RESPONSES OF GREEN GRAM (*Vigna radiata* L.) TO DIFFERENT PRIMING TREATMENTS ON GERMINATION, GROWTH AND YIELD

A THESIS SUBMITTED TO
SARDARKRUSHINAGAR DANTIWADA AGRICULTURAL UNIVERSITY
IN PARTIAL FULFILMENT OF THE REQUIREMENTS
FOR THE AWARD OF THE DEGREE

OF

MASTER OF SCIENCE
(Agriculture)

IN

SEED SCIENCE AND TECHNOLOGY

BY

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SEPTEMBER – 2022

[Reg. No. 04-AGRMA-02200-2020]

ABSTRACT

Responses of Green gram (*Vigna radiata* L.) to different priming treatments on germination, growth and yield

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ABSTRACT

Green gram (*Vigna radiata* L.) is a member of the *Leguminaceae* family, which is a self-pollinated crop. It is the third most important pulse crop next to chick pea and pigeon pea. It is also known as golden gram and mung. Mung bean is a warm season annual and short duration crop. It is an economically important legume which having character relatively more palatable, nutritive, easily digestible than other pulses with excellent source of high quality protein.

The present investigation entitled “Responses of Green gram (*Vigna radiata* L.) to different priming treatments on germination, growth and yield” was carried out during kharif 2021. The investigation was conducted in two parts: (1) Germination and its related parameters conducted in laboratory (2) Study on the effect of seed priming on yield and its attributing traits conducted at Agronomy Instructional Farm, Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar. The Laboratory experiment was conducted at Seed Science and Technology Laboratory, S. D. Agricultural University, Sardarkrushinagar during kharif 2021. Recorded data analysed by using Factorial Completely Randomized Design (FCRD) and Factorial Randomized Block Design (FRBD) in lab and field condition, respectively with three replications of two varieties *i.e.* GM-4 and GM-6 with fourteen seed priming treatments viz., control (T_1), hydro priming (T_2), GA_3 (5.0 ppm) (T_3), GA_3 (7.5 ppm) (T_4), GA_3 (10.0 ppm) (T_5), Salicylic acid (50 ppm) (T_6), Salicylic acid (100 ppm) (T_7), Salicylic acid (150 ppm) (T_8), PEG 6000 (2.5%) (T_9), PEG 6000 (5.0%) (T_{10}), PEG 6000 (7.5%) (T_{11}), KH_2PO_4 (0.5%) (T_{12}), KH_2PO_4 (1.0%) (T_{13}) and KH_2PO_4 (1.5%) (T_{14}) for 1 hrs. The seed priming treatments were given before sowing of seeds.

The perusal of the data under laboratory conditions showed that for variety GM-4 observed higher root length (6.58 cm), shoot length (9.77 cm), seedling length (16.35 cm), root dry weight (7.88 mg) and vigour index-I (1532.20) while, GM-6 recorded higher value of germination percentage (97.33%), shoot dry weight (24.05 mg), seedling fresh weight (373.26 mg), seedling dry weight (31.71 mg) and vigour index II (2969.41). In case of coefficient velocity of germination (97.45) recorded higher value in control. Seed primed with 7.5 % PEG-6000 obtained greater value in germination percentage (97.00%), root length (6.67 cm), shoot length (10.77 cm), seedling length (17.43 cm), root dry weight (9.10 mg), shoot dry weight (26.53 mg), seedling fresh weight (424.77 mg), seedling dry weight (35.63 mg), vigour index I (1690.60) and vigour index II (3457.20).

In field condition, variety GM-6 reported not only maximum value of field emergence (90.50%) but also took minimum days to 50% flowering (32.00 days) in case of number of pod per plant (25.51), plant height (57.98 cm), pod length (9.00 cm), 100 seed weight (4.43 g), seed yield per plant (15.26 g), seed yield per ha. (1033.92 kg) and biological yield per ha. (2736.91 kg) observed higher with variety GM-6 as compare to variety GM-4.

It was observed from the investigation that treatment 7.5% PEG-6000 recorded superior value for germination and its related parameter *i.e.* germination percentage, shoot length (cm), root length (cm), seedling length (cm), root dry weight (mg), shoot dry weight (mg), seedling fresh weight (mg), seedling dry weight (mg), vigour index-I and vigour index-II except coefficient velocity of germination in control. Again it was noted that higher value for yield and yield attributes i.e. field emergence (%), days taken to 50% flowering, number of pod per plant, number of seed per pod, pod length (cm), days to maturity, plant height at maturity (cm), number of primary branch per plant, hundred seed weight (g), seed yield per plant (g), seed yield per hectare (kg), biological yield per hectare (kg) and harvest index (HI) over to rest of all other treatments.

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CERTIFICATE – I

Date:15 /09/2022

This is to certify that the thesis entitled, "**RESPONSES OF GREEN GRAM (*Vigna radiata* L.) TO DIFFERENT PRIMING TREATMENTS ON GERMINATION, GROWTH AND YIELD"** submitted for the degree of **MASTER OF SCIENCE** in the subject of **SEED SCIENCE AND TECHNOLOGY** is a record of bonafide research work carried out by **BHANKHAR PRATIK D.** under my guidance and supervision and that no part of this thesis has been submitted for any other degree, diploma, associateship, fellowship or other similar titles. The assistance and help received during the course of investigation have been fully acknowledged.

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ACKNOWLEDGEMENT

With soul searching memories .....

Acknowledgement is written at last, placed at first and read the least, but still it is the only opportunity to thank one and all who are responsible in completion of this work. This memorable occasion provides me an unique privilege to express my deep sense of gratitude and indebtedness to my honourable Major Advisor **Dr. H. S. Bhadauria,** Associate professor, Department of Genetics and plant breeding, C. P. College of Agriculture, S. D. Agricultural University, Sardarkrushinagar for his valuable guidance, encouragement, constructive criticism, ever willing help and sustained interest right from the selection of my research problem up to the final shaping of the thesis in the present form as well as for his keen interest in the preparation of this manuscript.

I am very grateful to the members of my Advisory Committee, **Dr. S. D. Solanki**, Professor and Head, Department of Genetics and plant breeding, C. P. College of Agriculture, S. D. Agricultural University, Sardarkrushinagar, **Dr. N. V. Soni,** Assistant Professor, Department of Genetics and plant breeding, C. P. College of Agriculture, S. D. Agricultural University, Sardarkrushinagar, **Dr. A. K. Singh**, Assistant Research Scientist, Bio Science Research Center, S. D. Agricultural University, Sardarkrushinagar, for their constant encouragement during the tenure of this study.

I convey my deep sense of gratitude to the **Dr. R. M. Chauhan**, Hon'ble Vice Chancellor, Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar, **Dr. C. M. Murlidharan**, Director of Research and Dean, Post-Graduate Studies, Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar and **Dr. S. D. Solanki**, Principal and Dean, Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar for providing facilities and also feel much obliged to him for his co-operation and help in all respects throughout the study.

I express my sincere thanks also to **Dr. S. D. Solanki**, Professor and Head, Department of Genetics and plant breeding, C. P. College of Agriculture, S. D. Agricultural University, Sardarkrushinagar for his valuable comments and helpful suggestions during the course of this investigation.

I have also treasured immense assistance and incomparable affection from **Dr. N. B. Patel**, **Dr. P. R. Patel, Dr P. C. Patel, Dr Y. A. Viradiya, Dr. H. N. Zala** and all other staff members of the Department of Genetics and plant breeding, C. P. College of Agriculture, S. D. Agricultural University, Sardarkrushinagar

It is my profound privilege and pleasure to express my heartfelt gratitude towards **Dr. J. R. Patel** and **Shree Ankitbhai, Shree Sunilbhai, Shree Popatkaka** and **Shree Narsinhbhai** along with the other staff members of Agronomy Instructional farm, C. P. College of Agriculture, Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar for benevolent help, valuable advice and co-operation during my study period.

I am really grateful to my friends and I have long list of my dear friends. I wish to convey my special thanks to my best friend **Tarang, Rudra, Parth, Akhil, Bapu, Hiren, Mayank, Mayur, Ankit, Bhargav, Saurav, Milan, Meet, Jay, Krinish, Ravi, Princi, Anjali, Vaibhavi** for fully support and kind co-operation during the course of my study and also encouraged me in a number of ways and provide excellent company throughout my postgraduate curriculum. Special thanks to my seniors **Ajaybhai, Pratikbhai, Bhavyabhai, Charlibhai, Shyambhai, Hinsubhai, Hardikbhai and Jasminbhai** for their continuous and generous help rendered during my research work and for their timely help. It's my fortune to gratefully acknowledge the help of my juniors **Kishan, Kaushik, Darshan, Dhaval, Jimit, Parth, Dishan, Pinkesh.**

I am equally thankful to **Shri Aminbhai,** Senior Clerk (P.G.) for ever willing co-operation during my post-graduation.

Mr. Pratik Thakar deserves very special mention her hard work during nice computer settings of this dissertation.

Diction is not enough to express my gratitude my adorable father **"Shri Dhirajlal"** and Mother **"Smt. Manjulaben"** whose selfless love, filial affection, constant encouragement, obstinate sacrifices, sincere prayer, expectations and blessing have always been vital source of inspiration in my life. No words in this mortal world can suffice to express my feelings, high appreciation and thanks towards my beloved Dada **"Shri Nathabhai,"** Dadi **"Smt. Shantaben,"** Uncle **"Shri Parshtombhai, Shantilal"** Aunty **"Smt. Prafulaben, Daxaben"** my brothers **Milap, Vikas and Sid** and my sisters **Bhavishaben, Darshnaben, Chandniben, Meeraben, Shivangi** for their love, support, encouragement and inspiration throughout my study.

Finally, I frankly admit that, it is not possible to remember all the faces that stood behind me, omission of any name do not mean lack of gratitude. Now, as I carry this thesis in my hand. I carry with me lots of memories from this beautiful journey. I have taken literary license, but factorial errors are my responsibility alone.

Last but not least, I unassumingly bow my head in extreme regards to the Almighty "GOD", "My motherland" and "Maa Khodal" whose blessing enable me to reach this destination.

Looking forward for bright future! With Greatest Hope!

Date : 15 / 09/2022 **[Bhankhar Pratik D.]**
Place : Sardarkrushinagar

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ABBREVIATIONS AND SYMBOLES USED

ANOVA	**:**	Analysis of Variance
C.D	**:**	Critical difference
C.V.	**:**	Coefficient of Variation
cm	**:**	Centimeter
Conti.	**:**	Continuous
d.f.	**:**	Degree of freedom
Fig.	**:**	Figure
g	**:**	Gram
mg	**:**	Milligram
ml	**:**	Milliliter
MS	**:**	Mean Square
No.	**:**	Number
r	**:**	Replication
FRBD	**:**	Factorial Randomized Block Design
FCRD	**:**	Factorial Completely Randomized Design
S.E.	**:**	Standard Error
S.Em.±	**:**	Standard Error of mean
H	**:**	Hour
Ha	**:**	Hectare
Max.	**:**	Maximum
Min.	**:**	Minimum
RH	**:**	Relative humidity
PEG-6000	**:**	Polyethylene glycol
KH_2PO_4	**:**	Potassium dihydrogen phosphate
GA_3	**:**	Gibbrellic acid
T	**:**	Treatment
Temp.	**:**	Temperature
=	**:**	is equal to
.	**:**	Full stop
×	**:**	Multiply
@	**:**	at the rate
°C	**:**	Degree Celsius
&	**:**	And
( )	**:**	Bracket
[ ]	**:**	Square bracket
,	**:**	Comma
%	**:**	Per cent
>	**:**	Greater than
<	**:**	Less than
/	**:**	Per
Σ	**:**	N-ray summation
:	**:**	Colon
µ	**:**	General Mean

INTRODUCTION

I. INTRODUCTION

Pulses are one of the important segments of Indian agriculture after cereals and oil seeds. It constitutes the major source of dietary protein predominantly for vegetarians of the world. Now a days pulses are gaining globally significance, due to its nutritional value and suitability to its various cropping systems. Among the different pulses, mung bean (*Vigna radiata* L.Wilczek), is an important crop which ranks third in production after chickpea and pigeon pea (Economic and Statistics 2020-21). According to Vavilov (1926), mung bean is native of India and Central Asia. It is also known as green gram, golden gram or mung.

Mung bean is a self polinated crop and belongs to the family Leguminaceae and the genus *Vigna*. Only seven species of the genus *Vigna* are cultivated as pulse crops, five Asian species of subgenus *Ceratotropis*, *Vigna mungo* (blackgram), *V. radiata* (mung bean), *V. aconitifolia* (moth bean), *V. angularis* (azuki bean) *and V. umbellata* (rice bean) and two African species of subgenus *Vigna*, *Vigna unguiculata* (cowpea) and *V. subterranean* (the bambara groundnut).

Mung bean is closely related to adzuki (Red bean) and cowpea (in the same genus but different species). These are warm season annuals, small herbaceous and highly branched cowpea as wall a adzuki having upright and vine types of growth habit which also found in mung bean, with plants varying from one to five feet in length. The leaves are 5-10 cm long trifoliate with long petioles. The flowers of mung bean are hermaphrodite with pale yellow colour and borne in clusters of 12–15 near the top of the plant. The flower is a typical papilionaceous with having five sepals and five petals along with ten diadelphous (9+1) stamens and monocarpellary ovary with hairy style. In mung bean pollination takes place before the opening of the flower bud and its mature pods are variable in colour (yellowish-brown to black); about five inches long, and contain 10 to 15 seeds. Mature seed colour generally green but it can be yellow, brown, mottled black depending upon variety. Those having rounds to oblong seeds vary in size with the range of 25 to 70 grams per thousand seeds, depending upon genotype. Its germination is *epigeal* with the cotyledons and stem emerging from the seedbed (Oplinger *et al.* 2009).

Among the pulses, green gram (*Vigna radiata* L.) is one of the most important and extensively cultivated crop in India, which is cultivated in arid and semi-arid regions. Green gram is the third most important pulse crop of India covering an area of 4.5 million ha with a total production of 2.85 million tonnes and an average productivity of 548 kg per ha (Anonynomus, 2021[a]).

Major states in India which grow greengram are Andhra Pradesh, Madhya Pradesh, Uttar Pradesh, Maharashtra, Rajasthan, Bihar, Gujarat and Orissa. In Gujarat, it is cultivated in 164.74 thousand hectares with an annual production of 125.74 thousand tonnes leading to an average productivity of 745.18 kg per ha (Anonynomus, 2021[b]). It is mainly growing in the district of Kutch, Junagadh and Banaskatha in Gujarat.

Mung bean contains about 24 per cent protein, this being about half of the protein content in soybean, twice that of wheat and thrice that of rice. Mung bean seeds are rich in (amounts in 100 g) minerals like calcium (132 mg), iron (6.74 mg), magnesium (189 mg), phosphorus (367 mg) and potassium (1246 mg) and vitamins like ascorbic acid (4.8 mg), thiamine (0.621 mg), riboflavin (0.233 mg), niacin (2.251 mg), pantothenic acid (1.910 mg) and vitamin A (114 IU) (Kalim *et al.* 2021). Among pulses, mung bean is not only favoured for children but also elderly people because of its easy digestibility and low production of flatulence. Mung beans contain many healthy antioxidants, including phenolic acids, flavonoids, caffeic acid, cinnamic acid. Antioxidants help to neutralize potentially harmful molecules known as free radicals. In high amounts free radicals can interact with cellular components and wreak havoc. This damage is linked to chronic inflammation, heart disease, cancers and other diseases. Mung beans are believed to have anti-inflammatory properties that help protect against heat stroke, high body temperatures, thirst.

Mung bean can be grown in marginal soils with low inputs and is well suited to a large number of cropping systems due to its nitrogen-fixing ability. It can also improve soil fertility and texture (Graham and Vance 2003). Green gram is an economically important short duration grain legume characterized by relatively more palatable, nutritive, easily digestible than other pulses. Green gram is excellent source of high quality protein. Mung is consumed as whole grains, sprouted form as well as dal in a variety of ways in homes. It is used as purpose green manuring crop, as well as a feed for cattle.

Seed is not only the basic input for enhancing production but also maintain optimum plant density per unit area is the key for the optimum crop productivity. Hence, each and every seed should readily germinate and produce a vigorous and healthy seedling thereby ensuring its high productivity. The seed not only offers the highest economical and social returns among all the productions inputs but also ensures the optimum utilization of other inputs *viz.,* fertilizer, irrigation, pesticides etc. Seed possesses maximum vigour at the time of physiological maturity (Meena *et al.* 1994) and there after it gradually ages and declines in viability and vigour. The loss of vigour precedes loss in germination. Seed ageing leads to reduction in seed quality which reflects in its performance and stand establishment (Christiansen and Rowland 1981).

Seed deterioration is the major problem in agricultural production. Deterioration process in seed causes changes at the cellular level which brings physiological and biochemical changes and ultimately results in delayed germination, reduced seedling growth rate, decreased tolerance to adverse germination conditions and loss of germinability due to membrane deterioration, low oxygen uptake and high CO_2 output (Kharlukhi and Agrawal 1983).

Seed treatments with priming agents have been found effective in delaying and decreasing ageing effects (Savino *et al.* 1979 and Basu 1995). A post harvest treatment improves seed invigoration which results in higher seed vigour, improved germinability, greater storability and better field performance than the corresponding untreated (control) seed.

Osmo-primed seeds are being shown to germinate and emerge faster than untreated seeds. Osmotic agents are being used for pre-germination treatment which would reduce the required number of days of wet soil surface for successful seedling establishment. This process helps during dry season when soil surface dry faster by improving seedling establishment. Seed priming is a technique in which seeds are partially hydrated until the germination process begins but radical emergence does not occur. Priming promotes the metabolic processes necessary for germination which accelerates the germination and emergence of crop seeds. Priming causes rapid and uniform emergence of seedlings. This increase in emergence by priming is may be due to initiation of metabolic events in primed seeds. Another possible reason is that priming may also leach germination inhibitors from seeds. (Heydecker and Coolbear 1977).

The mung bean growing areas have sandy or sandy loam soil and less availability of sufficient water in soil, which again become less due to a major problem due to uneven rainfall distribution. To overcome this problem primed seeds may be used for sowing in the field, that can tolerate the problem of soil moisture stress to much extent, particularly during the initial stage of germination and seedling growth which may help to maintain optimum plant population. The seed treatments are also helpful in improving germinability of marginally sub standard seeds. Very less information is available on the effect of various pre sowing seed treatments on seed quality of mung bean. Hence, the present study was carried out to acertain the feasibility of enhancing germination level of marginally substandard seedslots by various priming treatment with following objectives.

OBJECTIVE OF INVESTIGATION

1. To study the effect of priming treatments on seed germination and its related parameters
2. To assess the potential of priming treatments on seedling vigour
3. To work out association of different priming treatments with relation to yield and its attributes

REVIEW OF LITERATURE

II. REVIEW OF LITERATURE

The research work carried out on germination, vigour and yield component characters were reviewed as per the following topics.

1. Effect of priming treatments on seed germination
2. Effect of priming on seedling vigour
3. Effect of priming on yield and its attributes

2.1 Effect of priming treatments on seed germination

Graf *et al*. (1987) Primed seed with 1% KH_2PO_4 and they showed a relatively positive effect of KH_2PO_4 on seed germination because phosphorous reserves in the seed play very important role in the metabolism of germinating seed.

Arjunan and Shrinivasan (1989) reported that seed hardening treatment of groundnut kernels with KH_2PO_4 (2.0%) increased pod yield through increased field germination per cent. higher dry matter accumulation and more number of matured pods per plant compared to control.

Khan *et al*. (2005) observed effect of priming on crop stand of mung bean. The effect of PEG 8000 at three concentrations levels *viz*., 100, 200, 300 g liter^{-1} water, water soaked and control (seed not treated) were observed on germination of two mung bean varieties, NM-92 and NM-98. Seeds were treated for 6 and 12 hours and then dried for a whole day in open air at room temperature at Agricultural Research Farm, NWFP Agricultural University, Peshawar during 2003. They have recommended that seeds of variety NM-92 primed in 0 MPa osmotic potential of PEG-8000 solution (water soaked) may be used for higher germination of mung bean.

Ghasemi Golezani *et al.* (2008) reported that in lentil hydro-priming treatments increased the weight of the seedling root, the germination rate, as well as shoot, root and seedling dry weight. 1% KNO_3 and PEG 6000 treatments increased germination percentages when compared to the control.

