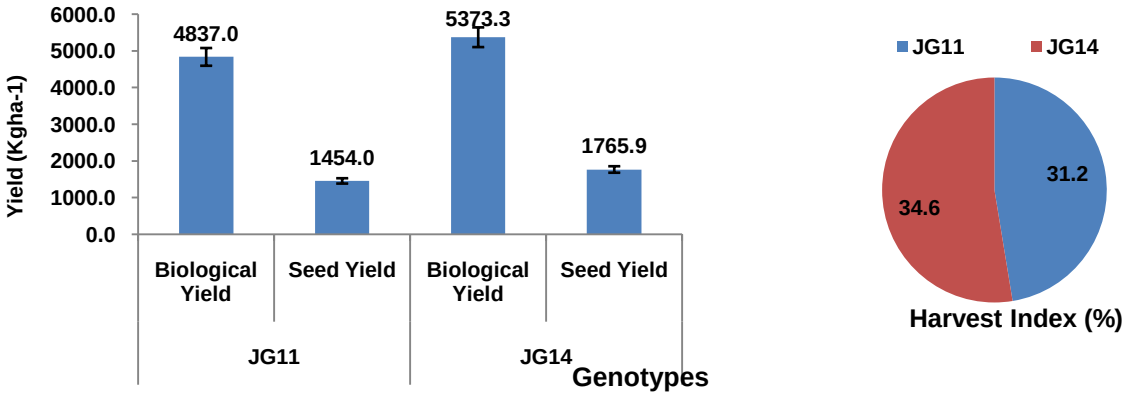


(b)

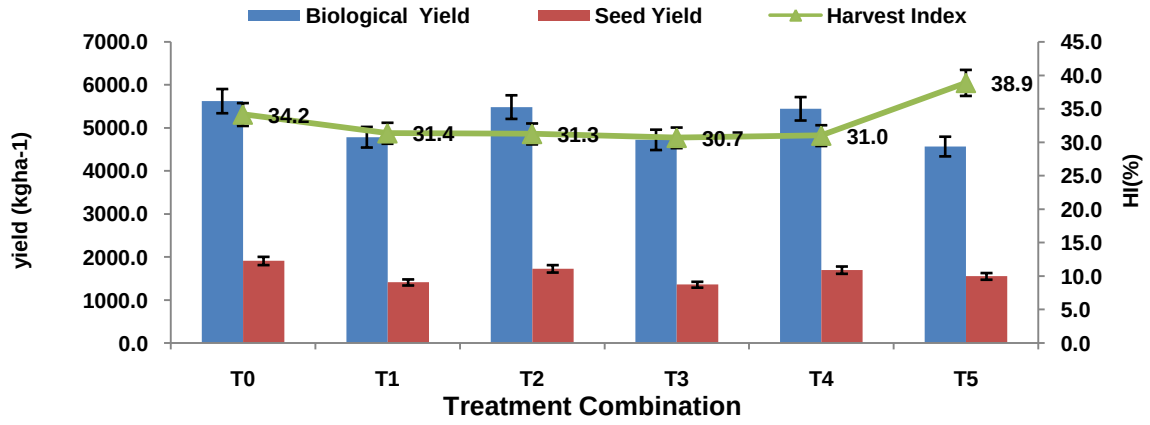


(c)

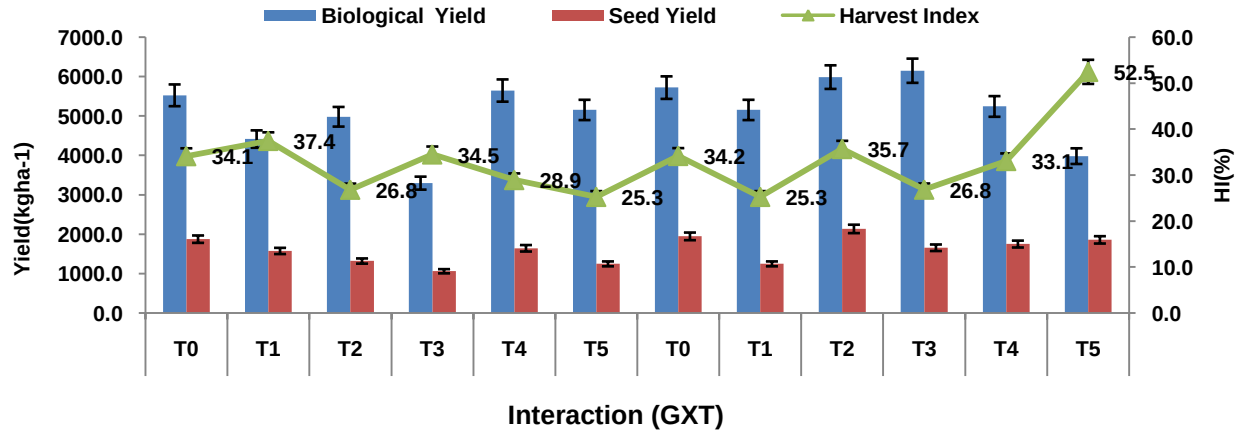
Figure No. 12: Effect of foliar application of water, salicylic acid and nutrient composition on total number of pod plant^{-1}, seed weight plant^{-1} and hundred seed weight of chickpea genotypes.