Umair *et al.* (2010) conducted an experiment to test the impact of priming on the germination and seedling vigour of mung bean (CM-97) under laboratory conditions. The seeds were soaked in water (hydropriming), solutions of KH_2PO_4, Manitol, Polyethylene glycol (PEG-6000), Na_2MO_4. $2H_2O$ (osmocoditioning) and salicylic acid (SA) (hormonal priming). Having two levels for each chemical (treatment). After giving all the priming treatments by soaking seeds for five hour, seeds were dried and sown in petri dishes in growth chamber at 27 ± 2 °C for seven days. All the treatments significantly improved the germination percentage, root and shoot length, seedling dry weight, mean germination time (MGT) decreased, significantly. Osmopriming using P at 0.60% applied in the form of KH_2PO_4 significantly improved final germination percentage.

Yari *et al*. (2010) evaluated the effect of different seed priming techniques on germination and early growth of two wheat cultivars (Azar-2 and Sardari 101). They primed seeds for 12, 24 and 36 hours at three temperature (20, 23 and 28°C) in seven priming media (Poly ethylene glycol (PEG-6000) 10%, PEG 20%, KCl 2%, KCl 4%, KH_2PO_4 0.5%, KH_2PO_4 1% and distilled water as control). Maximum seed germination percentage in cv.Azar-2 was observed when the seeds primed by PEG 20% for 12h and at 20°C. The most stem length was obtained for seeds osmoprimed with PEG 10% for 24h. Osmoprimed seeds with PEG 20% for 24h produced maximum radicle length of cv. Sardari. Maximum vigor index (VI) of cv. Azar-2 was obtained from seeds primed with KH_2PO_4 0.5% while the lowest germination percent, speed of germination and VI were observed in seeds which subjected to KCl 4% solution. Speed of germination was improved when the seed soaked water and PEG 10%. The most germination percent, VI and speed of germination were observed on 12h. Al together 20°C treatment had better effects than other temperatures on germination attributes and seedling parameters.

Sadeghi *et al.* (2011) studied the effect of seed osmopriming on seed germination behavior and vigour of soybean. Seeds were primed with six levels of Poly ethylene glycol (PEG 6000) as priming media (distilled water as control, -0.4, - 0.8, -1.2, -1.6 and -2 MPa) for 6, 12, 24 and 48 hours at 25°C. Results of variance analysis made clear that different osmotic potential and priming duration had significant effect on germination percentage, mean germination time, germination index and the time to get 50% germination. Also -1.2 MPa osmotic potential increased germination percentages, germination index.

Mahdi and Mehdi (2013) observed the effect of osmopriming on germination and seedling growth of soyabean (*Glycine max*. L.) seeds. They have primed the seeds in aerated solutions of PEG 6000, KNO_3 and KH_2PO_4 having -1.2 MPa osmotic potential. Among these materials, seed primed with PEG-6000 has recorded highest germination percentage and vigour parameters.

Jat *et al*. (2015) performed an experiment in laboratory and field together at Department of Genetics and Plant Breeding, Sam Higginbottom Institute of Agriculture, Technology and Sciences, Allahabad, U.P. during *Kharif* (2014), in order to standardize the best method of priming specific to cluster bean. It was found that all the priming methods showed significant differences with the control and the highest germination percentage, seedling length, weight were observed in T for PEG-6000 priming for 20 hrs.

Singh *et al.* (2016) Osmotic stress effect the germination, vigour, root:shoot ratio and nutrient content at seedling stage. Higher germination percentage was observed in HUL-57 at all the stages of observation at all the treatments *i.e*. of 0 (T_1), 5 (T_2), 15% (T_3) PEG-6000. HUL 57 had higher germination rate, germination energy, mean germination time, than DPL-62 under different treatments. As compared to T_1 root dry weight increased under treatment T_2 in HUL-57 and decreased under T_3 treatment, while in DPL-62 it was the maximum in control and decreased with increased PEG concentrations in the external medium.

Mishra *et al*. (2017) assessed different priming methods for seed quality parameters in pigeon pea (*Cajanus cajan* L.) seed. Seed priming using various methods *viz*., hydropriming, halopriming and osmoprimong, biopriming were evaluated by screening a range of duration and concentration *viz*., T_0 Control, hydropriming, osmopriming- PEG (20%), halopriming (KCl 1%), ($CaCl_2$ 1%), biopriming (Neem leaf Extract 5%) and (Eucalyptus extract 5%) for 14 hours. They have found that all the priming method showed signification difference with the control and the highest percentage germination, seedling length, weight and germination index were observed for PEG priming for 14 hours.

Pradhan *et al.* (2017) observed the influence of halopriming and organic priming on germination and seed vigour in blackgram (*Vigna mungo* L.) seeds. The seeds were treated with un-soaked seed (control), hydro-priming (soaked with distilled water for 12 hrs), organic priming (Cow urine, Coconut water), halopriming with KNO_3, KCl, and $CaSO_4$ (1% solution) soaked for 12 hrs, on seed of blackgram. KCl @1% primed seed recorded higher germination percent (83.25%), energy of emergence (78.75), seedling length (40.30 cm), seedling dry weight (0.452 gm per 10 seedlings), vigour index I (3358.93) and vigour index II (37.66). The treatment interactions were significant & the seeds treated with KCl followed by KNO_3 recorded numerically higher values compared to control.

Singh *et al*. (2017) studied the effect of hydropriming and osmopriming on germination and vigour of pea seeds. They have evaluated osmopriming and hydropriming methods by screening a range of durations and concentrations *viz*., T_0 - Unprimed Control, T_1 - Distilled water hydration (for 12 hrs), T_2 - Distilled water (for 24 hrs), T_3 - Mennitol (3%) hydration (for 12 hrs), T_4 - Mennitol (3%) hydration (for 24 hrs), T_5 - Glycrol (5%) hydration (for 12 hrs), T_6 - Glycrol (5%) hydration (for 24 hrs), T_7 - Polyethylene Glycol 6000 (20%) hydration (for 12 hrs) and T_8 - Polyethylene Glycol 6000 (20%) hydration (for 24 hrs). All the priming methods showed significance difference with the control. The highest germination percentage, seedling length (cm), seedling fresh weight (gm), seedling dry weight (gm) and vigour index were observed in T_8 (PEG 6000 priming for 24 hrs). The study helped to improve the quality of seeds with the help of seed priming treatments which were cost effective, economic, non toxic and ecofriendly sources.

Afrayeem *et al*. (2018) conducted an experiment in the laboratory of Seed Science and Technology, Sam Higginbottom University of Agriculture, Technology and Sciences, Allahabad during 2013, in order to standardize the best method of priming specific for Black gram. Seed priming using various method like that *viz*., hydropriming, helopriming and osmoprimong were evaluated by screening a range of duration and concentration *viz*., hydropriming- T_0 Unprimed Control, T_1 - Distilled water, helopriming- T_2 - NaCl (5%), T_3 -$CaCl_2$ (1%), T_4 - KCl (5%) and osmopriming- T_5 - PEG (25%) for 14 hours. It was found that all the priming method showed signification difference with the control and the highest germination percentage, seedling length, weight and germination index were observed for PEG priming for 14 hours. Seed priming, its simplicity and no requirement for expensive equipment and chemical could be used as a simple method for overcoming related to a poor germination and seedling establishment and helps in sustaining agriculture.

Barthwal and Prabha (2018) studied the effect of ageing and hormonal priming on different physiological attributes on french bean (*Phaseolus vulgaris*). They have taken IAA, kinetin and GA_3 with three concentration 5 ppm, 10 ppm, and 15 ppm. For accelerated ageing seeds were treated with 1% solution of sodium hypo chloride for 5 min. After that seeds were primed with different doses of growth regulators, which were GA_3, IAA and kinetin. Seeds primed with 5 ppm solution of GA_3 showed the highest germination percentage, speed of germination, germination value, root length, shoot length, seedling length and seedling vigor index-1 and vigor index-2. This indicates that the lower concentration of growth regulators favors the increased enzymatic activity which leads to the favorable environment for the germination. This present study showed that growth regulator in higher concentrations inhibits the seed germination. It can be concluded that significant variation was found in GA_3 5 ppm.

Sohail *et al.* (2018) concluded that seed priming with PEG 6000 (osmopriming) was found to be the best priming treatments. Priming with PEG 2% is having more pronounced effect on germination behavior in kabuli chickpea seeds.

Aryal *et al.* (2020) studied effect of priming using various priming agents on germination characteristics of Blackgram through Hydropriming, Osmo-priming (PEG600 @ 1%, 2%, 5% and 10%), Halo-priming (NaCl @ 1% and 2%) and Hormonal priming (GA_3 @ 5 and 10 ppm) as treatments and compared with unprimed seeds as control treatment. Priming with PEG @ 2% showed a better overall germination parameters and seedling characteristics including a higher seedling length (8.979 cm), dry weight (1.308 gm) and germination percentage (96%) indicating higher seedling vigor. In addition, seeds primed with PEG 5% exhibited quicker germination and seedling development with higher germination index (103.3). Osmopriming with PEG600 up to 5% concentration was found beneficial.

Das *et al*. (2020) evaluated the effect of various seed priming options on rapeseed-mustard varieties. Experiment comprised six rapeseed-mustard varieties (Anushka, Sanchita, TBM- 143, TBM-204, Kranti and Pusa Bold) in main plot and five seed priming options (KH_2PO_4 @ 0.15 mol 100 ml water-1 5 g seeds-1, KNO_3 @ 0.1 mol 100 ml water-1 5 g seeds-1, PEG-6000 @ -0.3 MPa 100 ml water-1 5 g seeds-1, hydro priming @ 100 ml 5 g seeds-1 and control) in subplot, replicated thrice in a split plot design. Observations on growth and yield contributing parameters were recorded from the field. Further, various quality parameters of seed and seedlings were evaluated in the laboratory. Data on all the parameters were finally statistically analyzed. Results recorded among the varieties, Pusa Bold performed better in terms of growth, yield contributing parameters and seed yield under seed priming through either KH_2PO_4 @ 0.15 mol 100 ml water-1 5 g seeds-1 or PEG-6000 @ -0.3 MPa 100 ml water-1 5 g seeds-1. Seed and seedling quality parameters such as root and shoot lengths, seedling fresh and dry weights, germination % and vigour index were also improved.

Ejeta (2020) conducted the field experiment in randomized complete block design using three varieties of soyabean (Belessa95, Wello and Gishama), three priming types [GA_3 (100 ppm), KH_2PO_4 (50 ppm) and water] and three priming durations (0, 6, 12 hours). Seed were harvested and seed quality analysis was tested at laboratory by using Completely Randomized Design in three replications. The result of the study showed that highly significant ($P \leq 0.01$) difference between interaction of varieties by priming type and soaking durations for Seedling dry weight, speed of germination. Varieties by priming type interaction showed highly significant ($P \leq 0.01$) difference for seedling dry weight and speed of germination. The highest shoot length was observed for Belessa95 varieties primed with GA_3(16.31 cm) and the highest root length was observed for Belessa95 varieties (6.98 cm) and seed primed with water (7.22 cm). The highest seedling dry weight was recorded when Belessa95 variety primed with water for 12hr (250 gm).

Raja *et al*. (2020) evaluated electrospun poly vinyl alcohol (PVA) nanofibers as carriers for hormones (IAA and GA_3) delivery in seed invigoration for enhancing germination and seedling vigor of agricultural crops (groundnut and blackgram). The nanofiber was infused with plant growth promoting hormones, gibberellic acid (GA_3) and indole acetic acid (IAA). Hormones-infused PVA nanofibers were evaluated for its bio-efficacy on seed quality under in vitro condition, and the results revealed that IAA incorporated nanofiber coated seeds such as groundnut and black gram had registered higher germination at 88% and 86%, seedling vigour at 3458 and 3431 respectively.

Chakraborty and Bordolui (2021) in their experiment primed eight genotypes of green gram *viz*, Pusa Vishal, PM-11-9, IPM-2-3, Meha (IPM 99-125), Samrat, IPM-512-1, TMB-37, SML-1822 with GA_3 and Ag-nanoparticle for six hours. The laboratory experiment was done in seed testing laboratory, BCKV, West Bengal during 2019 & 2020. Germination percentage and vigour were observed to determine the change of seed quality after priming with GA_3. It improved the seed germination as compared to control.

Uddin *et al.* (2021) evaluated the effect of seed priming on growth and performance of mung bean (*Vigna radiata* L.) under induced drought stress. The present study was aimed to determine the effect of seed priming under inducing drought stress on legume plant, *Vigna radiata* (NIFA Mung-2017) variety. Seeds were obtained from the nuclear institute for food and agriculture, Peshawar and sown in earthen pots having a diameter of 18 cm, height 20 cm and 1.5 cm thickness. The designed experiment contains nine treatments each having three replicates, the seeds of the first three treatments weren't primed, while the seeds of the next three treatments were primed with PEG, similarly seeds of the last three treatments were primed with 4˚C. Drought stress of seven days and fourteen days was induced during the experiment to all non-primed, PEG primed and thermoprimed treatments. Seed priming with PEG increased the seedling vigor index while thermo-priming showed a non-significant effect.

2.2 Effect of priming on seedling vigour

Rangaswamy *et al*. (1993) reported that the soaking of groundnut seeds in 10 per cent KH_2PO_4 solution slightly increased vigour index and root-shoot ratio.

Umair *et al.* (2010) studied the impact of priming on seedling vigour of mung bean (CM-97) under laboratory conditions. The seeds were soaked in water (hydropriming), solutions of KH_2PO_4, Manitol, Polyethylene glycol (PEG-6000), $Na_2MO_4.2H_2O$ (osmocoditioning) and salicylic acid (SA) (hormonal priming). Having two levels for each chemical (treatment). After giving all the priming treatments by soaking seeds for five hour, seeds were dried and sown in petri dishes in growth chamber at 27 ± 2 °C for seven days. All the treatments significantly improved the seedling vigour index (SVI). Osmopriming using P at 0.60% applied in the form of KH_2PO_4 significantly improved seed vigour. It is concluded that seed priming (osmo-priming and hormonal priming) can be used as effective tool for in vigouration of mung bean seeds, for vigour enhancement.

Eskandari and Kazemi (2011) observed the effect of seed priming on germination properties and seedling establishment of cowpea (*Vigna sinensis*). They evaluate the effects of hydropriming (8, 12 and 16 hours duration) and halo priming (solutions of 1.5% KNO_3 and 0.8% NaCl) on seedling vigor and field establishment of cowpea. Analysis of variance of laboratory data showed that hydropriming significantly improved germination rate, seed vigor index, and seedling dry weights. However, germination percentage for seeds primed with KNO_3 and non-primed seeds were statistically similar, but higher than those for NaCl priming. Invigoration of cowpea seeds by hydropriming and NaCl priming resulted in higher seedling emergence and establishment in the field, compared to control and seed priming with KNO_3.

Sadeghi *et al*. (2011) has studied the effect of seed osmopriming using PEG-6000 media on germination and vigour index of soyabean. Results has revealed that priming treatment and duration has significant effect on vigour index. Seed primed for 12 hours has shown increased seed vigour than control treatment in aspect of studied criteria.

Sarika *et al.* (2013) conducted a lab experiment to study various physiological and biochemical changes by priming in French bean at Bangalore. They reported that chemo priming with GA_3 and Ethrel improved the seed quality and showed improved seedling length, seedling dry weight which in turn improved higher seedling vigour index, germination speed and mean germination time. Significant increase in initial (6.02 cm) and final (11.5 cm) root length, initial and final shoot length, seedling vigour index and dry seedling weight with GA_3 is observed in the crop.

Jat *et al.* (2015) conducted the experiment in laboratory and field together at Department of Genetics and Plant Breeding, Sam Higginbottom Institute of Agriculture, Technology and Sciences, Allahabad, U.P. during *kharif* (2014), in order to standardize the best method of priming specific to cluster bean. It was found that all the priming methods showed significant differences with the control and vigour index were observed in T for PEG-6000 priming for 20 hrs.

Kujur and Lal (2015) studied the effect of hydropriming and osmopriming on vigour and germination behaviour of soyabean (*Glycine max*. L.) seeds. They have primed soyabean seeds with distilled water, KNO_3 (1%), NaCl (0.5%) and PEG 6000 (5%) for 8, 12, 24 and 48 hrs. at 25ºC. Mean comparison has showed that the highest vigour index-I (2259), vigour index-II (9378), germination (72%), seedling length (31 cm) and seedling dry weight (130 mg) was achieved by priming with PEG-6000 (5%) for 12 hours.

Poonguzhali (2016) investigated for improvement in vigour and viability of black gram cv.co 6 (*Vigna mungo* L.) through seed priming with in organics. Seeds of soaking followed by drying for different durations ranging from 1h, 2h and 3h with different inorganic chemicals *viz*., Vitamin E (a-tocopherol), Para Amino Benzoic Acid (PABA) and Salicylic Acid at concentrations of 2.5 mM, 5.0 mM and

7.5 mM in 1:1 seed to solution ratio was attempted. The results shows that it improved seed vigour and viability in all the seed lots.

Thorat *et al.* (2017) evaluated the effects of organic and inorganic growth regulators on germination and vigour of cowpea (*Vigna unguiculata* L. Walp.) The experiment consist of three concentrations of lemon juice (2, 4 and 6%), three concentrations of coconut Water (2, 4 and 6%), three concentrations of GA_3 (10, 20 and 30 ppm) and three concentrations of IAA (10, 20 and 30 ppm). T8 (GA_3 20ppm) proved significantly superior in germination per cent, germination index, shoot length, root length, seedling length, fresh weight of seedling, dry weight of seedling, seed vigour index-I, and seed vigour index-II.

Sohail *et al.* (2018) concluded that seed priming with PEG-6000 (osmopriming) was found to be the best priming treatments. Priming with PEG 2% is having more pronounced effect on germination vigour in kabuli chickpea seeds.

Narayanan *et al*. (2019) investigated the effect of various seed priming treatments on quality seed production in sesame cv. VRI 1. The seeds of sesame were given with various priming treatments *i.e.*, priming with GA_3 @ 100 ppm, IAA @ 100 ppm, $MnSO_4$ @ 0.5, $FeSO_4$ @ 0.5%, KCl @ 0.5%, *Prosopis* leaf extract @ 2%, pungam leaf extract @ 2%, arappu leaf extract @ 2%, tamarind leaf extract @ 2% and nochi leaf extract @ 2%. Seeds treated with just water acted as control. All the treated seeds were evaluated for the initial quality characteristics and field performance. Among the treatments, it was found that *Prosopis* leaf extract treatment @ 2% registered higher values for initial seed qualities. In field evaluation also, *Prosopis* leaf extract treatment @ 2% recorded higher growth, physiological and yield parameters in sesame cv. VRI 1.

Ejeta (2020) conducted field experiment in randomized complete block design using three varieties of soyabean (Belessa 95, Wello and Gishama), three priming types [GA_3 (100 ppm), KH_2PO_4 (50 ppm) and water] and three priming durations (0, 6, 12 hours). Seed were harvested and seed quality analysis was tested at laboratory by using Completely Randomized Design in three replications. The result of the study showed that highly significant ($P \leq 0.01$) difference between interaction of varieties by, priming type and soaking durations for seedling vigour index-2, and significant ($P \leq 0.05$) difference for seedling vigour index-1 were observed. The highest seedling vigour index1 was recorded when Gishema variety primed with KH_2PO_4 for 6hr, the highest seedling vigor index-2 was recorded when Belessa95 variety primed with water for 12hr.

Bera (2021) observed the effect of seed priming in two varieties of chickpea with eight different treatments of PEG and AMT with compared to hydropriming and controlled conditions at laboratory and field conditions. In laboratory conditions, hydropriming treatment gave best results in germination percent and seedling vigour index-I whereas, AMT gave significant results. While, in field conditions PEG-6000 gave best results in field conditions.

Lamichhane *et al.* (2021) carried out on experiment to evaluate the effects of different priming on okra seeds germination and seedling vigor using Arka Anamika variety at Horticulture lab of Agriculture and Forestry University, Rampur, Chitwan, Nepal. Investigation was carried out with 6 treatments (T_1: seed priming with tap water, T_2: seed priming with 200 ppm NAA solution, T_3: seed priming with 10% PEG-200 solution, T_4: seed priming with 200 ppm GA_3 solution, T_5: seed priming with 5% *Trichoderma* solution and T_6 no priming) with 4 replications in Complete Randomized Design (CRD). Seeds primed with T_1 to T_5 were soaked for 24 hours and shade dried for 6 hours before sowing. Priming with T_4 was found to be best in terms of maximum seed germination (60.12%), seed vigor index (5772.68 cm), mean germination rate (7.53 seeds per day). The highest shoot length (81.40 mm) was observed at T_1 where enhancement of root length occurred with the priming with T_3. All treatments had a significant positive effect on all the germination parameters in comparison to control.

Salah *et al.* (2021) determined the effect of seed priming under induce drought stress on legume plant, *Vigna radiata* (NIFA Mung-2017) variety. The designed experiment contain nine treatments each having three replicates, the seeds of first three treatments weren't primed, while the seeds of next three treatments were primed with Polyethylene glycol (PEG), similarly seeds of last three treatments were primed with 4 °C. Drought stress of seven days and fourteen days were induced during the experiment to all non-primed, PEG primed and thermo-primed treatments. Seed priming with PEG increased the seedling vigor index while thermo-priming showed non-significant effect.

Thinh (2021) investigated the influence of seed priming with Spirulina Platensis extract on seed quality properties in black gram (*Vigna mungo* L.). The blue-green microalgae *Spirulina Platensis* contains variously beneficial substances, including macro and micro nutrients, vitamins, amino acids and antioxidants. The aim of this study is to improve the vigour and germination. Medium vigour black gram seeds were subjected to hydropriming for three hours (T_2); other seeds were primed with *Spirulina platensis* extract at 1.5% for three hours (T_3) while unprimed seeds served as control (T_1). The results revealed that the hydropriming and control of black gram seeds were significantly lower in all physiological and biochemical seed quality parameters than seeds primed with *Spirulina platensis* extract at 1.5% for three hours.

2.3 Impact of priming on yield and its attributes

Srimathi and Sujatha (2006) used chemical priming for appraisement of improvement in seed yield and quality of black gram *(Vigna mungo* (L.) *Hepper*) var.CO 5. The effects of seed priming using 1% KCl, 1% KH_2PO_4 and 1% $CaCl_2$, applied alone or in different combinations, 1% NaCl, 0.5 and 1% $FeSO_4$, 0.5% KNO_3, 100 ppm gibberellic acid, 100 ppm kinetin, 100 ppm IAA and 100 ppm IBA on the yield and quality of black gram cv. CO 5 were determined in laboratory and field experiments.

Arif *et al*. (2008) studied improvement in emergence and yield of soybean due to seed priming. They have primed the seeds using 0 (deionized water), -0.2, -0.5, -1.1 and -1.8 MPa polyethylene glycol (PEG) solutions for 6, 12 and 18 hours using dry seed (non primed) as a control. Then, dried back the seeds to its original moisture content at room temperature. Based on the obtained results they have concluded that, seed priming hastens and improves emergence and enhances grain yield of soybean.

Khan *et al.* (2008) worked on patchy plant stand due to uneven germination in mung bean (*Vigna radiata* W.) production. Mung bean cultivars (NM-92 and NM-98) seed were primed for 6 and 12 hours in different solution of water and osmotic solution (ψo) of polyethylene glycol (PEG-8000) equivalent to 0, -0.2, -0.5 and -1.1 MPa (Mega Pascal). The primed seed along with control (un-primed) were sown in field experiments at the Research Farm of NWFP Agricultural University Peshawar during 2003 and 2004. Delayed phenological observations were recorded in NM-98 compared to NM-92, but no differences in yield and yield components were observed for both cultivars of mung bean except grains per pod being higher for NM-98. Primed seed performed better when compared to control, and resulted in 12 % more grain yield. A decrease in osmotic potential in treatment solution from

0 to -1.1 MPa resulted in better performance, in terms of yield and yield components, but was not consistent. Significant interaction of Varieties × Duration × PEG Treatment for days to emergence, grain and biological yield suggest the differential response of each treatment levels over the other. It was concluded that hydro-primed and/or seed primed in -0.5 MPa osmotic potential solution of PEG were better in phenology and yield than all other treatments.

Mohamedy and Abd El-Baky (2008) evaluated the different types of seed treatment on improvement of growth and yield quality of pea plant in Nobaria province. They have reported that in seed primed with PEG, obtained pod length was higher than control treatment.

Arif *et al*. (2014) observed the impact of osmopriming varying with polyethylene glycol concentrations and durations on soybean. They have concluded that averaged over all treatments, priming for 6 hours with -1.1 MPa, was the most beneficial treatments. The priming treatment had reduced the days to maturity and days to flowering. Also, using this treatment they have recorded higher plant height, number of branches, number of grain per pod, 100 seed weight, grain yield and harvest index.

Chavan *et al*. (2014) conducted an experiment of to determine the importance seed priming on field performance and seed yield of soybean. There were two varieties *viz.*, Phule Kalyani and JS-335 while priming treatments KH_2PO_4 @ 50 ppm and GA_3 @ 20 ppm, seed priming generally improves the most parameters of soybean varieties through improving plant height, number of branches, number of pods per plant, number of seeds per pod and seed yield.

Mubeen *et al*. (2015) showed that seed priming with GA_3 increase the efficiency of *Rhizobium* inoculation and biofortification, which can improve not only seed quality including optimizing mung bean yields.

Toklu (2015) performed an experiment to analyze effects of different priming treatments on seed germination properties, yield components and grain yield of lentil (*Lens culinaris* Medik.). The priming treatments used were control, KNO_3 (1%), KCl (2%), KH_2PO_4 (1%), $ZnSO_4$ (0.05%), PEG-6000 (20%), IBA (100 ppm), Mannitol (4%), GA_3 (100 ppm) and distilled water. The result of the study showed maximum pod per plant, 1000 grain weight and biological yield due to PEG-6000 (20%) priming treatment.

Abebe (2016) reported the effect of seed priming for improving chickpea variety productivity and determine the effectiveness of seed priming treatment and variety on stand establishment. Experiment indicated that all the phenological and growth traits significantly differed as a result of priming treatment and variety with respect to yield and yield related traits, only seed yield $kgha^{-1}$, harvest index (%), seeds per plant and seeds per pod were significantly affected by the main effect. While, the rest of yield related traits responded differently due to variety alone. However, all variables studied in the field were not significantly affected by the interactions of the main effects. Improvement made due to main effect hydro and osmopriming was statistically similar for all phenological traits; seeds per plant and seeds per pod was considerably improved as a result of osmopriming than hydropriming. However, plant height, stand count at emergence and at harvest, seed yield kg ha^{-1} were substantially increased by 7, 10, 12 and 15%, respectively as a result of water priming over the control. Present study can be concluded that hydropriming can step-up economical benefit of chickpea growing farmers.

Prajapati *et al*. (2017) investigated the effect of seed hardening on morpho-physiological and yield parameters in black gram. The black gram var. GU-1 was imposed with various seed hardening treatments *i.e*., $CaCl_2$ @ 2%, 500 ppm cycocel, 1000 ppm cycocel, 25 ppm NAA, 50 ppm NAA, 150 ppm KNO_3, 150 ppm KCl and absolute control. The study revealed that seeds hardened with $CaCl_2$ @ 2% recorded higher plant height (36.40 cm), leaf area (544.40cm^2), leaf dry weight (10.64 g), shoot dry weight (24.81 g), total dry weight (35.10 g), seed yield (4.36 g per plant), 100 seed weight (4.74 g) and seed yield (821 kg per ha.) at harvest as compared to other treatments and control.

Krishnaprabu (2018) evaluated the effect of different priming treatments on the growth and yield attributes of blackgram. seed priming cause increase in the no. of pods per plant, no. of seeds/pod, 1000 seed weight (g) and seed yield by seed priming increased seed yield. It is concluded that seed priming with GA_3 at 15^oC for 24 hours can be suitable and enhancing the seed yield under varying moisture conditions.

Lamichaney *et al*. (2018) has primed the chickpea seed with different concentration of poly ethylene glycol, mannitol, salicylic acid, gibberellic acid and water for varying duration. Dry unprimed seed was used as control. Germination percent, time to 50% germination, uniformity of germination, germination energy, field emergence, hundred seed weight, seed yield were determined to understand the physiological basis of priming. Out of nine treatments, seeds primed with PEG at -0.5 and -1.0 Mpa for 24 hrs were most effective in enhancing field emergence and seed yield of chickpea.

Bhadane *et al*. (2020) observed the effect of seed priming and foliar spraying of plant growth regulators on morpho-physiology, growth and yield in green gram (*Vigna radiata* L.). Seeds of mungbean variety GAM-5 were primed and also foliar spraying at 30 DAS with $CaCl_2$ 2% and 1%, cycocel 500, 1000 ppm, NAA 25, 50 ppm. Seed priming with 2% $CaCl_2$ followed by 1% foliar spraying at 30 DAS (T_{11}) significantly improved most of morpho-physiological parameters *viz*., plant height, number of branches per plant, days to 50% flowering, maturity, leaf area, chlorophyll content, seed protein content, number of pods per plant, number of seeds per pod, test weight, pod length, yield per plant, yield per hectare, harvest index in green gram followed by the seed priming with cycocel 1000 ppm followed by foliar spraying at 30 DAS (T_{13}) and seed priming with NAA 50 ppm followed by foliar spraying at 30 DAS (T_{15}). The treatment T_{11} is more efficient.

Devi *et al.* (2021) studied the effect of presowing seed treatment, sowing windows and seasons on seed yield and quality of greengram by sowing the treated seeds on two dates each in summer and *kharif*. This research experiment provided evidence that pre sowing seed treatments can be effectively utilized to enhance yield and seed quality of greengram in a region with high temperature, humidity and rainfall during summer and cold, foggy and dry during winter. The best treatment was found to be priming with 5 ppm gibberellic acid.

Hansaliya (2021) carried out an experiment for pre-sowing seed priming treatment in four cumin with various concentration of PEG and KNO_3 compared to controlled conditions. Results showed that treatment and varieties had significant variation on germination and growth parameters in laboratory and yield and its component characters in field conditions. At -0.1 MPa PEG concentration recorded best results under laboratory conditions for growth parameters whereas in field conditions 0.4 % concentration of KNO_3 results best for yield and it's component characters.

Nomkhosi *et al.* (2021) studied effect of osmo-priming on germination, growth and green pod yield of okra [*Abelmoschus esculentus* (L.)]. Priming of seeds with (PEG) concentrations of 5%, 10%, 15%, and 20% and unprimed control. A completely randomized design was used for the laboratory experiment. Results showed a significant effect of seed priming on the germination index, mean germination time and final germination percentage of okra seeds. Significantly the highest germination index (5.2) and final germination percentage (66%) were recorded in priming with 15% PEG. Thus, it can be concluded that seed priming with 15% PEG is the most effective in improving the germination, growth and yield of okra in the study area.

MATERIAL AND METHODS

III. MATERIAL AND METHODS

The present investigation entitled, **"Responses of Green Gram (*Vigna radiata* L.) to different Priming Treatments on Germination, Growth and yield"** was carried out at Agronomy Instructional Farm, Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar in *kharif* 2021. The details of the materials used and methods adopted for the investigation are described in this chapter.

3.1 Climate and weather conditions

Geographically, Sardarkrushinagar is situated at 24^0 19´ North latitude and 72^0 19´ East longitude with an elevation of 154.52 meter above the mean sea level and situated in the North Gujarat Agro-climatic region. Climate of this region is sub-tropical monsoon type and falls under semi-arid region. In general, the monsoon is warm and moderately humid, winter is fairly cold and dry, while summer is largely hot and dry.

The climate of Dantiwada region is sub-tropical monsoon type. The weather condition is quite favourable for normal growth and development of mung bean crop. The monsoon commences by middle of June and retreat by the middle of September. The maximum temperature during rainy season ranges from 29.0 to 39.1°C and minimum temperature range between 15.9 to 26.8°C. Monthly average wind speed is 6.5 km hr^{-1}.

The overall climatologically data indicated that the weather conditions were observed normal and favourable for the normal growth and development of the green gram crop during *kharif* season of 2021.

3.2 Cultural practices

3.2.1 Preparation of land

The experimental field was cultivated by tractor drawn cultivator. To obtain fine seed bed, field was again cultivated in both directions by tractor drawn cultivator followed by planking, the experiment was laid out as per layout plan and plots were leveled manually to open the furrows. Furrows were opened at 45 cm distance with the help of cultivator.

3.2.2 Intercultural operations

For better plant growth the field keep weed free, intercultural operation and manual weeding has been done throughout the growing season of green gram crop and 3 hand weeding were carried out during season.

3.2.3 Soil characteristics

The experiment was carried out in the sandy loam soils, highly productive with appropriate textural makeup. The mechanical and chemical analysis of the soil of the field was analyzed before the initiation of the experiment to ascertain the nutritional status of the soil.

3.3 Experimental material

3.3.1 Seed material

The seeds of green gram varieties GM-4 and GM-6 were obtained from Pulse Research Station, Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar, in *kharif* 2021.

3.4 Experimental details

The seeds of green gram were primed with different chemicals for 1 hrs and dried up to the original moisture content as per the treatment. The details are as given below.

3.4.1 Treatment details

To assess the effect of seed priming treatments on germination, vigour and yield the seeds of green gram variety GM-4 and GM-6 were soaked in different chemicals viz., water, GA_3 (5.0 ppm, 7.5 ppm, 10.0 ppm), salicylic acid (50 ppm, 100 ppm, 150 ppm), PEG-6000 (2.5 %, 5.0 %, 7.5 %), KH_2PO_4 (0.5 %, 1.0 %, 1.5 %).

Table 3.1: List of experimental treatments

Sr. No.	Treatment number	Treatment name	Sr. No.	Treatment number	Treatment name
1	T_1	Control	8	T_8	150 ppm Salicylic acid
2	T_2	Hydro priming	9	T_9	2.5 % PEG-6000
3	T_3	5 ppm GA_3	10	T_{10}	5.0 % PEG-6000
4	T_4	7.5 ppm GA_3	11	T_{11}	7.5 % PEG-6000
5	T_5	10.0 ppm GA_3	12	T_{12}	0.5 % KH_2PO_4
6	T_6	50 ppm Salicylic acid	13	T_{13}	1.0 % KH_2PO_4
7	T_7	100 ppm Salicylic acid	14	T_{14}	1.5 % KH_2PO_4

Table 3.2: Treatment combinations

Sr. No.	Treatment combinations	Sr. No.	Treatment combinations	Sr. No.	Treatment combinations	Sr. No.	Treatment combinations
1	V_1T_1	**8**	V_1T_8	**15**	V_2T_1	**22**	V_2T_8
2	V_1T_2	**9**	V_1T_9	**16**	V_2T_2	**23**	V_2T_9
3	V_1T_3	**10**	V_1T_{10}	**17**	V_2T_3	**24**	V_2T_{10}
4	V_1T_4	**11**	V_1T_{11}	**18**	V_2T_4	**25**	V_2T_{11}
5	V_1T_5	**12**	V_1T_{12}	**19**	V_2T_5	**26**	V_2T_{12}
6	V_1T_6	**13**	V_1T_{13}	**20**	V_2T_6	**27**	V_2T_{13}
7	V_1T_7	**14**	V_1T_{14}	**21**	V_2T_7	**28**	V_2T_{14}

Table 3.3: Experimental layout details

1	**Experimental Title**	**"Responses of Green Gram (*Vigna radiata* L.) to Different Priming Treatments on Germination, Growth and Yield"**
2	**Experimental Site**	Seed Science and Technology laboratory, Department of Genetics and Plant Breeding, C. P. College of Agriculture, Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagr – 385 506 (Lab study) Agronomy Instructional Farm, Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagr – 385 506 (Field study)
3	**Experimental Design**	In laboratory study: Factorial Completely Randomized Design (FCRD concept) For field study: Factorial Randomized Block Design (FRBD concept)
4	**Number of replication**	3
5	**Treatments**	28 Combinations (2 Varieties × 14 Chemical Treatments)
6	**Spacing**	45 cm × 10 cm
7	**Length of Row**	4.0 meter
8	**Gross plot area**	4 m × 1.80 m = 7.2 m^2
9	**Net plot area**	0.9 m × 3.2 m = 2.88 m^2
10	**Season**	*Kharif* 2021
11	**Agronomic practice**	As per recommendations
12	**Plant protection measure**	As per recommendations

3.5 Details of observation

The observations on different traits were recorded on five randomly selected plants from the each treatments, the average of that was worked out for further analysis.

3.5.1 Laboratory observation

3.5.1.1 Germination percentage

The laboratory germination test was conducted according to ISTA (2015). Hundred seeds from each treatment were kept for germination at 25 ± 2°C temperature and 90 ± 2% relative humidity for 7 days using top of the paper method. The seedlings were categorized into normal, abnormal, freshly ungerminated seeds and dead seeds.

$$\text{Germination percentage} = \frac{\text{Number of normal seedlings}}{\text{Total number of seeds kept for germination}} \times 100$$

3.5.1.2 Coefficient of velocity of germination (Nichols and Heydecker 1968)

$$\frac{N1 + N2 + \cdots + Ni}{N1T1 + \cdots + NiTi} \text{ x } 100$$

Where,

N = number of seed germinated every day

T = number of days from seedling corresponding to N

3.5.1.3 Root length (cm)

Five normal seedlings from each treatment were randomly selected on the 14th day for measuring root length from collar region to the tip of root in centimeter. The average root length was computed and expressed in centimeter**.**

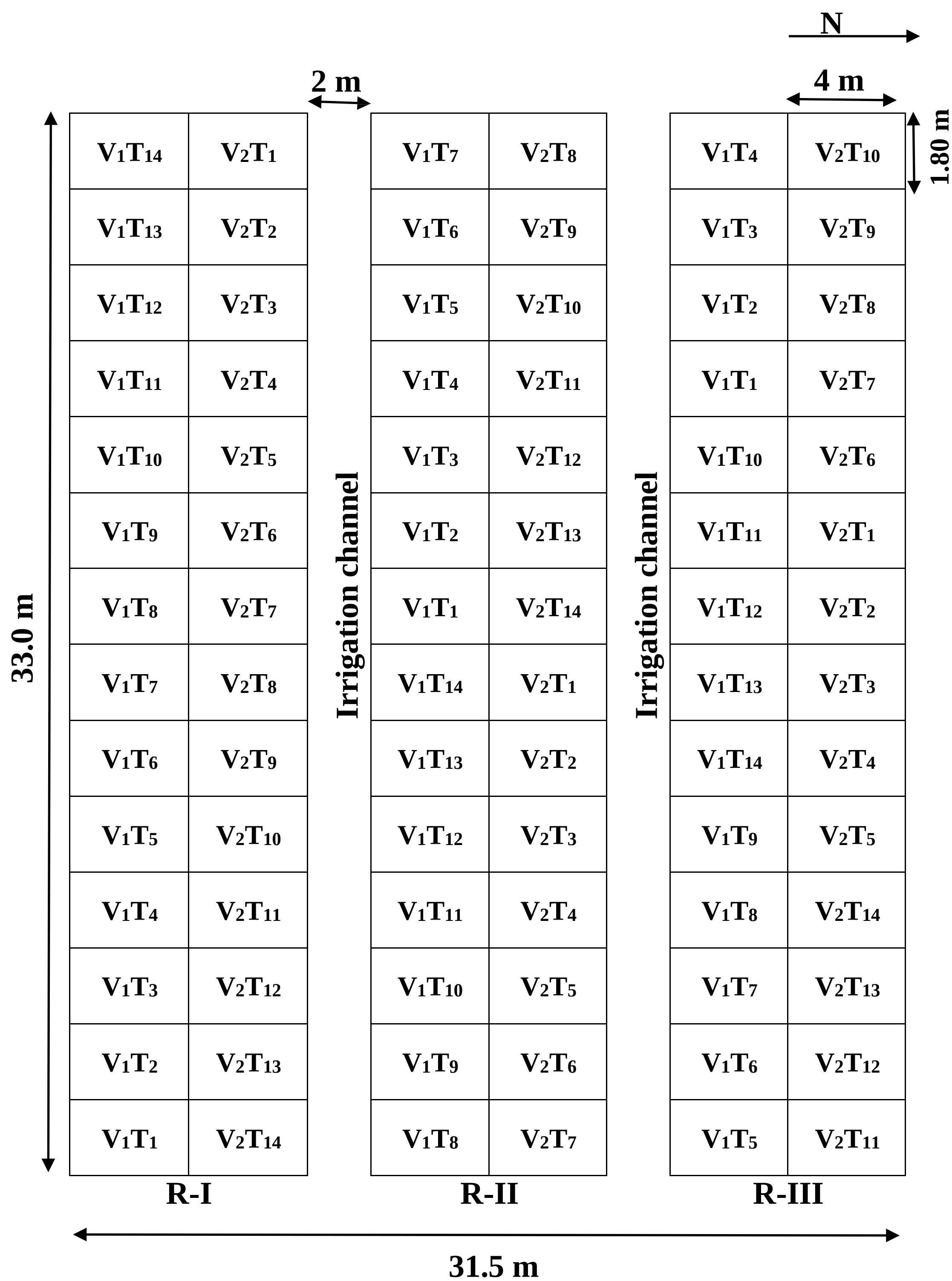
3.5.1.4 Shoot length (cm)

The shoot length was measured from five randomly selected seedlings used for measuring the shoot length. The length between collar region and tip of the shoot was considered as shoot length. Then mean value of shoot length was calculated and expressed in centimeter.

3.5.1.5 Root dry weight (mg)

The sample weighed for five root fresh weights was dried in hot air oven at 60^0C constant for 24 hrs and further weighed and average out mean value and expressed in milligram.