(a)

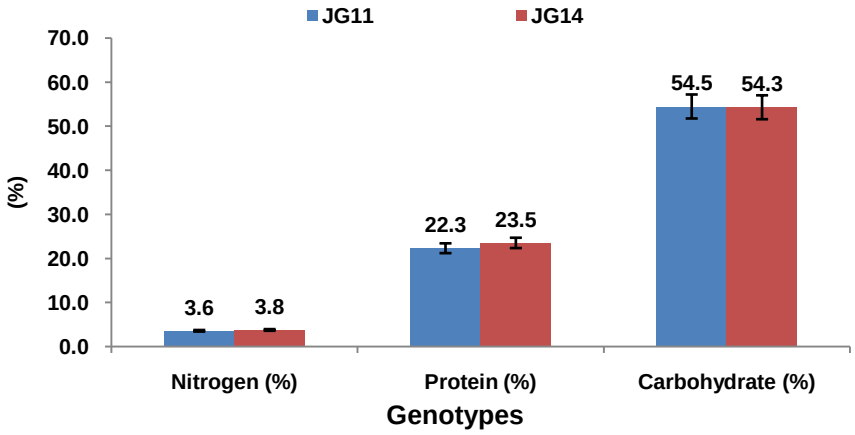


(b)

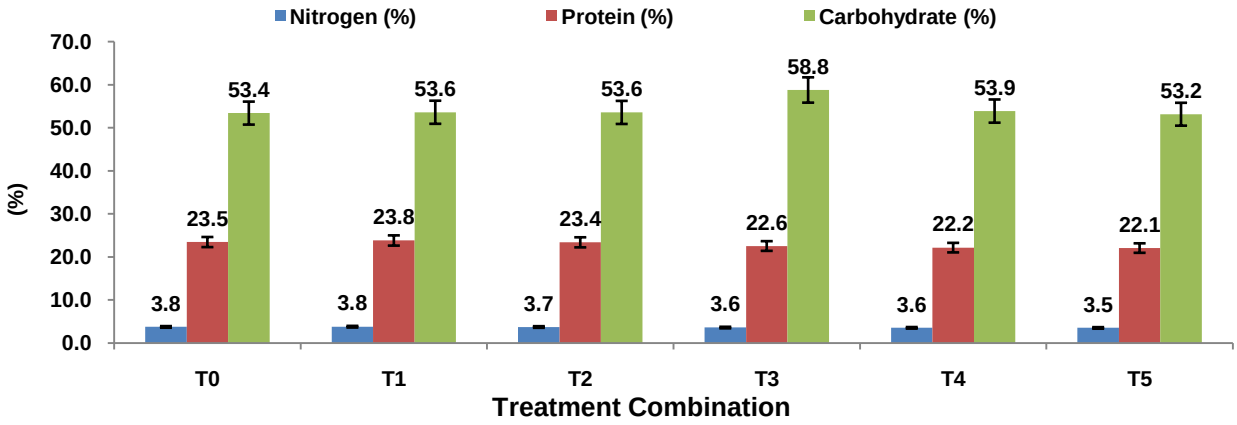


(c)