Fig. 3.1: Lay-out plan of the field experiment



Row × Row: 45 cm	Plant × Plant: 10 cm	No of row per plot: 4
No of plant per row: 40	Plot area: 4 m × 1.80 m	Total area: 30 m × 31.05 m
Treatment: 14	Variety: 2	Replication: 3

3.5.1.6 Shoot dry weight (mg)

The sample weighed for five shoot dry weight was measured as per root dry weight and expressed in milligram.

3.5.1.7 Seedling length (cm)

Five normal seedlings were selected at random from the each treatments then tip of root to tip of shoot length was measured and mean value of seedling length was worked out.

3.5.1.8 Fresh weight of seedling of root and shoot (mg)

To record seedling fresh weight five seedling were taken randomly from each treatments and cut root and shoot separately then fresh weight was recorded and mean value of both was average out.

3.5.1.9 Seedling dry weight (mg)

Seedlings selected for measuring their length were analyzed further for their dry weight. These seedlings were placed in paper bags; sun dried then transferred into hot air oven (60°C) constant for 24 hours. Seedling dry weight was recorded in milligram. The average weight of five seedlings was calculated for driving the seedling vigour index- II.

3.5.1.10 Vigour Index (I)

The vigour index I was calculated using the formula suggested by Abdul- Baki and Anderson (1973) and expressed in whole number.

$$\text{Vigour index (I)} = \text{Germination (\%)} \times \text{Seedling length (cm)}$$

3.5.1.11 Vigour Index (II)

The vigour index II was again calculated using the formula suggested by Abdul-Baki and Anderson (1973) and expressed in whole number.

$$\text{Vigour index (II)} = \text{Germination (\%)} \times \text{Seedling dry weight. (mg)}$$

3.5.2 Field observations

Five plant from each treatment and replication were randomly selected for recording the morphological and yield attributing characters from experimental field.

3.5.2.1 Field emergence percentage

Field emergence percentage was counted on the experimental plot. Emergence of seedling count was under taken on 10th day after sowing for each treatments and replications.

3.5.2.2 Days to taken to 50% flowering

The days taken from date of sowing to 50 per cent plants from the plot found bloomed was noted then mean value of 50 per cent flowering average out.

3.5.2.3 Number of pod per plant

The pods on five taged plants was counted and mean number of pods per plant averaged out.

3.5.2.4 Number of seed per pod

The five randomly selected pod were collected separately and mean number of seeds per pod was recorded worked out.

3.5.2.5 Pod length (cm)

Five pod taken from selected plant and length of pod was measured then mean value averaged out.

3.5.2.6 Days to maturity

Days to maturity were recorded in each treatment when all the plants in each treatment showed yellowing and pods attained physiological maturity then mean value of days to maturity work out.

3.5.2.7 Plant height (cm)

The height of the randomly selected five plants were measured (cm) from the base of the plant to the tip of main shoot and average height (cm) per plant was worked out.

3.5.2.8 Number of primary branch per plant

The number of branches emerged from the main stem of randomly selected five plants was counted from each treatments and mean value of primary branches per plant worked out.

3.5.2.9 100 seeds weight (g)

The sample of 100 seeds was drawn from threshed randomly selected five plants then weight taken by electronic balance and mean value of 100-seed weight was worked out.

3.5.2.10 Seed yield per plant (g)

The pods of five randomly selected plant set apart and seeds were separated out then cleaned thoroughly and seed weight were recorded per plant with help of balance and expressed in gram per plant.

Plate 2: General view of experimental field

Plate 1: Application of priming treatments

3.5.2.11 Seed yield per hectare (kg)

The total pods from net plot of each treatment were threshed separately and cleaned to obtain seeds and their weight was recorded separately and average seed yield per plot was worked out. The seed yield from net plot was converted on hectare basis (kg/ha). The seeds harvested from the plants of net plot in each treatment plot were recorded as seed yield per ha in green gram.

3.5.2.12 Biological yield per hectare (kg)

Biological yield is the total yield of crop including economic yield and the stover yield and it recorded from net plot after harvest then calculated on per hectare basis.

3.5.2.13 Harvest Index (HI)

The harvest index (HI) is expressed in the percentage, it is ratio between the economic yield and biological yield (Sharma and Smith, 1987). It was worked out using formula given below

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

3.6 Statistical analysis

The statistical analysis on following aspects was carried out.

3.6.1 Factorial Completely Randomized Block Design used for analysis of observations recorded in the laboratory

The characters *viz.*, germination percentage, coefficient of velocity of germination, root length (cm), shoot length (cm), seedling length (cm), fresh weight of seedling of root and shoot (mg), root dry weight (mg), shoot dry weight (mg), Seedling fresh weight (mg), seedling dry weight (mg), Seedling vigour index-I, Seedling vigour index-II. were analyzed by Factorial Completely Randomize Design described by Panse and Sukhatme (1985).

3.6.2 Factorial Randomized Block Design used for analysis of observations recorded in the field

The characters *viz.*, field emergence percentage, days taken 50 percent to flowering, number of per plant pod, number of seed per pod, Pod length (cm), days to maturity, plant height at maturity (cm), number of primary branch per plant, 100 seeds weight (g), seed yield per plant (g), seed yield per hectare,(kg) biological yield per hectare (kg) and harvest Index (HI) were analyzed by used of Factorial Randomized Block Design deserved by Panse and Sukhatme (1985).

Table 3.4: Analysis of variance for Factorial Completely Randomized Design

Source	d.f.	Sum of Square	Mean sum of square	Cal F
Factor A	(a-1)	$\frac{\sum Y^2 .j.}{rb} - CF$	SS/df= MS (A)	MS(A)/MSE
Factor B	(b-1)	$\frac{\sum Y^2 .k.}{ra} - CF$	SS/df= MS (B)	MS(B)/MSE
A × B	(a-1) (b-1)	$\frac{\sum Y^2 .jk.}{r} - \frac{\sum Y^2 .j.}{rb} - \frac{\sum Y^2 .k.}{ra} + CF$	SS/df= MS (AB)	MS(AB)/MSE
Error	(r-1) ab	TSS− ASS− BSS−RSS− ABSS	SS/df= MSE	
Total	rab-1	$\sum Y^2_{ijk} - CF$		

Where,

r = Number of replications, a = Number of factor A, b = Number of factor

Error SS = TSS – ASS – BSS – RSS – ABSS

Table 3.5: Analysis of variance for Factorial Randomized Block Design

Source	d.f.	Sum of Square	Mean sum of square	Cal F
Replication	(r-1)	$\frac{\sum_i^r Y^2 i.}{ab} - \frac{\left(\sum_{ijk}^{rab} Y_{ijk}\right)^2}{rab}$	SS/df= MS (R)	MS(R)/MSE
Factor A	(a-1)	$\frac{\sum Y^2 .j.}{rb} - CF$	SS/df= MS (A)	MS(A)/MSE
Factor B	(b-1)	$\frac{\sum Y^2 .k.}{ra} - CF$	SS/df= MS (B)	MS(B)/MSE
A × B	(a-1) (b-1)	$\frac{\sum Y^2 .jk.}{r} - \frac{\sum Y^2 .j.}{rb} - \frac{\sum Y^2 .k.}{ra} + CF$	SS/df= MS (AB)	MS(AB)/MSE
Error	(r-1) (ab-1)	TSS− ASS− BSS−RSS− ABSS	SS/df= MSE	
Total	rab-1	$\sum Y^2_{ijk} - CF$		

Where,

r = Number of replications, a = Number of factor A, b = Number of factor B

CF = Correction factor = $\frac{\left(\sum_{ijk}^{rab} Y_{ijk}\right)^2}{rab}$ = $(GT^2)/rab$

Error SS = TSS – ASS – BSS – RSS – ABSS

Standard Error of Mean (S.Em.)

Standard error of mean was calculated by the following formula:

The standard error of mean for factor A = S.Em. (A) = $\sqrt{\frac{MSE}{rb}}$

The standard error of mean for factor B = S.Em. (B) = $\sqrt{\frac{MSE}{ra}}$

The standard error of mean for interaction between A and B = $\sqrt{\frac{MSE}{r}}$

Where,

MSE = Error mean sum of square

Critical Differences (C.D.)

Critical differences was calculated by the following formula:

C.D. = $t_{(0.05)}$ $(e._{df})$ x√2 x S.Em

Where,

t = Table 't' value for error degree of freedom at 0.05 level of probability for field as well as for laboratory studies.

S.Em = Standard error of mean

Coefficient of Variation

It is the measure of variability evolved. Coefficient of variation is the ratio of standard deviation of a sample to its mean and expressed in percentage.

$$\text{C.V.}(\%) = \frac{\sqrt{\text{Ems}}}{\overline{\text{Y}}} \times 100$$

Where,

Ems= Error mean square,

$\overline{Y}$= General mean of particular character.

RESULTS AND DISCUSSION

IV. RESULTS AND DISCUSSION

The research experiment entitled **“Responses of Green gram (*Vigna radiata* L.) to different priming treatments on germination, growth and yield"**, was conducted at Agronomy Instructional Farm, Chimanbhai Patel College of Agriculture, Sardarkrushinagar Dantiwada Agricultural University, S. D. Agricultural University in *Kharif* 2021 to study the effect of seed priming treatments on germination, vigour and yield characters.

The purpose of seed priming treatment is to maintain the seed quality and produced higher seed yield. In recent days, plant population per unit area is one of the most important factor determining the crop yield. The optimum plant population per hectare needs to maintain for getting higher yield but poor crop stand leads to reduce crop yield. Uniform germination and seedling emergence is an important factor for successful establishment of plant population and it is reported that the seed priming is one of the most important development to help in uniform germination, seedling emergence and increase its tolerance to adverse environmental factors. Therefore, present study was undertaken to determine the effect of seed priming on germination, vigour and yield quality parameters in green gram.

The seed were treated for 1 hour with different priming materials *i.e* GA_3 (5.0, 7.5, 10.0 ppm), Salicylic acid (50, 100, 150 ppm), PEG-6000 (2.5, 5.0, 7.5 per cent), KH_2PO_4 (0.5, 1.0, 1.5 per cent) and dried back to original moisture content before they were sown in the experimental plot. The experiment was conducted using Factorial Randomized Block Design (FRBD). The germination, vigour and yield attributing parameters were recorded in field and the seed quality characters were studied in laboratory analysis using Factorial Completely Randomized Design (FCRD). The results obtained from different attributes have been presented and discussed below in following heads.

4.1 Analysis of variance for the experimental design

4.1.1 Analysis of variance (mean sum of square) for the laboratory experiment

4.1.2 Analysis of variance (mean sum of square) for the field experiment

4.2 Effect of seed priming treatment on seed germination and its related parameters

4.3 Effect of seed priming on yield and component

4.1 Analysis of variance for the experimental design

The analysis of variance from the mean data was carried out as per the factorial completely randomized design of the laboratory experiment and factorial randomized block design of the field experiment. The result revealed highly significant differences due to seed treatments and varieties for most of all the characters under study. Mean sum of square due to the replication were non-significant all the characters for both the experiment.

4.1.1 Analysis of variance (mean sum of square) for the laboratory experiment

In laboratory conditions, the results of analysis of variance (mean sum of square) shown in Table 4.1, observed that the significant variation for almost all characters under study *viz*., germination, coefficient of velocity of germination, root length, shoot length, seedling length, root dry weight, shoot dry weight, seedling dry weight, seedling fresh weight, vigour index-I, vigour index-II except germination and coefficient of velocity of germination.

The analysis of variance (mean sum of square) due to the treatment has shown significant variation for almost all characters under study while, the analysis of variance (mean sum of square) due to the interaction effect of varieties and treatment has shown non-significant variation for all characters.

4.1.2 Analysis of variance (mean sum of square) for the field experiment

In field conditions, the analysis of variance (mean sum of square) shown in Table 4.2, found that the variety has shown significant variation for almost all characters under study *viz*., No. of pod per plant, pod length, plant height, days to maturity, seed yield per plant, seed yield per hectare, biological yield per hectare, hundred seed weight except field emergence (%), days taken to 50 % flowering, number of seed per pod, number of primary branches per plant and harvest index.

In field conditions, analysis of variance (mean sum of square) due to the treatment has shown significant variation for almost all characters under study *viz*., No. of pod per plant, pod length, plant height, days to maturity, seed yield per plant, seed yield, biological yield, field emergence, days taken to 50 % flowering, number of seed per pod, number of primary branches per plant and harvest index except hundred seed weight and harvest index.

Table 4.1: Analysis of variance (mean sum of square) for experimental design FCRD of two varieties and fourteen treatments for various characters in green gram

Source of variation	d. f.	Germination %	Coefficient of Velocity of Germination	Root length (cm)	Shoot Length (cm)	Seedling length (cm)	Root dry weight (mg)	Shoot dry weight (mg)	Seedling dry weight (mg)	Seedling fresh weight (mg)	Vigour index-I	Vigour index-II
Varieties	1	1.19	0.55	44.01**	29.76**	146.15**	1.05**	142.48**	119.05**	6786.01**	1298388.14**	1009854.57**
Treatments	13	34.37**	43.64**	1.41**	6.32**	13.68**	4.59**	38.04**	69.03**	9735.45**	186445.92**	910269.95**
Interaction	13	0.37	1.63	0.14	0.01	0.17	0.03	0.97	1.22	16.74	1428.26	15617.47
Error	56	8.61	4.31	0.08	0.03	0.10	0.08	0.67	0.85	45.67	2503.68	18221.72

* and ** indicates significance at 5 % and 1 % levels of probability, respectively.
Where, d. f. = Degree of freedom

Table 4.2: Analysis of variance (mean sum of square) for experimental design FRBD of two varieties and fourteen treatments for various characters in green gram

Source of variation	d.f.	Field emergence %	Days to 50% Flowering	Number of Pod per Plant	Number of Seed per Pod	Number of Primary Branches per Plant	Days to Maturity	Plant Height (cm)	Pod Length (cm)	100 Seed Weight (g)	Seed Yield per Plant (g)	Seed yield per hectare (kg)	Biological Yield per hectare (kg)	Harvest Index (HI)
Replications	2	14.08	14.44	7.11	0.34	0.76	2.39	22.42	0.77	0.00	2.47	17486.09	83701.41	9.50
Varieties	1	154.71	22.01	60.69**	0.01	0.65	618.86**	526.00**	14.58**	2.02**	27.89**	38468.64*	226263.24**	0.45
Treatments	13	127.12*	21.37**	21.95**	3.39**	2.95**	40.51**	135.58**	3.30**	0.01	6.19**	31869.63**	342451.15**	2.83
Interaction	13	1.23	0.17	0.03	0.11	0.07	2.01	0.04	0.12	0.00	0.03	62.69	93.82	0.15
Error	54	63.56	8.03	4.88	1.14	0.48	9.69	24.29	0.55	0.03	1.50	9101.76	31075.55	7.38

*and** indicates significance at 5% and 1% levels of probability, respectively.
Where, d. f. = Degree of freedom

Analysis of variance (mean sum of square) due to the interaction effect of varieties and treatments have shown non-significant variation for all characters under study whereas the analysis of variance (mean sum of square) due to the replication has shown non-significant variation for all characters.

4.2 Effect of seed priming on seed germination and its related parameters

4.2.1 Effect of seed priming on germination

The results regarding to germination percentage as influenced by seed priming treatments and varieties presented in Table 4.3 and Fig. 4.1.

From the data it was observed that the effect of seed priming on germination differed non-significantly among the varieties. Slightly higher germination was recorded by variety GM-4 (93.57), as compared to variety GM-6 (93.33).

Seed priming effect on germination showed significant difference among all the treatments. Highest germination was recorded by treatment 7.5% PEG-6000 (T_{11}) (97.00) and it was at par with T_{10} (96.50), T_9 (95.83), T_{13} (95.50), T_{14} (95.50), T_{12} (94.17) and T_5 (93.50) whereas, the lowest (89.50) germination was obtained in control (T_1). The interaction effect between varieties and treatments were found non-significant.

Increase in germination percentage in primed seeds due to rapidly imbibe and revive the seed metabolism, resulting in higher germination percentage and reduction in the germination inhibitors. These results were also supported by the findings of Mishra *et al*. (2017) in pigeon pea, Afrayeem *et al*. (2018) in blackgram and Khan *et al*. (2005) in mung bean.

4.2.2 Effect of seed priming on coefficient of velocity of germination

The results related to coefficient of velocity of germination as influenced by seed priming treatments and varieties presented in Table 4.3 and Fig. 4.2.

From the data it was observed that the seed priming effect on coefficient of velocity of germination differed non-significant among the varieties. Maximum coefficient of velocity of germination (92.95%) was recorded by variety GM-4 (V_1) over to variety GM-6 (V_2) which recorded (92.79%) coefficient of velocity of germination.

Seed priming effect on coefficient of velocity of germination differed significantly among all the treatments. Superior value of coefficient of velocity of germination (96.76%) was recorded with treatment control (T_1), which was at par

Table 4.3: Influence of different priming treatments and varieties on germination (%), coefficient of velocity of germination, root length and shoot length

Priming Treatments	**Germination (%)**			**Coefficient of Velocity Germination (%)**			**Root length (cm)**			**Shoot length (cm)**		
	GM-4 (V_1)	**GM-6 (V_2)**	**Treatment (Mean)**	**GM-4 (V_1)**	**GM-6 (V_2)**	**Treatment (Mean)**	**GM-4 (V_1)**	**GM-6 (V_2)**	**Treatment (Mean)**	**GM-4 (V_1)**	**GM-6 (V_2)**	**Treatment (Mean)**
T_1 (Control)	89.67	89.33	**89.50**	96.07	97.45	**96.76**	6.00	4.13	**5.07**	8.13	6.80	**7.47**
T_2 (Hydro priming)	91.00	90.00	**90.50**	95.66	95.08	**95.37**	6.07	4.33	**5.20**	8.47	7.20	**7.83**
T_3 (5 ppm GA_3)	93.00	92.33	**92.67**	94.65	94.89	**94.77**	6.40	4.87	**5.63**	9.40	8.27	**8.83**
T_4 (7.5 ppm GA_3)	93.33	93.33	**93.33**	94.41	94.61	**94.51**	6.53	5.20	**5.87**	9.80	8.53	**9.17**
T_5 (10 ppm GA_3)	93.67	93.33	**93.50**	94.37	93.03	**93.70**	6.67	5.27	**5.97**	9.87	8.73	**9.30**
T_6 (50 ppm salicylic acid)	91.00	90.33	**90.67**	95.93	96.45	**96.19**	6.33	4.33	**5.33**	8.47	7.40	**7.93**
T_7 (100 ppm salicylic acid)	92.00	91.33	**91.67**	94.59	94.86	**94.72**	6.27	4.73	**5.50**	8.93	7.67	**8.30**
T_8 (150 ppm salicylic acid)	92.33	91.67	**92.00**	92.59	94.21	**93.40**	6.47	4.67	**5.57**	9.33	8.07	**8.70**
T_9 (2.5 % PEG-6000)	95.67	96.00	**95.83**	91.75	90.88	**91.32**	6.87	5.87	**6.37**	10.80	9.60	**10.20**
T_{10} (5 % PEG-6000)	96.33	96.67	**96.50**	89.66	90.63	**90.14**	6.93	5.73	**6.33**	10.87	9.67	**10.27**
T_{11} (7.5 % PEG-6000)	96.67	97.33	**97.00**	88.76	87.35	**88.05**	7.20	6.13	**6.67**	11.40	10.13	**10.77**
T_{12} (0.5 % KH_2PO_4)	94.33	94.00	**94.17**	91.21	90.04	**90.62**	6.73	5.33	**6.03**	10.27	9.13	**9.70**
T_{13} (1 % KH_2PO_4)	95.67	95.33	**95.50**	91.12	89.82	**90.47**	6.80	5.60	**6.20**	10.47	9.40	**9.93**
T_{14} (1.5 % KH_2PO_4)	95.33	95.67	**95.50**	90.53	89.72	**90.12**	6.87	5.67	**6.27**	10.53	9.47	**10.00**
Variety (Mean)	**93.57**	**93.33**		**92.95**	**92.79**		**6.58**	**5.13**		**9.77**	**8.58**	

	S.Em. ±	**C. D. at 5%**	**S.Em. ±**	**C.D. at 5%**	**S.Em. ±**	**C.D. at 5%**	**S.Em. ±**	**C.D. at 5%**
V	0.45	NS	0.32	NS	0.04	0.13	0.03	0.07
T	1.20	3.39	0.85	2.40	0.12	0.34	0.07	0.19
V X T	1.69	NS	1.20	NS	0.17	NS	0.10	NS
C.V. %	**3.14**		**2.23**		**4.97**		**1.81**	

with treatments *viz*., T_2, T_3, T_4, T_6 and T_7, though lowest value of coefficient of velocity of germination (88.05%) was registered with 7.5 % PEG-6000 (T_{11}). The interaction effect between varieties and treatments was not found significant for coefficient of velocity of germination.

Coefficient of velocity of germination value increases when the number of germinated seeds increased and the time required for germination decreased. Similar finding were obeserved by Singh *et al.* (2016) in lentil.

4.2.3 Effect of seed priming on root length

The results of root length as influenced by seed priming treatments and varieties are presented are Table 4.3 and Fig. 4.3.

From the examine of data it was revealed that the seed priming effect on root length differed among the varieties, significantly highest root length (6.58 cm) was recorded in variety GM-4 (V_1), while, the lowest root length (5.13 cm) was obtained with variety GM-6 (V_2).

Seed priming effect on root length were registered significant among all the treatments and highest root length (6.67 cm) was recorded with treatment 7.5% PEG-6000 (T_{11}), which was found at par with T_9 and T_{10} treatments, followed by (6.27 cm) seed primed with 1.5% KH_2PO_4 (T_{14}), though, the significantly lowest (5.07 cm) root length was obtained by control (T_1) as compared to the rest of other treatments. The interaction effect between varieties and treatments were found non-significant.

Priming treatment with PEG might be alter metabolic processes which, improved membrane integrity and enhanced physiological growth parameters like root shoot length. Present findings were also agreementd by the results of Sohail *et al*. (2018) in kabuli chickpea and Afrayeem *et al*. (2018) in blackgram.

4.2.4 Effect of seed priming treatments on shoot length

The results pertaining to shoot length as differed by seed priming treatments and varieties presented in Table 4.3 and Fig. 4.4.

Perusal of the data indicated that the seed priming effect on shoot length varied significantly in both the varieties, highest shoot length (9.77 cm) was recorded by variety GM-4 (V_1), whereas, the lowest shoot length (8.58 cm) was recorded with variety GM-6 (V_2).

Priming effect on shoot length revealed significant difference among all the treatments. Superior value of shoot length (10.77 cm) recorded with treatment 7.5%

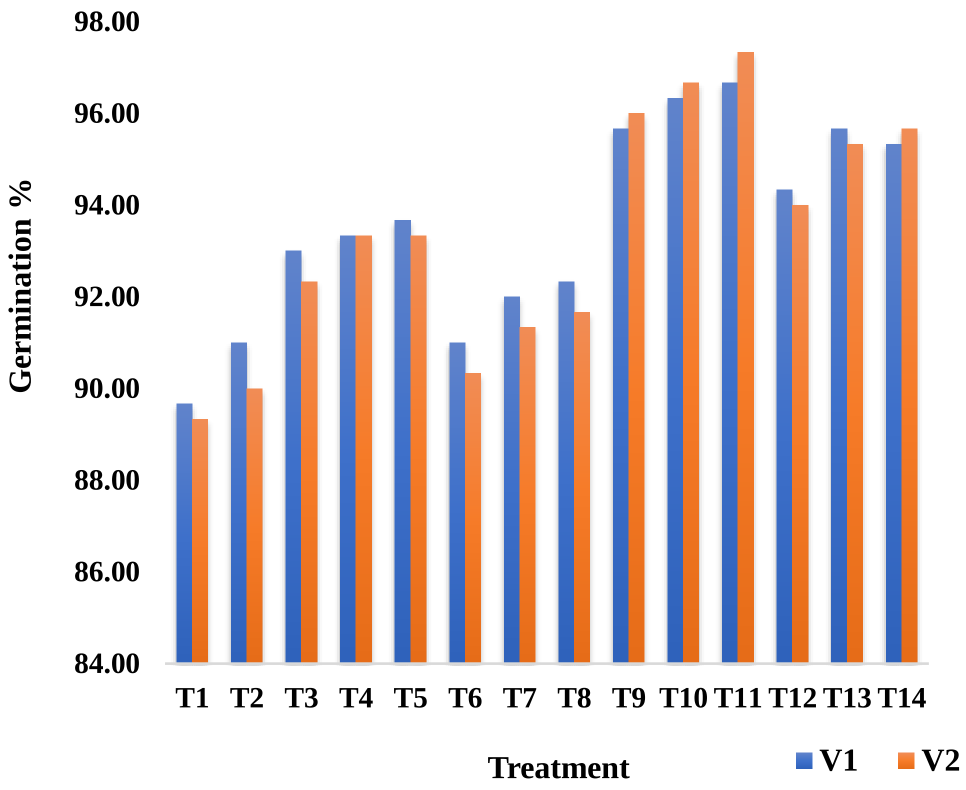


Fig. 4.1: Effect of priming treatments and varieties on seed germination percentage

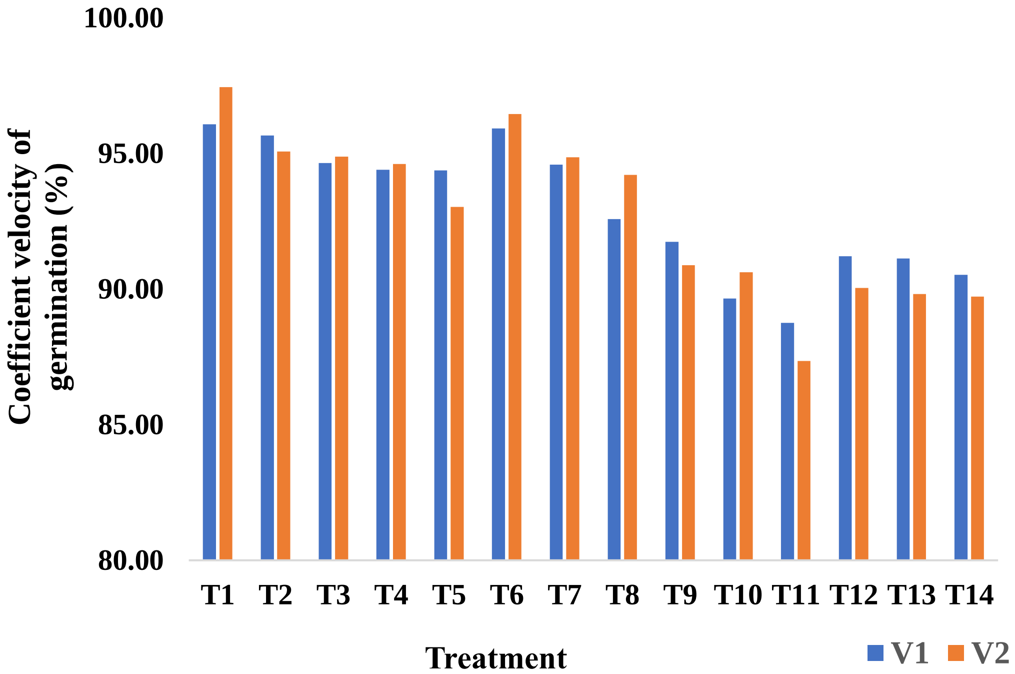


Fig. 4.2: Effect of priming treatments and varieties on coefficient of velocity of germination

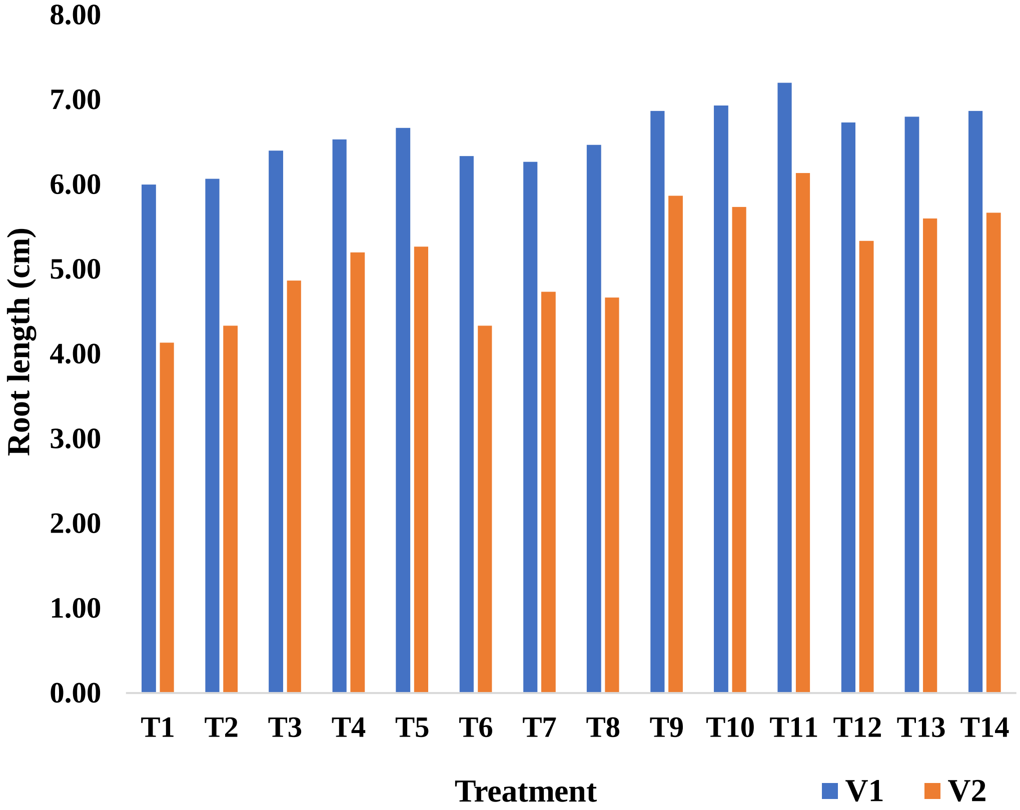


Fig. 4.3: Effect of priming treatments and varieties on root length (cm)

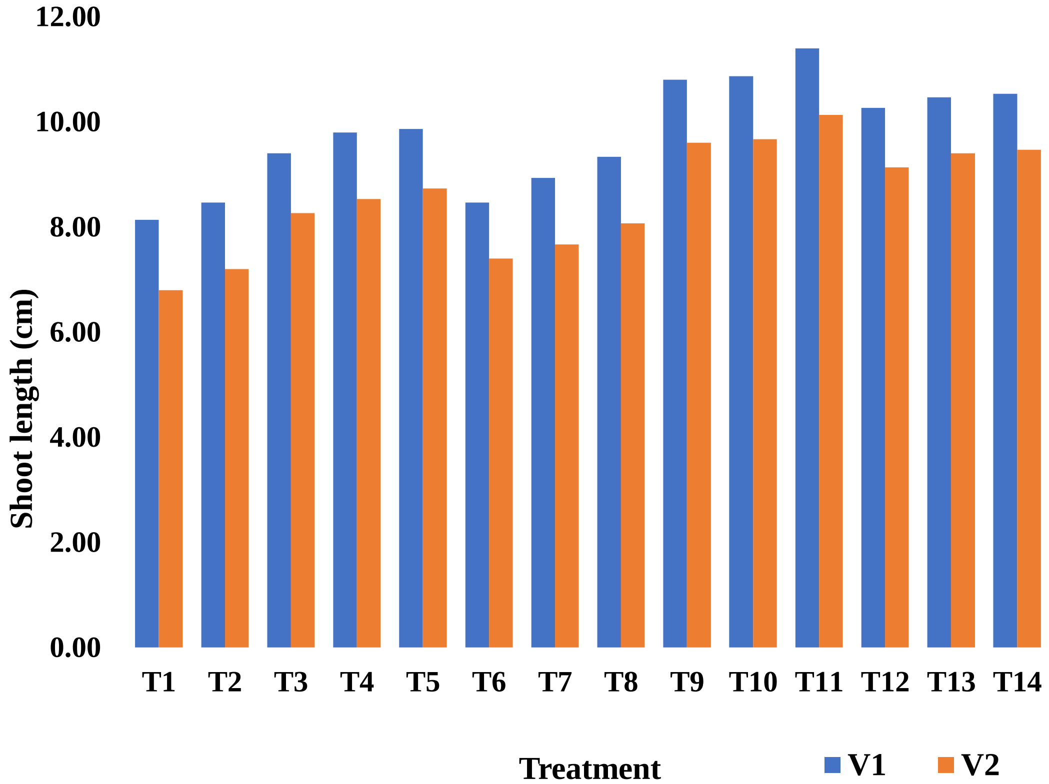


Fig. 4.4: Effect of priming treatments and varieties on shoot length (cm)

PEG-6000 (T_{11}) followed by seed primed with 5% PEG-6000 (T_{10}) (10.27 cm). Although, lowest value of shoot length was observed with control (7.47 cm) (T_1) as compared to the rest of other treatments. The interaction effect between varieties and treatments was found non-significant.

Priming treatment with PEG might be alter metabolic processes which, improved membrane integrity and enhanced physiological growth parameters like shoot length. Similar findings were also reported by Mishra *et al*. (2017) in pigeon pea and Singh *et al*. (2017) in pea.

4.2.5 Effect of seed priming treatments on seedling length

The results regarding seedling length as influenced by seed priming treatments and varieties presented in Table 4.4 and Fig. 4.5.

From the data it was observed that seed priming effect on seedling length differed among the varieties. Significantly higher seedling length (16.35 cm) was recorded by variety GM-4 (V_1), as compare to variety GM-6 (V_2) which was recorded seedling length (13.71 cm).

Priming effect on seedling length differed significantly among all the treatments, highest seedling length (17.43 cm) was recorded by seed primed with 7.5% PEG-6000 (T_{11}) followed by seed primed with 5% PEG-6000 (T_{10}) (16.60 cm) and the lowest seedling length was reported by control (T_1) (12.53 cm). The interactions effect between varieties and treatments were found non-significant.

Increase in seedling length is might be due to effect of priming treatments which, increase the cell size and cell elongation which resulted into improve the overall growth of seedlings. Our results were also supported by the findings of Mahdi and Mehdi (2013) in soyabean and Kujur and Lal (2015) in soyabean.

4.2.6 Effect of seed priming treatments on dry weight of root

The results pertaining to dry weight of root a varied by seed priming treatments and varieties presented in Table 4.4 and Fig.4.6.

Perusal of the data showed that the seed priming effect on dry weight of root differed significantly in both the varieties. Highest dry weight of root (7.88 mg) recorded with variety GM-4 (V_1), whereas, the lowest dry weight of root (7.66 mg) was recorded by variety GM-6 (V_2).

Priming effect on dry weight of root differed significantly among all the treatments. Superior value of root dry weight recorded by application with 7.5%

Table 4.4: Influence of different priming treatments and varieties on seedling length, dry weight of root, dry weight of shoot and Seedling fresh weight

Priming Treatments	Seedling length (cm)			Dry weight of root (mg)			Dry weight of shoot (mg)			Seedling fresh weight (mg)		
	GM-4 (V_1)	GM-6 (V_2)	Treatment (Mean)	GM-4 (V_1)	GM-6 (V_2)	Treatment (Mean)	GM-4 (V_1)	GM-6 (V_2)	Treatment (Mean)	GM-4 (V_1)	GM-6 (V_2)	Treatment (Mean)
T_1 (Control)	14.13	10.93	**12.53**	6.40	6.13	**6.27**	17.87	19.27	**18.57**	289.53	303.20	**296.37**
T_2 (Hydro priming)	14.53	11.53	**13.03**	6.87	6.47	**6.67**	18.67	20.27	**19.47**	304.47	319.00	**311.73**
T_3 (5 ppm GA_3)	15.80	13.13	**14.47**	7.67	7.27	**7.47**	20.80	23.20	**22.00**	345.53	363.60	**354.57**
T_4 (7.5 ppm GA_3)	16.33	13.73	**15.03**	7.73	7.73	**7.73**	21.33	24.00	**22.67**	353.60	370.60	**362.10**
T_5 (10 ppm GA_3)	16.53	14.00	**15.27**	7.93	7.73	**7.83**	22.07	24.40	**23.23**	361.27	378.60	**369.93**
T_6 (50 ppm salicylic acid)	14.80	11.73	**13.27**	7.00	6.53	**6.77**	18.87	20.73	**19.80**	309.27	324.47	**316.87**
T_7 (100 ppm salicylic acid)	15.20	12.40	**13.80**	7.27	6.93	**7.10**	19.80	21.80	**20.80**	324.13	340.47	**332.30**
T_8 (150 ppm salicylic acid)	15.80	12.73	**14.27**	7.47	7.20	**7.33**	20.20	22.20	**21.20**	334.13	350.27	**342.20**
T_9 (2.5 % PEG-6000)	17.67	15.47	**16.57**	8.80	8.60	**8.70**	23.47	27.27	**25.37**	396.47	417.73	**407.10**
T_{10} (5 % PEG-6000)	17.80	15.40	**16.60**	8.80	8.73	**8.77**	23.73	27.60	**25.67**	399.93	421.40	**410.67**
T_{11} (7.5 % PEG-6000)	18.60	16.27	**17.43**	9.20	9.00	**9.10**	24.80	28.27	**26.53**	413.00	436.53	**424.77**
T_{12} (0.5 % KH_2PO_4)	17.00	14.47	**15.73**	8.13	8.00	**8.07**	22.40	25.13	**23.77**	369.47	392.80	**381.13**
T_{13} (1 % KH_2PO_4)	17.27	15.00	**16.13**	8.53	8.40	**8.47**	23.27	26.20	**24.73**	385.80	400.00	**392.90**
T_{14} (1.5 % KH_2PO_4)	17.40	15.13	**16.27**	8.53	8.47	**8.50**	23.00	26.40	**24.70**	387.40	407.00	**397.20**
Variety (Mean)	**16.35**	**13.71**		**7.88**	**7.66**		**21.45**	**24.05**		**355.29**	**373.26**	

	S.Em. ±	C. D. at 5%	S.Em. ±	C.D. at 5%	S.Em. ±	C.D. at 5%	S.Em. ±	C.D. at 5%
V	0.05	0.14	0.04	0.12	0.13	0.36	1.04	2.95
T	0.13	0.36	0.11	0.32	0.33	0.94	2.76	7.82
V X T	0.18	NS	0.16	NS	0.47	NS	3.90	NS
C.V. %	**2.09**		**3.54**		**3.59**		**1.86**	

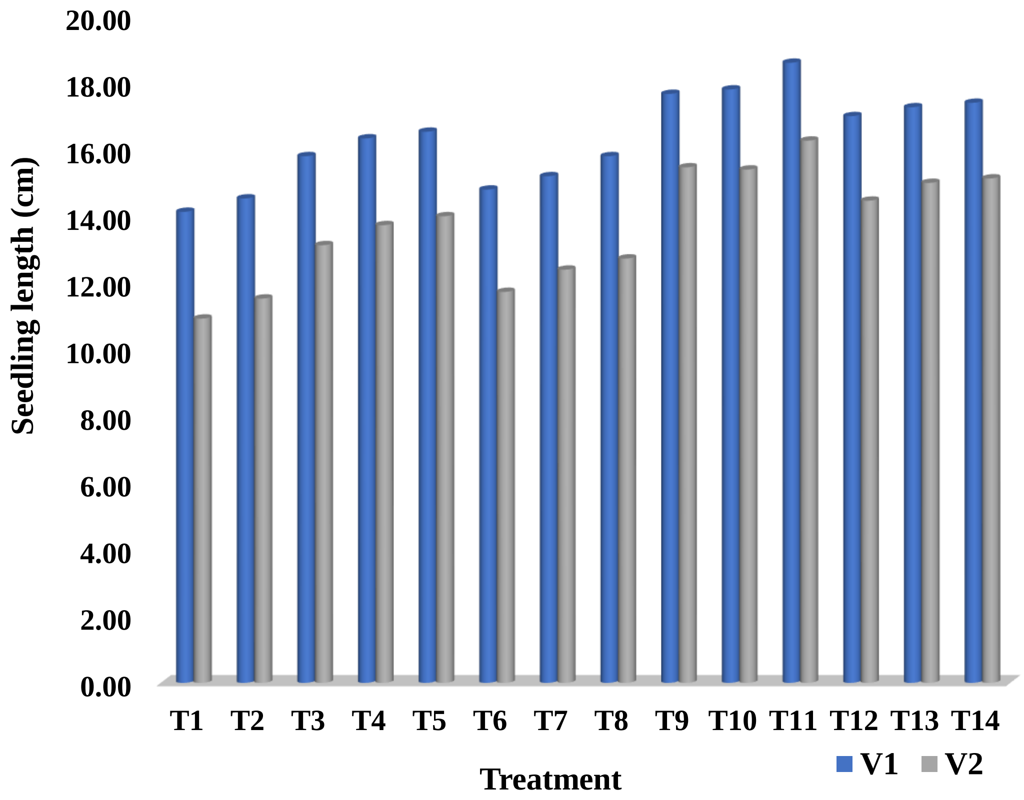


Fig. 4.5: Effect of priming treatments and varieties on seedling length (cm)