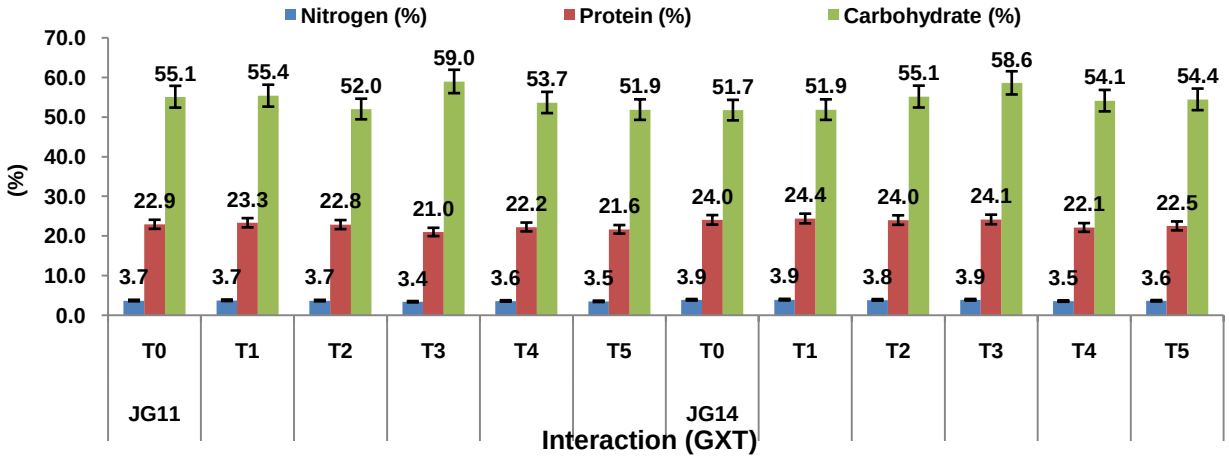
Figure No. 13: Effect of foliar application of water salicylic acid and nutrient composition on biological yield, seed yield and harvest index of chickpea genotypes.



(a)

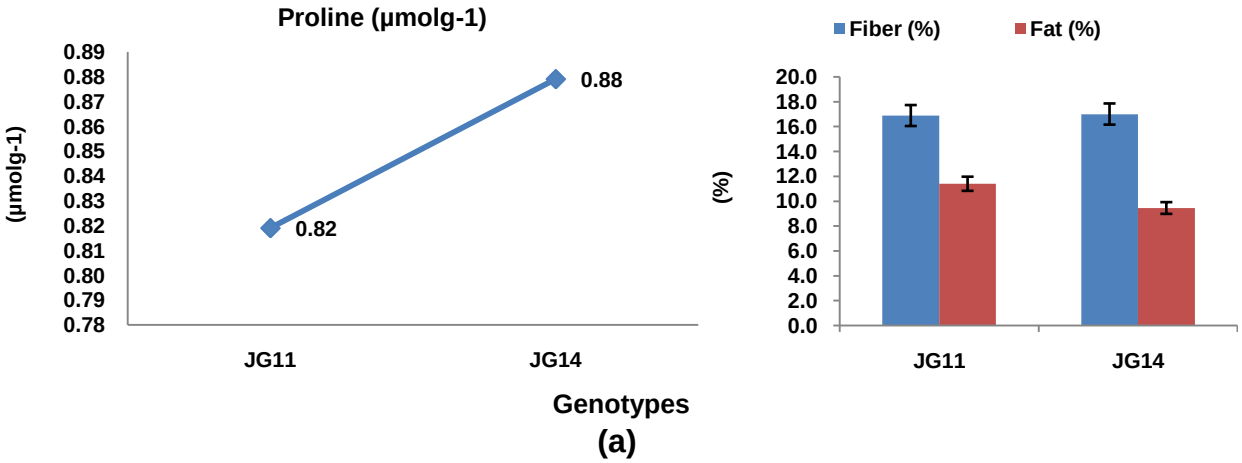


(b)

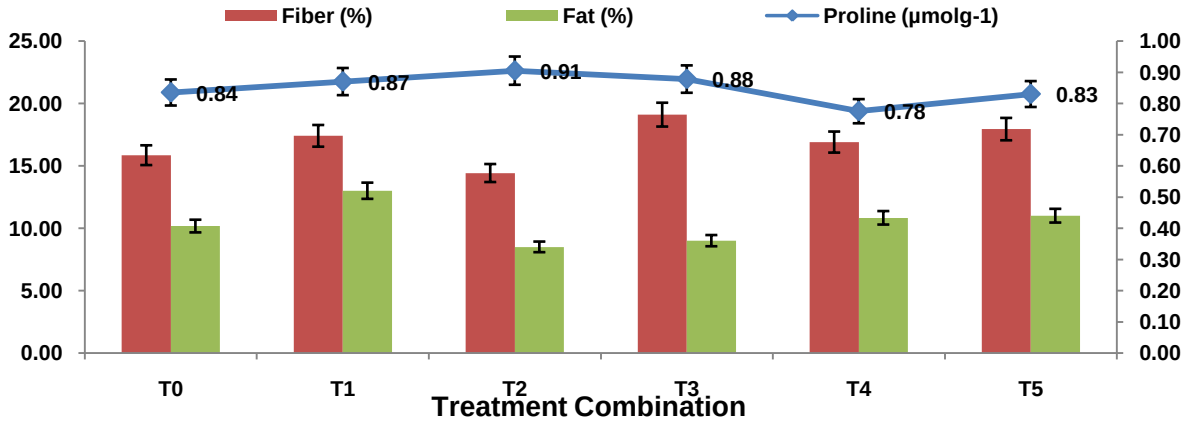


(c)

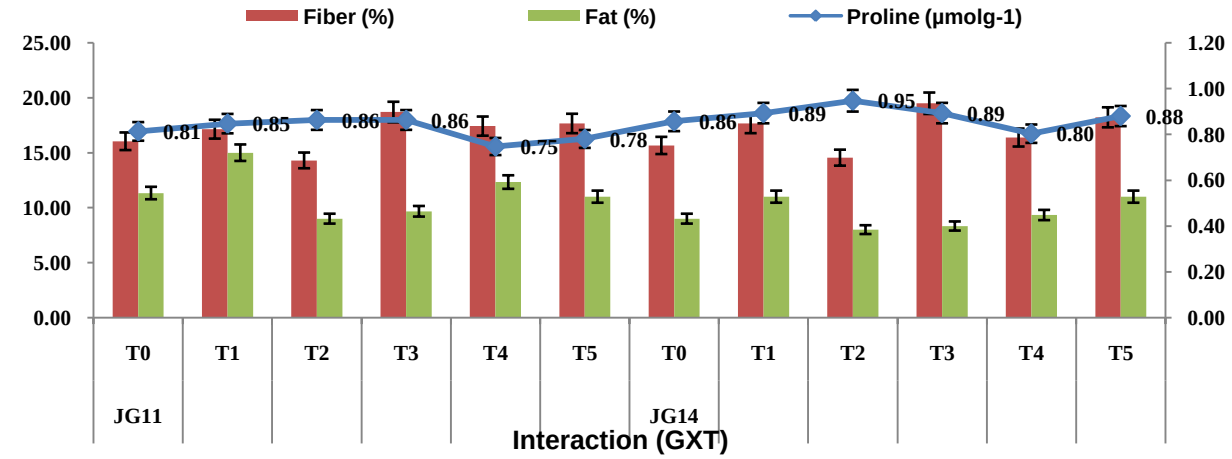
Figure No. 14: Effect of foliar application of water, salicylic acid and nutrient composition on nitrogen, protein and carbohydrate content in chickpea seeds.



(a)

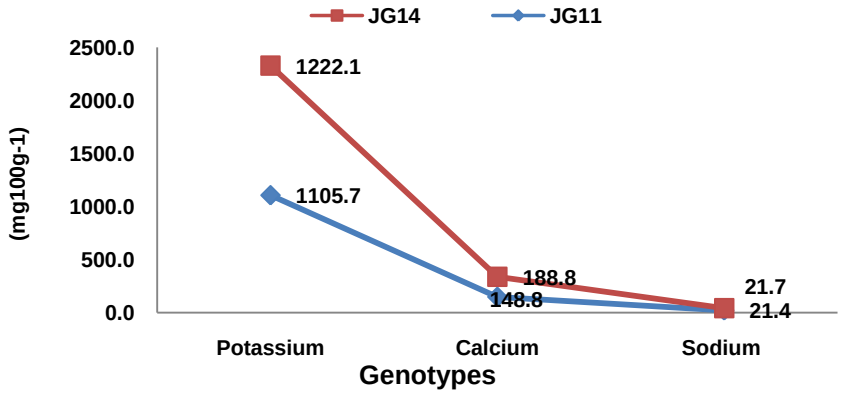


(b)