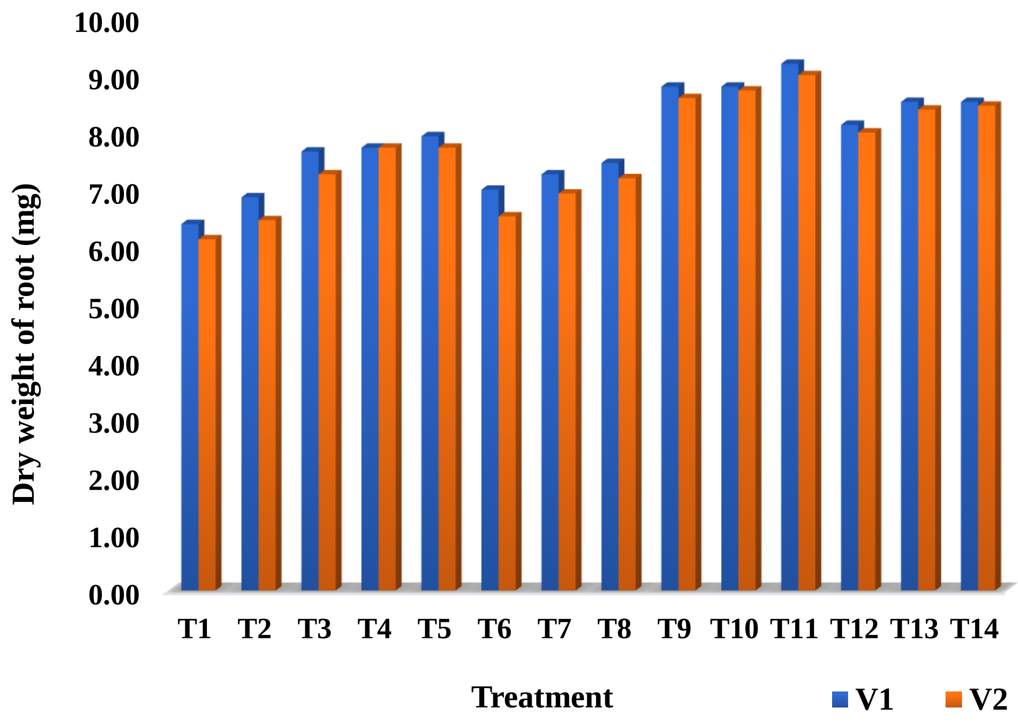


Fig. 4.6: Effect of priming treatments and varieties on dry weight of root (mg)

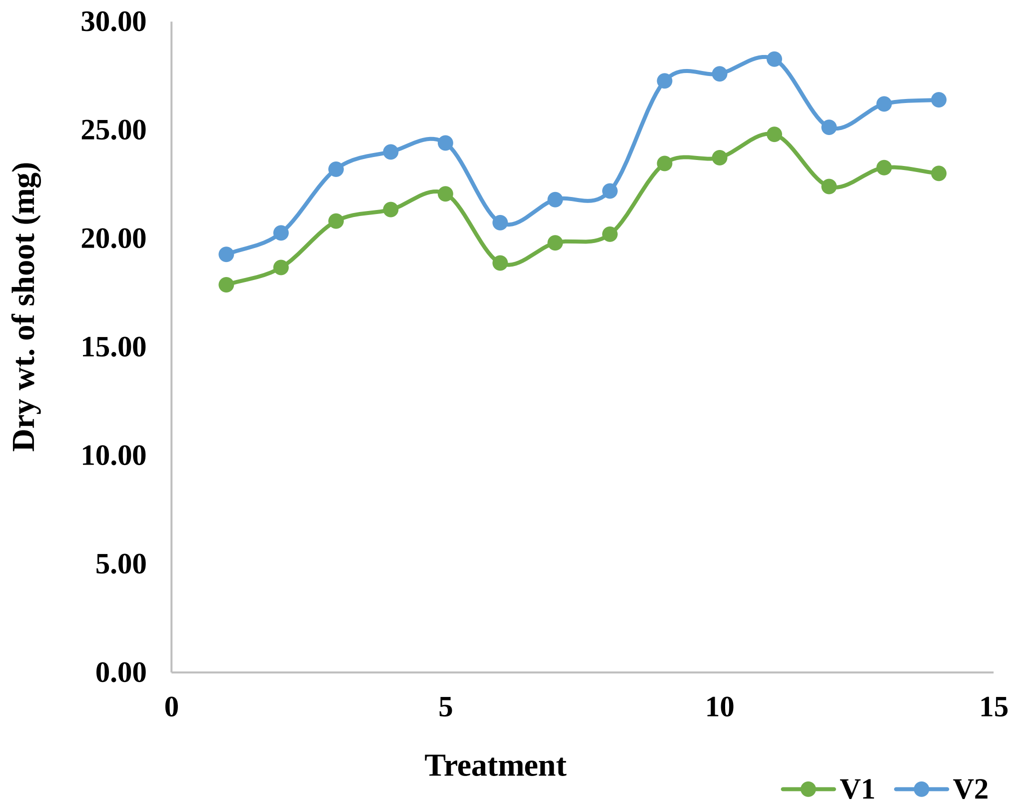


Fig. 4.7: Effect of priming treatments and varieties on dry weight of shoot (mg)

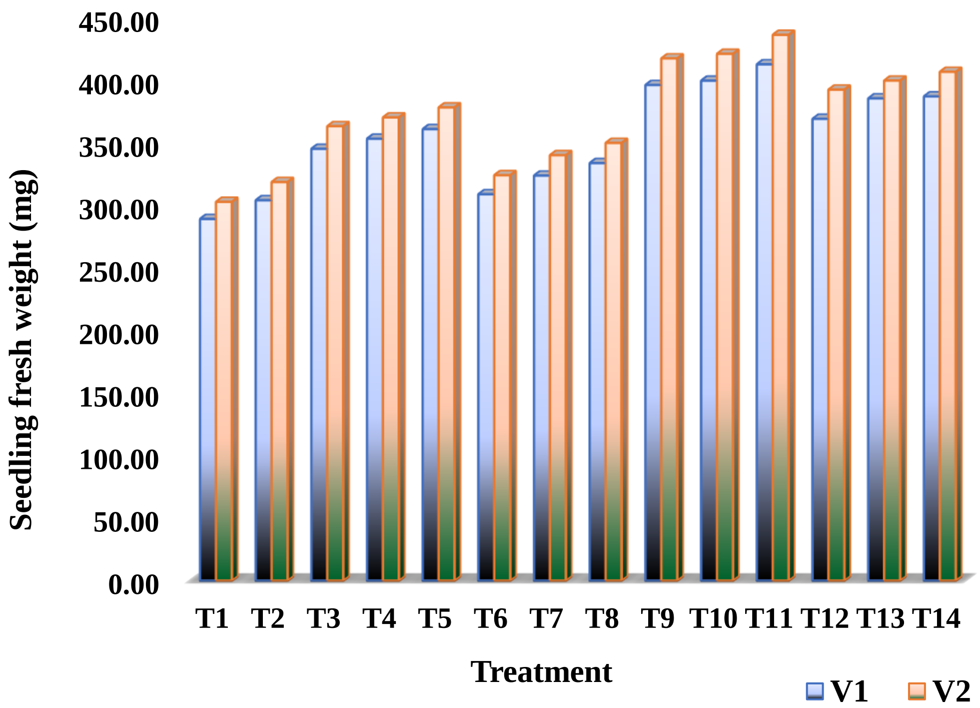


Fig. 4.8: Effect of priming treatments and varieties on seedling fresh weight (mg)

PEG-6000 (T_{11}) (9.10 mg) followed by (8.77 mg) seed primed with 5% PEG-6000 (T_{10}) though, the lowest value of dry weight of root was observed with control (T_1) (6.27 mg). The interactions effect between varieties and treatments was not found significant.

The reason behind superiority of PEG is might be due to its potency to maintain turgor pressure of cell and to increase metabolism. Same results were also reported by Uddin *et al.* (2021) in mung bean.

4.2.7 Effect of seed priming treatments on dry weight of shoot

The results of dry weight of shoot differed with seed priming treatments and varieties are presented in Table 4.4 and Fig. 4.7.

From the data, examine it was observed that the seed priming effect on dry weight of shoot differed within the varieties and it was found that the highest dry weight of shoot was observed in variety GM-6 (24.05 mg) whereas, the lowest dry weight of shoot was observed in variety GM-4 (21.45 mg).

Seed priming effect on dry weight of shoot were registered significantly differ among all the treatments. Highest shoot dry weight was recorded by seed primed with 7.5% PEG-6000 (26.53 mg), followed by 5% PEG-6000 (T_{10}) (25.67 mg) though, the lowest dry weight of shoot (18.57 mg) was obtained in control (T_1) as compared to the rest of other treatments. The interactions effect between varieties and treatments were not found significant.

It was observed due to effect of priming treatment induce water uptake that maintain turgor pressure of cell and increased metabolism, which might be increased growth. Present study were also supported by the results of Uddin *et al.* (2021) in mung bean.

4.2.8 Effect of seed priming treatments on seedling fresh weight

The results regarding to seedling fresh weight as influenced by seed priming treatments and varieties presented in Table 4.4 and Fig. 4.8.

Table 4.4 showed that the seed priming effect on seedling fresh weight differed significantly in both the varieties. Superior value of seedling fresh weight (373.26 mg) was reported by variety GM-6, whereas, the lowest value seedling fresh weight (355.29 mg) was obtained in variety GM-4.

Impact of priming on seedling fresh weight were differed significantly in all the priming treatments. The highest seedling fresh weight (424.77 mg) was observed in treatment 7.5% PEG-6000 (T_{11}) followed by (410.67mg) seed primed with 5% PEG-6000 (T_{10}) whereas minimum seedling fresh weight (296.37 mg) was observed with control (T_1) as compared to the rest of other treatments. The interactions effect between varieties and treatments were found non-significant. Increase in seedling fresh weight is might be due to increasing water absorption.

These results were consistent with the findings obtained by Sohail *et al*. (2018) in kabuli chickpea and Afaryeem *et al.* (2018) in blackgram.

4.2.9 Effect of seed priming treatments on seedling dry weight

The results related to seedling dry weight differed by seed priming treatments and varieties presented in Table 4.5 and Fig. 4.9.

From the examine of data containing in Table 4.5 revealed that the seed priming effect on seedling dry weight varied significantly within the varieties. Maximum valued seedling dry weight (31.71 mg) was recorded by variety GM-6 (V_2), as compare to variety GM-4 (V_1) (29.33 mg).

Seed priming effect on seedling dry weight differed significantly among all the priming treatments. The superior value of seedling dry weight (35.63 mg) was recorded by treatment 7.5% PEG-6000 (T_{11}) followed by (34.43 mg) seed primed with 5% PEG-6000 (T_{10}) and lowest seedling dry weight (24.83 mg) was reported by control (T_1) as compared to the rest of other treatments. The interactions effect due to varieties and treatments were found at par to each other.

Our findings were also supported by the Sadeghi *et al*. (2011) in soyabean, Singh *et al*. (2017) in pea and Afaryeem *et al*. (2018) in blackgram.

4.2.10 Effect of seed priming treatments on vigour index - I

The results related to vigour index–I as influenced by seed priming treatments and varieties presented in Table 4.5 and Fig. 4.10.

Perusal of the data revealed that the seed priming effect on vigour index–I differed significantly in both the varieties. Maximum value of vigour index–I was recorded (1532.20) by variety GM-4 (V_1), over to variety GM-6 (V_2) (1283.55).

Seed priming effect on vigour index–I influenced significantly among all the treatments. The highest vigour index-I (1690.60 mg) was recorded by treatment 7.5% PEG-6000 (T_{11}) followed by (1601.33) seed primed with 5% PEG-6000 (T_{10}), whereas, the lowest vigour index-I (1122.10) was reported by control (T_1). The interaction effect by combination of varieties and treatments was found non-significant.

Table 4.5: Influence of different priming treatments and varieties on seedling dry weight, vigour index-I and vigour index - II

Priming Treatments	Seedling dry weight (mg)			Vigour Index - I			Vigour Index - II		
	GM-4 (V_1)	GM-6 (V_2)	Treatment (Mean)	GM-4 (V_1)	GM-6 (V_2)	Treatment (Mean)	GM-4 (V_1)	GM-6 (V_2)	Treatment (Mean)
T_1 (Control)	24.27	25.40	**24.83**	1267.40	976.80	**1122.10**	2175.53	2269.07	**2222.30**
T_2 (Hydro priming)	25.53	26.73	**26.13**	1322.33	1037.93	**1180.13**	2322.07	2406.53	**2364.30**
T_3 (5 ppm GA_3)	28.47	30.47	**29.47**	1468.60	1212.73	**1340.67**	2646.20	2812.47	**2729.33**
T_4 (7.5 ppm GA_3)	29.07	31.73	**30.40**	1524.47	1282.53	**1403.50**	2712.53	2964.93	**2838.73**
T_5 (10 ppm GA_3)	30.00	32.13	**31.07**	1548.47	1306.73	**1427.60**	2809.47	2998.87	**2904.17**
T_6 (50 ppm salicylic acid)	25.87	27.27	**26.57**	1345.00	1060.00	**1202.50**	2352.87	2462.73	**2407.80**
T_7 (100 ppm salicylic acid)	27.07	28.73	**27.90**	1398.07	1131.67	**1264.87**	2489.80	2626.40	**2558.10**
T_8 (150 ppm salicylic acid)	27.67	29.40	**28.53**	1459.27	1167.47	**1313.37**	2553.67	2696.13	**2624.90**
T_9 (2.5 % PEG-6000)	32.27	35.87	**34.07**	1690.33	1484.47	**1587.40**	3089.40	3444.07	**3266.73**
T_{10} (5 % PEG-6000)	32.53	36.33	**34.43**	1714.27	1488.40	**1601.33**	3136.73	3512.93	**3324.83**
T_{11} (7.5 % PEG-6000)	34.00	37.27	**35.63**	1797.73	1583.47	**1690.60**	3286.93	3627.47	**3457.20**
T_{12} (0.5 % KH_2PO_4)	30.53	33.13	**31.83**	1604.07	1359.47	**1481.77**	2881.27	3115.47	**2998.37**
T_{13} (1 % KH_2PO_4)	31.80	34.60	**33.20**	1652.27	1430.00	**1541.13**	3040.87	3299.60	**3170.23**
T_{14} (1.5 % KH_2PO_4)	31.53	34.87	**33.20**	1658.53	1448.00	**1553.27**	3004.40	3335.13	**3169.77**
Variety (Mean)	**29.33**	**31.71**		**1532.20**	**1283.55**		**2750.12**	**2969.41**	

	S.Em. ±	C.D. at 5%	S.Em. ±	C.D. at 5%	S.Em. ±	C.D. at 5%
V	0.14	0.40	7.72	21.87	20.83	59.01
T	0.38	1.07	20.43	57.87	55.11	156.12
V X T	0.53	NS	28.89	NS	77.94	NS
C.V. %	**3.03**		**3.55**		**4.72**	

This result was agreemented with the results of Mahdi and Mehdi (2013) in soyabean and Mishra *et al*. (2017) in pigeon pea.

4.2.11 Effect of seed priming treatments on vigour index – II

The results of vigour index–II differed by seed priming treatments and varieties presented in Table 4.5 and Fig. 4.11.

From the perusal of data it was found that the seed priming effect on vigour index–II differed significantly in both the varieties. Variety GM-6 recorded superior value of seedling (2969.41) vigour index-II over to variety GM-4 (2750.12).

Priming effect on vigour index–II showed significant difference among all the treatments. Vigour index–II was recorded maximum (3457.20) by treatment 7.5% PEG-6000 (T_{11}), which was at par with (3324.83) 5% PEG-6000 (T_{10}), whereas, the lowest vigour index–II (2222.30) was reported by control (T_1) as compared to the rest of other treatments. The interactions effect between varieties and treatments was found non-significant.

Our results were supported by the findings of Sohail *et al*. (2018) in kabuli chickpea and Bera (2021) in chickpea.

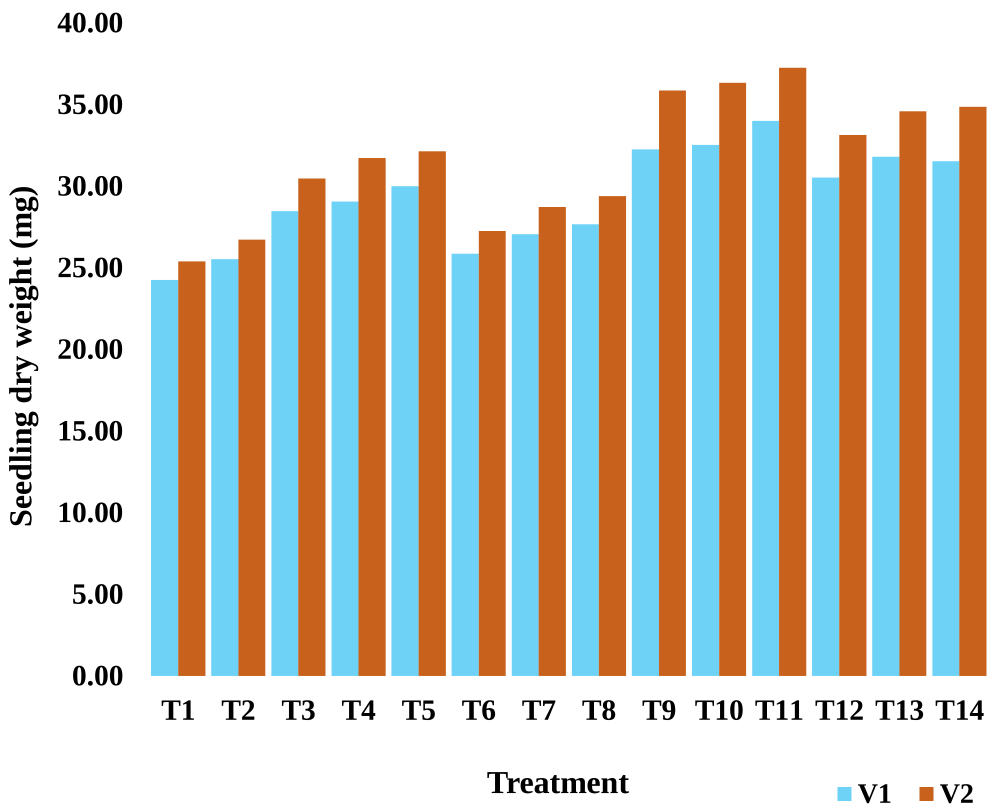


Fig. 4.9: Effect of priming treatments and varieties on seedling dry weight (mg)

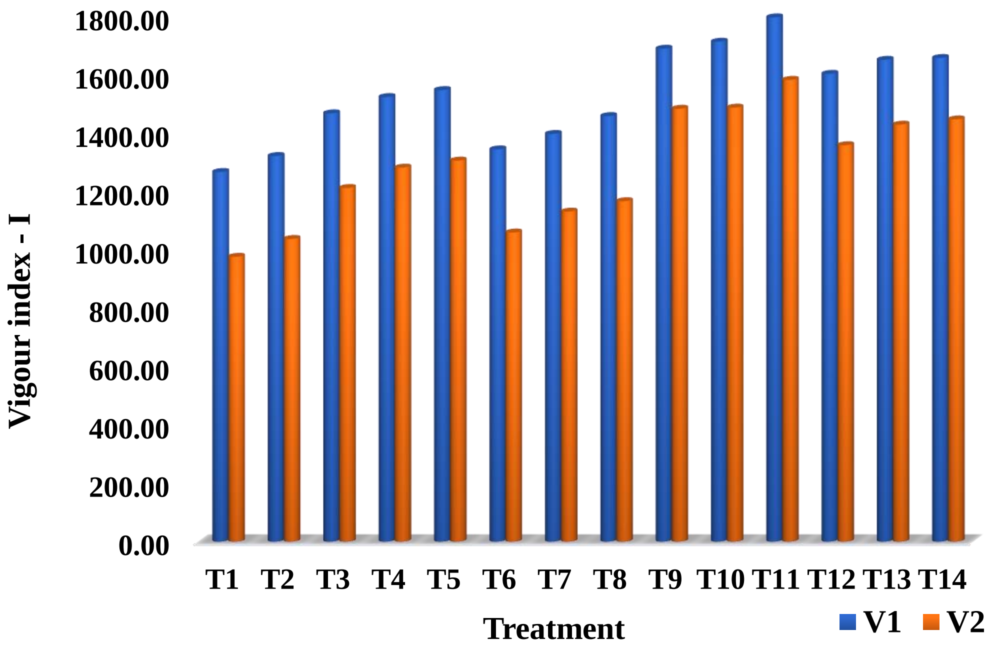


Fig. 4.10: Effect of priming treatments and varieties on vigour index-I

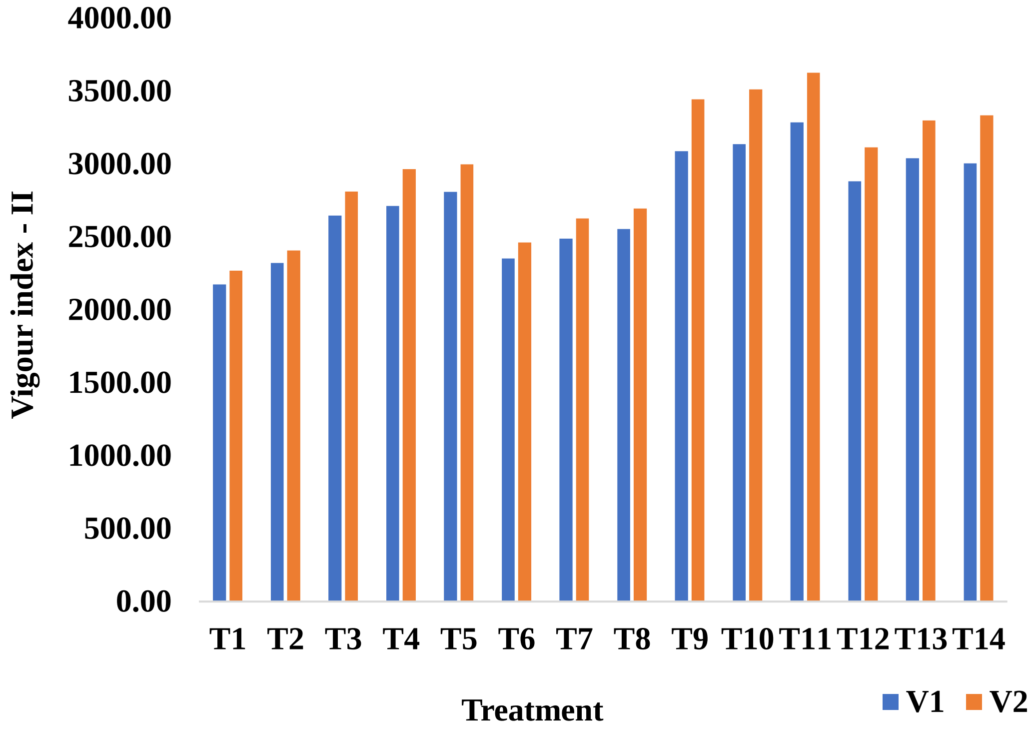


Fig. 4.11: Effect of priming treatments and varieties on vigour index-II

4.3 To study the effect of seed priming treatment on yield and its component

4.3.1 Effect of seed priming treatments on field emergence

The results pertaining to field emergence as influenced by seed priming treatments and varieties presented in Table 4.6 and Fig. 4.12.

From the data it is crystal cleared that the seed priming effect on field emergence was found non-significant in both the varieties, although, highest field emergence (85.33%) was recorded by variety GM-6 (V_2) and lowest variety GM-4 (V_1) (82.62%).

Impact of seed priming on field emergence was found significant among all the treatments. Maximum field emergence was recorded (90.50%) by treatment 7.5% PEG-6000 (T_{11}), showed significant superiority over to control, hydropriming and priming with salicylic acid 50 and 100 ppm in case of field emergence, whereas a rest of all other treatments were found at par with each other. The interaction effect between varieties and treatments was not found significant.

PEG enhanced phenology in mung bean due to primed seed is associated with uniform emergence and reduced germination imbibition. Same line of findings were also reported by Mishra *et al.* (2017) in pigeonpea and Lamichaney *et al*. (2018) in chickpea.

4.3.2 Effect of seed priming treatments on days taken to 50 % flowering

The results related to days taken to 50 % flowering was differed with seed priming treatments and varieties presented in Table 4.6 and Fig. 4.13.

Perusal of the data indicated that the seed priming effect on days to 50 % flowering not differed significantly between the varieties. Though, minimum (34.71 days) days took for 50 % flowering variety GM-6 (V_2) as compared variety GM-4 (V_1).

Seed priming effect on days to 50 % flowering was found significantly different among all the treatments. The lowest (32) days taken to 50 % flowering recorded by treatment 7.5% PEG-6000 (T_{11}), which was at par with T_{10}, T_8, T_{14}, T_{13}, T_{12} and T_5, whereas, the highest (38) days taken to 50 % flowering was recorded in control (T_1) which recorded (35.74) days taken for 50 % flowering. The interaction effect between varieties and treatments was found non-significant.

Such earliness in flowering behaviour may be ascribed to faster emergence and better growth of plants as reflected with higher number of leaves resulting in higher

Table 4.6: Influence of different priming treatments and varieties on Field emergence (%), Days to 50% flowering, No. of pod per plant and No. of seed per pod

Priming Treatments	Field emergence (%)			Days to 50% Flowering			No. of pod per plant			No. of seed per pod		
	GM-4 (V_1)	GM-6 (V_2)	Treatment (Mean)	GM-4 (V_1)	GM-6 (V_2)	Treatment (Mean)	GM-4 (V_1)	GM-6 (V_2)	Treatment (Mean)	GM-4 (V_1)	GM-6 (V_2)	Treatment (Mean)
T_1 (Control)	75.00	77.67	**76.33**	38.66	37.33	**38.00**	20.53	22.40	**21.47**	11.00	10.53	**10.77**
T_2 (Hydro priming)	76.33	79.67	**78.00**	37.66	37.00	**37.33**	21.27	23.13	**22.20**	11.27	10.80	**11.03**
T_3 (5 ppm GA_3)	81.00	84.33	**82.67**	36.33	35.66	**36.00**	23.27	25.00	**24.13**	11.87	11.73	**11.80**
T_4 (7.5 ppm GA_3)	82.00	85.00	**83.50**	36.00	35.00	**35.50**	23.73	25.47	**24.60**	11.93	11.93	**11.93**
T_5 (10 ppm GA_3)	83.67	86.00	**84.83**	35.66	34.66	**35.16**	24.00	25.73	**24.87**	12.13	12.20	**12.17**
T_6 (50 ppm salicylic acid)	77.33	79.67	**78.50**	37.66	36.66	**37.16**	21.47	23.40	**22.43**	11.33	11.07	**11.20**
T_7 (100 ppm salicylic acid)	78.67	81.67	**80.17**	37.33	36.33	**36.83**	22.27	24.00	**23.13**	11.53	11.40	**11.47**
T_8 (150 ppm salicylic acid)	80.33	83.00	**81.67**	37.33	36.00	**36.66**	22.73	24.53	**23.63**	11.73	11.53	**11.63**
T_9 (2.5 % PEG-6000)	87.00	89.67	**88.33**	33.33	32.33	**32.83**	25.87	27.53	**26.70**	12.67	12.93	**12.80**
T_{10} (5 % PEG-6000)	87.33	91.00	**89.17**	33.00	32.66	**32.83**	26.07	27.53	**26.80**	12.80	12.93	**12.87**
T_{11} (7.5 % PEG-6000)	89.33	91.67	**90.50**	32.66	31.33	**32.00**	26.87	28.33	**27.60**	13.07	13.40	**13.23**
T_{12} (0.5 % KH_2PO_4)	84.00	87.67	**85.83**	35.33	34.33	**34.83**	24.47	26.13	**25.30**	12.27	12.40	**12.33**
T_{13} (1 % KH_2PO_4)	85.33	88.33	**86.83**	35.00	33.33	**34.16**	25.33	27.00	**26.17**	12.47	12.73	**12.60**
T_{14} (1.5 % KH_2PO_4)	89.33	89.33	**89.33**	34.33	33.33	**33.83**	25.53	27.00	**26.27**	12.53	12.73	**12.63**
Variety (Mean)	**82.62**	**85.33**		**35.74**	**34.71**		**23.81**	**25.51**		**12.04**	**12.02**	

	Field emergence (%)		Days to 50% Flowering		No. of pod per plant		No. of seed per pod	
	S.Em. ±	**C. D. at 5%**	**S.Em. ±**	**C. D. at 5%**	**S.Em. ±**	**C.D. at 5%**	**S.Em. ±**	**C.D. at 5%**
V	1.23	NS	0.44	NS	0.34	0.97	0.16	NS
T	3.25	9.23	1.16	3.28	0.90	2.56	0.44	1.24
V X T	4.60	NS	1.64	NS	1.28	NS	0.62	NS
C.V. %	**9.49**		**8.05**		**8.96**		**8.87**	

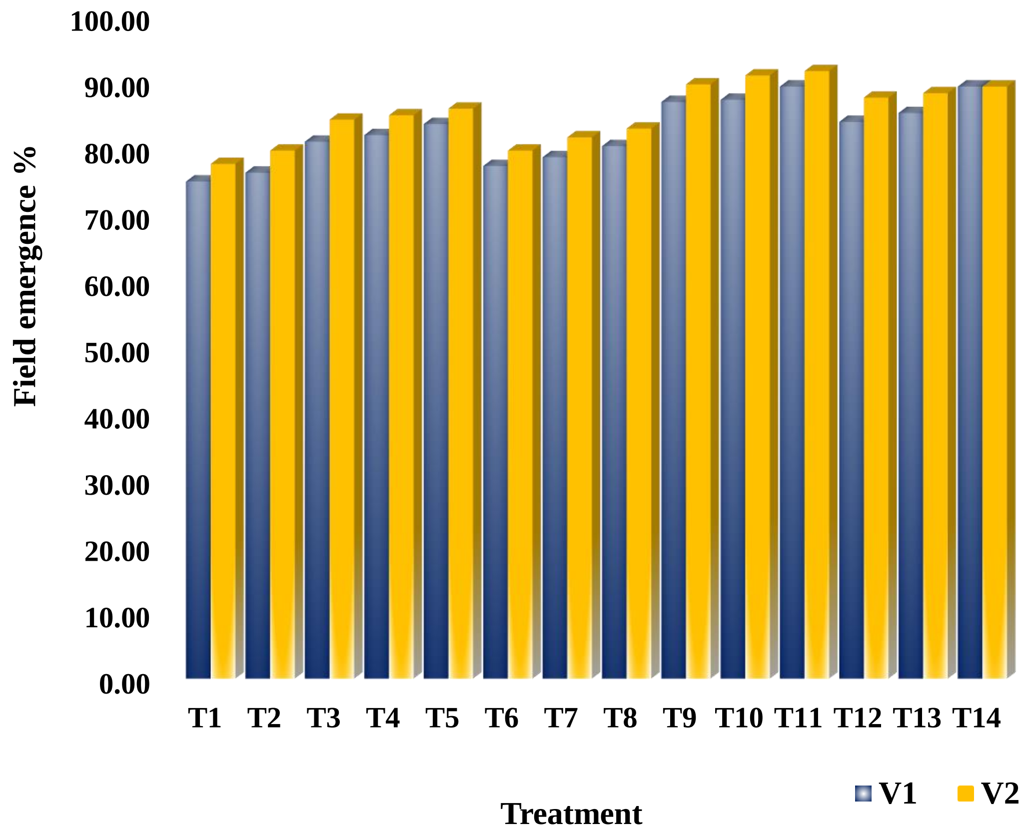


Fig. 4.12: Effect of priming treatments and varieties on field emergence (%) at field level

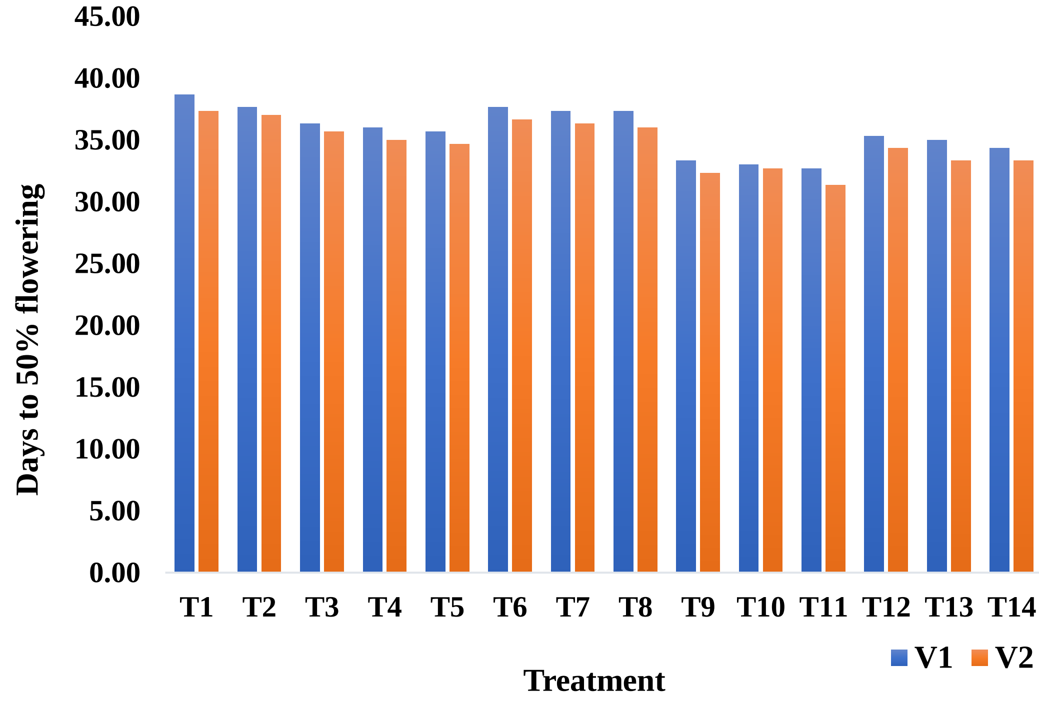


Fig. 4.13: Effect of priming treatments and varieties on days to 50 % flowering at field level

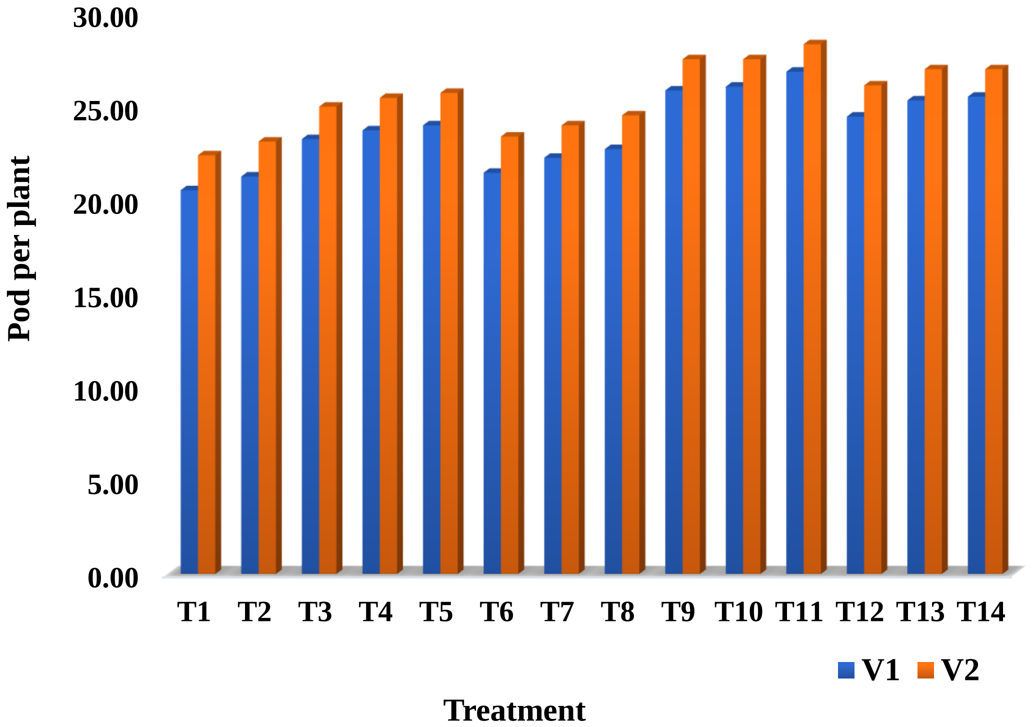


Fig. 4.14: Effect of priming treatments and varieties on no. of pod per plant at field level

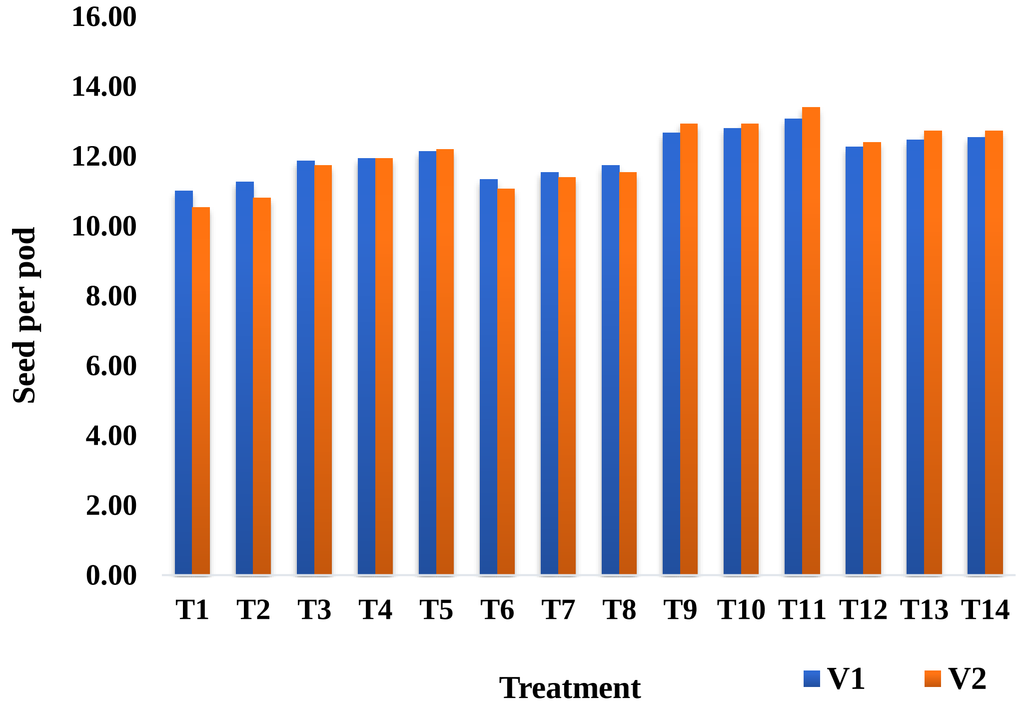


Fig. 4.15: Effect of priming treatments and varieties on no. of seed per pod at field level

photosynthetic activity triggering the synthesis of hormones involved in flowering behaviour and their active role in various physiological and bio-chemical processes of the plants. The result was consistent with the results of Khan *et al.* (2008) in mung bean and Arif *et al*. (2014) in soyabean.

4.3.3 Effect of seed priming treatments on number of pod per plant

The results related to number of pod per plant varied significantly by seed priming treatments and varieties presented in Table 4.6 and Fig. 4.14.

Carefully evaluate the data revealed that the seed priming effect on pods per plant differed significantly in both the varieties. The highest pods per plant (25.51) was observed in variety GM-6, however, the lowest pods per plant (23.81) was recorded by variety GM-4.

Different priming treatment effect on number of pod per plant influenced significantly among all the treatments. Superiority observed in case of pods per plant (27.60) with treatment 7.5% PEG-6000 (T_{11}), which was at par with treatments *viz.*, T_{10}, T_9, T_{14}, T_{13} and T_{12}, while, the lowest (21.47) number of pod per plant recorded in control (T_1). The interaction effect between varieties and treatments was not found significant for pods per plant.

PEG priming treatment improved number of branches per plant and decreased the flower abscission and increased pod setting on the plant. Our findings were at agreement with results of Bera (2021) in chickpea and Toklu (2015) in lentil.

4.3.4 Effect of seed priming treatments on number of seed per pod

The results of seeds per pod as significantly differed with seed priming treatments and varieties presented in Table 4.6 and Fig. 4.15.

The perusal of data revealed that the seed priming effect on number of seed per pod differed non-significantly within the varieties.

Priming of seed showed significant differences in case number of seed per pod and highest number of seed per pod (13.23) was recorded by priming with 7.5% PEG-6000 (T_{11}), which was found at par with treatments *viz.*, T_{10}, T_9, T_{14}, T_{13}, T_{12} and T_5, while, the lowest (10.77) number of seed per pod was obtained in control (T_1). The interaction effect between varieties and treatments were found non-significant for number of seed per pod.

Similar findings were also reported by Khan *et al.* (2008) in mung bean and Arif *et. al.* (2014) in soyabean.

4.3.5 Effect of seed priming treatments on pod length

The results related to pod length as influenced by seed priming treatments and varieties presented in Table 4.7 and Fig. 4.16.

Perusal of the data showed that the seed priming effect on pod length differed significantly in both the varieties. The highest pod length (9.00 cm) was observed in variety GM-6 (V_2), whereas, minimum value of pod length (8.17 cm) recorded with variety GM-4 (V_1).