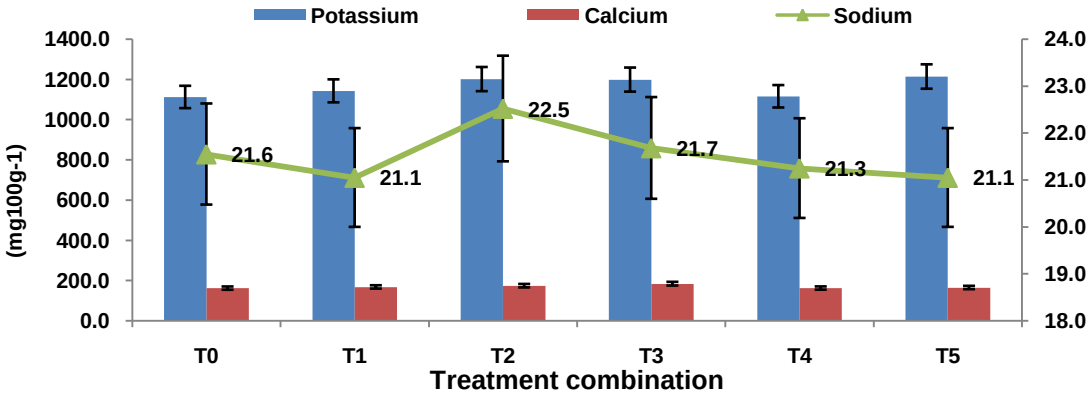


(c)

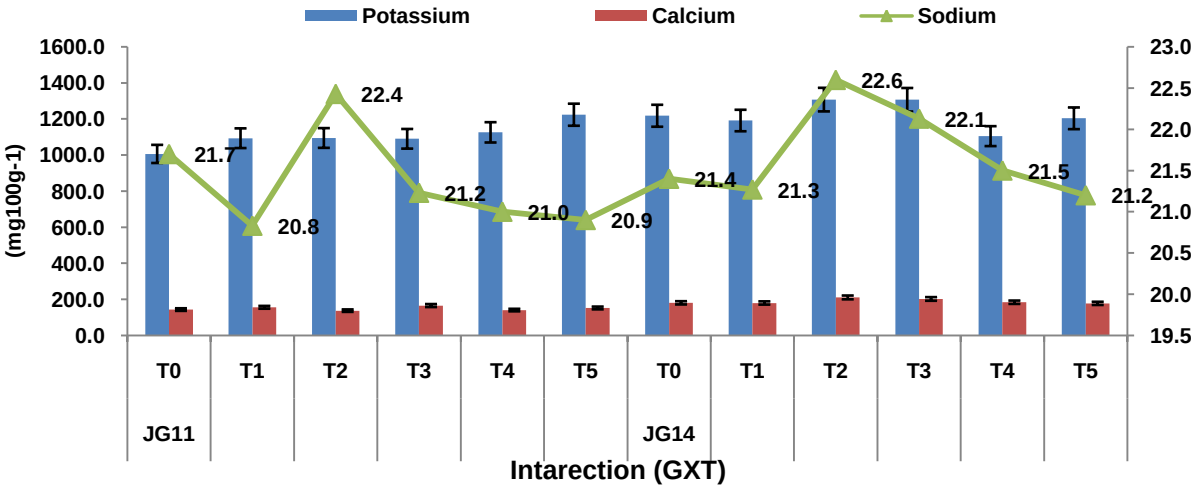
Figure No. 15: Effect of foliar application of water, salicylic acid and nutrient composition on proline, fiber, and fat level in chickpea seeds.



(a)

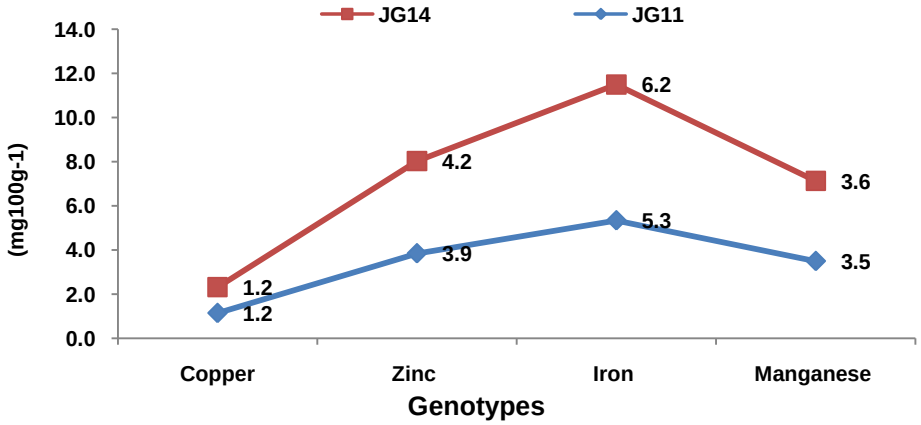


(b)

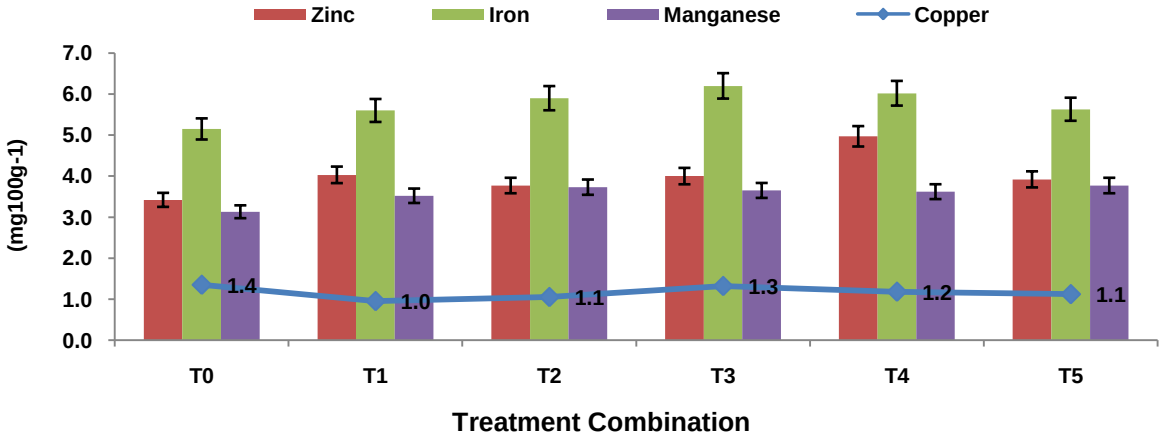


(c)

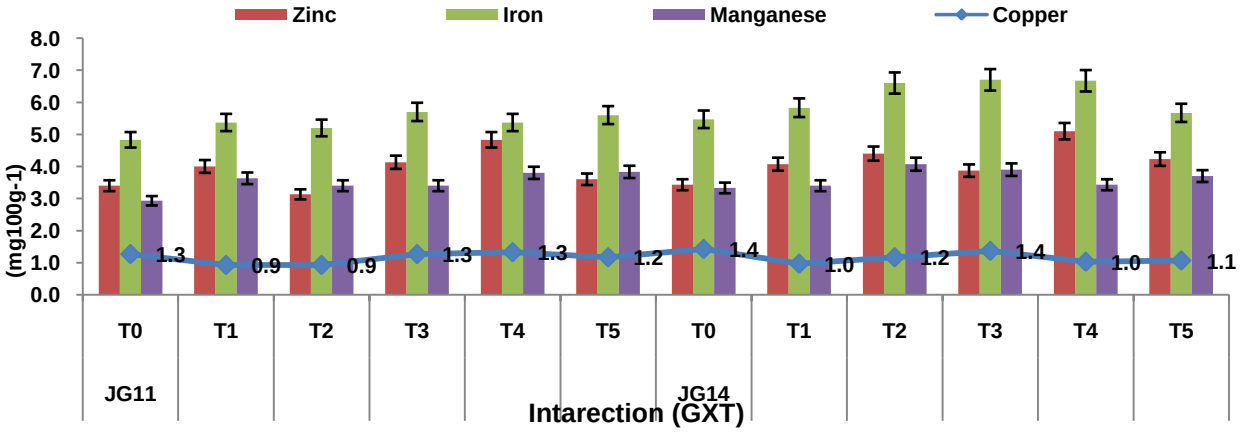
Figure No. 16: Effect of foliar application of water, salicylic acid and nutrient composition on potassium, calcium and sodium content in chickpea seeds.



(a)



(b)



(c)

Figure No. 17: Effect of foliar application of water, salicylic acid and nutrient composition on zinc, iron, manganese, and copper content in chickpea seed.