Seed priming effect on pod length was found significant in all the treatments. Maximum value of pod length was recorded with treatment 7.5% PEG-6000 (T_{11}) (9.73 cm), which was at par with treatments *viz*., T_{10}, T_9, T_{14}, T_{13} and T_{12}, while, the lowest pod length (7.40 cm) was reported by control (T_1). The interactions effect between varieties and treatments were observed at par to each other for pod length.

Increase in pod length in priming treatments due to the increased metabolic activity of plant which resulted overall increase growth of the plant. The results were also supported by the findings of Mohamedy and Abd El-Baky (2008) in pea for pod length.

4.3.6 Effect of seed priming treatments on days to maturity

The results regarding to days to maturity varied by seed priming treatments and varieties presented in Table 4.7 and Fig. 4.17.

From the data it was observed that the seed priming effect on days to maturity differed significantly within the varieties. Significantly lowest days to maturity was recorded by variety GM-4 (V_1) (64.36) as compared to variety GM-6 (V_2), which taken (69.79) days to maturity.

Seed priming effects on days to maturity differed significantly among all the treatments. Lowest days to maturity was recorded by treatment 7.5% PEG-6000 (T_{11}) (62.66), which was at par with *viz*., T_{10}, T_9, T_{14}, T_{13} and T_{12}, however, highest (70.83 days) days to maturity was observed in control (T_1). The interaction effect between varieties and treatments was found non-significant.

Similar results were also observed by Arif *et al*. (2014) found that PEG reduced the days to maturity in soyabean.

4.3.7 Effect of seed priming treatments on plant height

The results of plant height differed by seed priming treatments and varieties presented in Table 4.7 and Fig. 4.18.

Table 4.7: Influence of different priming treatments and varieties on Pod length, days to maturity, plant height and primary branches per plant

Priming Treatments	Pod Length (cm)			Days to maturity			Plant height			Primary branches per plant		
	GM-4 (V_1)	GM-6 (V_2)	Treatment (Mean)	GM-4 (V_1)	GM-6 (V_2)	Treatment (Mean)	GM-4 (V_1)	GM-6 (V_2)	Treatment (Mean)	GM-4 (V_1)	GM-6 (V_2)	Treatment (Mean)
T_1 (Control)	6.73	8.07	**7.40**	67.33	74.33	**70.83**	45.00	50.00	**47.50**	4.80	4.60	**4.70**
T_2 (Hydro priming)	7.00	8.20	**7.60**	66.66	73.66	**70.16**	46.87	51.80	**49.33**	5.00	4.93	**4.97**
T_3 (5 ppm GA_3)	7.87	8.73	**8.30**	64.66	71.33	**68.00**	51.60	56.60	**54.10**	5.67	5.73	**5.70**
T_4 (7.5 ppm GA_3)	8.13	9.00	**8.57**	64.66	70.66	**67.66**	52.53	57.80	**55.17**	5.80	5.87	**5.83**
T_5 (10 ppm GA_3)	8.27	9.13	**8.70**	64.33	69.66	**67.00**	53.40	58.40	**55.90**	5.87	6.07	**5.97**
T_6 (50 ppm salicylic acid)	7.13	8.27	**7.70**	67.00	73.00	**70.00**	47.40	52.40	**49.90**	5.13	5.07	**5.10**
T_7 (100 ppm salicylic acid)	7.53	8.53	**8.03**	66.33	72.00	**69.16**	49.20	54.20	**51.70**	5.33	5.47	**5.40**
T_8 (150 ppm salicylic acid)	7.67	8.67	**8.17**	65.66	72.00	**68.83**	50.33	55.40	**52.87**	5.40	5.47	**5.43**
T_9 (2.5 % PEG-6000)	9.00	9.60	**9.30**	62.00	66.00	**64.00**	57.60	62.93	**60.27**	6.40	6.80	**6.60**
T_{10} (5 % PEG-6000)	9.13	9.80	**9.47**	61.66	65.66	**63.66**	58.53	63.47	**61.00**	6.40	6.87	**6.63**
T_{11} (7.5 % PEG-6000)	9.53	9.93	**9.73**	61.00	64.33	**62.66**	60.00	65.07	**62.53**	6.73	7.20	**6.97**
T_{12} (0.5 % KH_2PO_4)	8.53	9.27	**8.90**	63.66	68.66	**66.16**	55.47	60.20	**57.83**	6.00	6.33	**6.17**
T_{13} (1 % KH_2PO_4)	8.87	9.40	**9.13**	63.00	68.00	**65.50**	56.73	61.73	**59.23**	6.33	6.60	**6.47**
T_{14} (1.5 % KH_2PO_4)	9.00	9.47	**9.23**	63.00	67.66	**65.33**	57.00	61.73	**59.37**	6.33	6.67	**6.50**
Variety (Mean)	**8.17**	**9.00**		64.36	69.79		**52.98**	**57.98**		**5.80**	**5.98**	

	Pod Length: S.Em. ±	Pod Length: C. D. at 5%	Days to maturity: S.Em. ±	Days to maturity: C. D. at 5%	Plant height: S.Em. ±	Plant height: C.D. at 5%	Primary branches: S.Em. ±	Primary branches: C.D. at 5%
V	0.11	0.32	0.48	1.36	0.76	2.16	0.11	NS
T	0.30	0.86	1.27	3.60	2.01	5.71	0.28	0.80
V X T	0.43	NS	1.80	NS	2.85	NS	0.40	NS
C.V. %	**8.64**		**4.64**		**8.88**		**11.78**	

Data related to plant height critically reviewed which revealed that the seed priming effect on plant height differed significantly in both the varieties. Maximum plant height (57.98 cm) was recorded by variety GM-6 (V_2), whereas, the lowest plant height (52.98 cm) was recorded by variety GM-4 (V_1).

Seed priming effect on plant height also differed significantly among all the treatments and highest plant height was recorded with treatment 7.5% PEG-6000 (T_{11}) (62.53 cm), which was at par with treatments *viz*., T_{10}, T_9, T_{14} and T_{13}, though, the lowest value of plant height (47.50 cm) was recorded in control. The interactions effect between varieties and treatments was found non-significant for plant height.

Plant height is an important morphological parameter exhibiting direct related with grain yield. Since leaves and branches are born on stem, leaf development and biomass production, closely related with plant height. The effect of seed priming on height showed rapid increase in growth. The present results supported by the findings of Sohail *et al*. (2018) in kabuli chickpea and Lamichaney *et al*. (2018) in chickpea.

4.3.8 Effect of seed priming treatments on primary branches per plant

The results pertaining to primary branches per plant varied by seed priming treatments and varieties presented in Table 4.7 and Fig. 4.19.

Perusal of the data revealed that the seed priming effect on primary branches per plant was found non-significant in case of varieties.

Seed priming effect on primary branches per plant differed significantly among all the treatments. Highest primary branches per plant (6.97) was observed with treatment 7.5% PEG-6000 (T_{11}), which was at par with treatments *viz*., T_{10}, T_9, T_{14}, T_{13} and T_{12}, whereas, the significantly lowest (4.70) primary branches per plant reported in control (T_1). The interaction effect between varieties and treatments was not found significant for primary branches per plant.

PEG improved number of branches per plant and grain per pod and reduced the flower dropping. Our result was consistent with the findings of Khan et al. (2008) in mung bean and Arif *et al.* (2014) in soybean.

4.3.9 Effect of seed priming treatments on hundred seed weight

The results of hundred seed weight were differed by seed priming treatments and varieties depicted in Table 4.8 and Fig. 4.20.

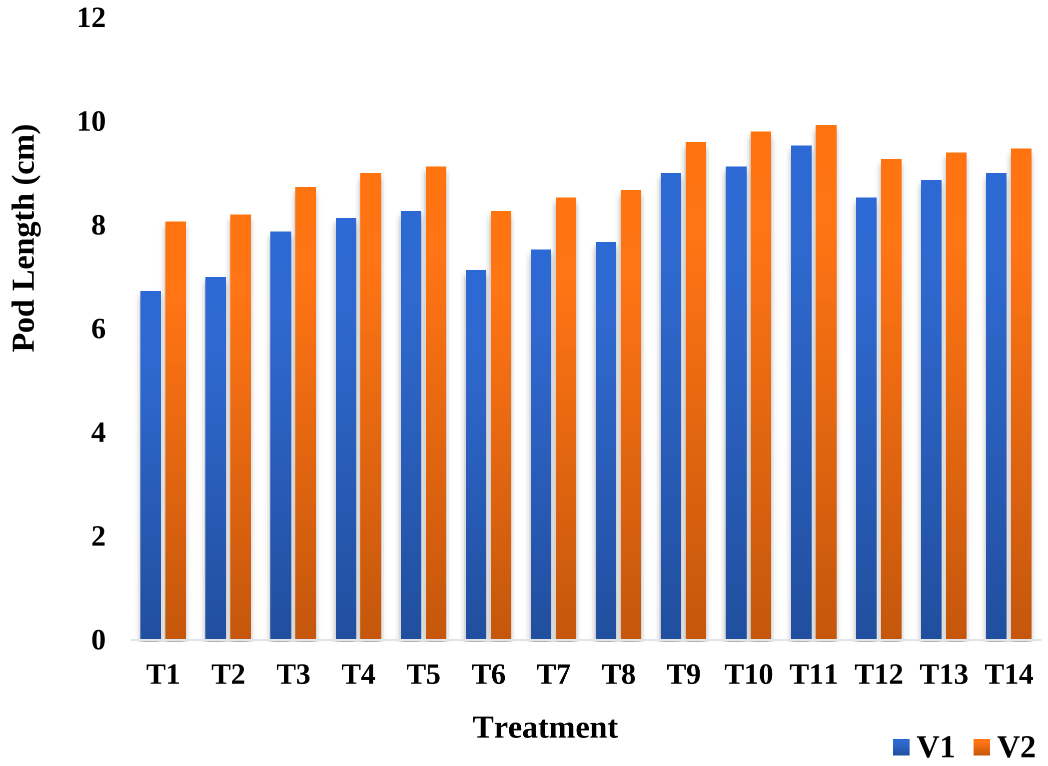


Fig. 4.16: Effect of priming treatments and varieties on pod length at field level

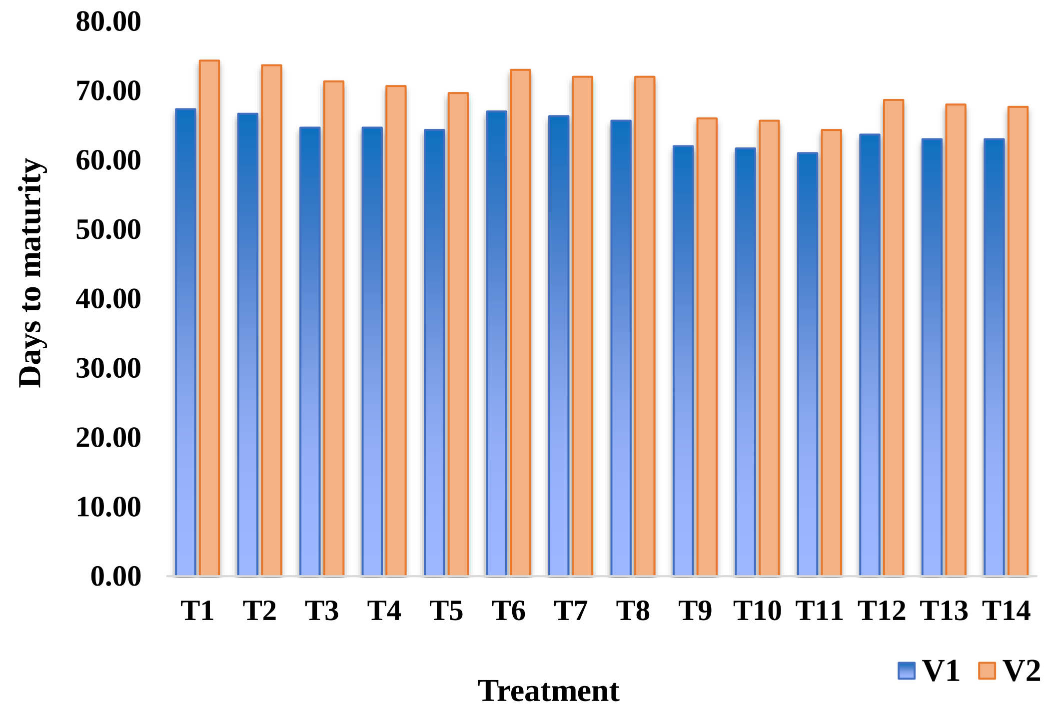


Fig. 4.17: Effect of priming treatments and varieties on days to maturity at field level

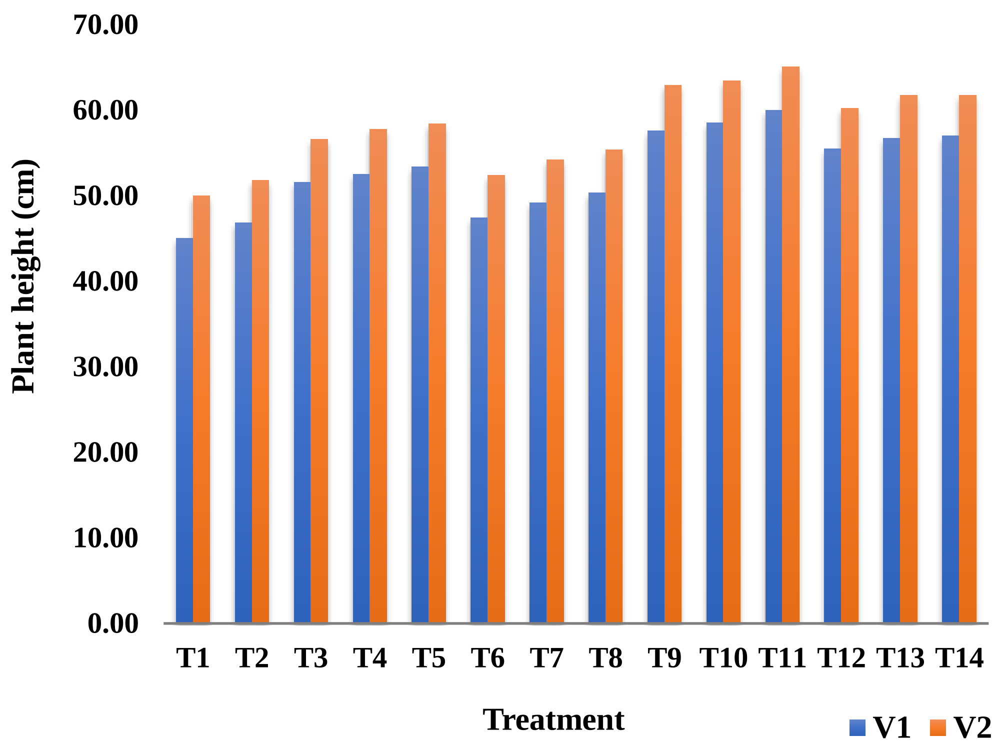


Fig. 4.18: Effect of priming treatments and varieties on plant height at field level

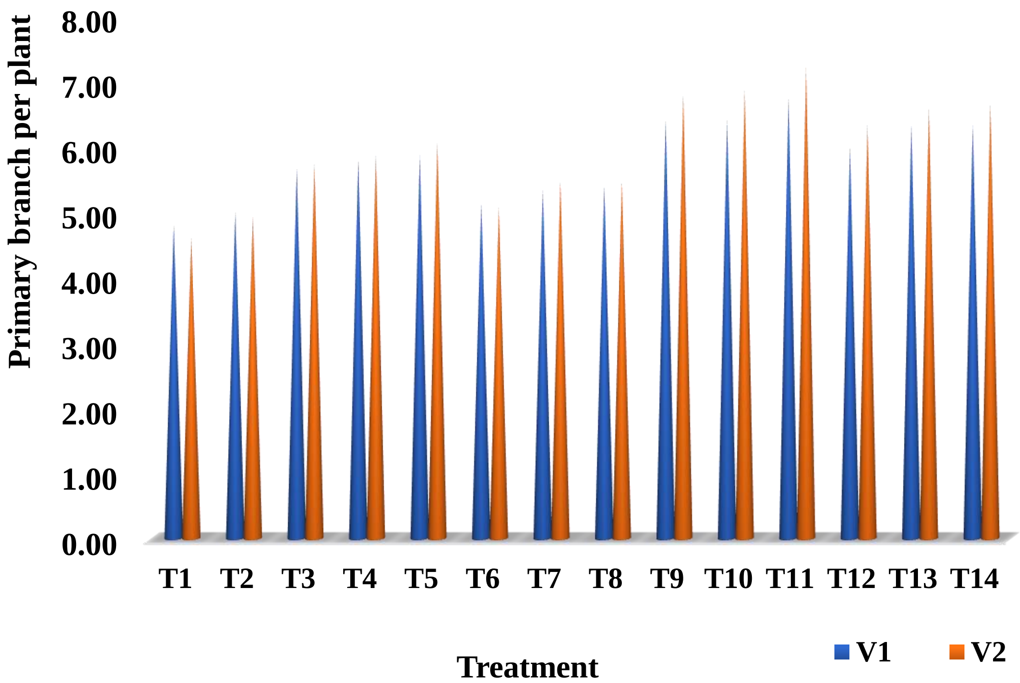


Fig. 4.19: Effect of priming treatments and varieties on primary branches per plant at field level

From the data it was found that the seed priming effect on hundred seed weight differed significantly among the varieties. Variety GM-6 was observed superior (4.43 g) value of hundred seed weight over to variety GM-4.

Seed priming effect on hundred seed weight was found non-significant among all the treatments. Although, numerically higher value (4.33 g) of hundred seed weight was recorded by treatment 7.5% PEG-6000 (T_{11}) and lowest (4.23 g) hundred seed weight was reported by control (T_1). The interaction effect between varieties and treatments were found non-significant for hundred seed weight.

Similar findings were also reported by Toklu (2015) in lentil and Abebe *et al*. (2016) in chickpea.

4.3.10 Effect of seed priming treatments on seed yield per plant

The results belongs to seed yield per plant were influenced by seed priming treatments and varieties presented in Table 4.8 and Fig. 4.21.

Data indicated that the seed priming effect on seed yield per plant differed significantly in both the varieties. The higher seed yield per plant (15.26 g) was recorded by variety GM-6 (V_2) as compared to variety GM-4 (V_1) which recorded (14.11 g) seed yield per plant.

Priming effect on seed yield per plant differed significantly in different treatments. Maximum seed yield per plant (16.20 g) was recorded with treatment 7.5% PEG-6000 (T_{11}), which was at par with treatments *viz*., T_{10}, T_9, T_{14}, T_{13}, T_{12} and T_5. However lowest seed yield per plant was obtained (12.97 g) with control (T_1).

The interaction effect between varieties and treatments was found non-significant for seed yield per plant.

Yield increased due to PEG primed treatment enhanced the faster emergence and better growth of plants as reflected with higher number of leaves resulting in higher photosynthetic activity triggering the synthesis of hormones involved in flowering as well as various physiological and bio-chemical processes of the plants. Our results also supported by the findings of Lamichaney *et al.* (2018) in chickpea. Similarly, Arif *et al.* (2008) in soybean.

4.3.1 Effect of seed priming treatments on seed yield per hectare

The obtained results for seed yield per hectare influenced by seed priming treatments and varieties were presented in Table 4.8 and Fig. 4.22.

Table 4.8: Influence of different priming treatments and varieties on 100 seed weight, seed yield per plant and seed yield per hectare

Priming Treatments	100 Seed Weight (g)			Seed Yield per Plant (g)			Seed yield per hectare (kg)		
	GM-4 (V_1)	GM-6 (V_2)	Treatment (Mean)	GM-4 (V_1)	GM-6 (V_2)	Treatment (Mean)	GM-4 (V_1)	GM-6 (V_2)	Treatment (Mean)
T_1 (Control)	4.11	4.35	**4.23**	12.40	13.53	**12.97**	874.00	906.00	**890.00**
T_2 (Hydro priming)	4.11	4.37	**4.24**	12.80	13.87	**13.33**	900.87	935.00	**917.93**
T_3 (5 ppm GA_3)	4.12	4.42	**4.27**	13.87	14.93	**14.40**	972.60	1012.53	**992.57**
T_4 (7.5 ppm GA_3)	4.12	4.44	**4.28**	14.07	15.20	**14.63**	986.00	1031.80	**1008.90**
T_5 (10 ppm GA_3)	4.13	4.44	**4.29**	14.40	15.47	**14.93**	999.47	1046.33	**1022.90**
T_6 (50 ppm salicylic acid)	4.11	4.37	**4.24**	12.93	14.13	**13.53**	909.87	944.73	**927.30**
T_7 (100 ppm salicylic acid)	4.12	4.40	**4.26**	13.27	14.40	**13.83**	936.73	973.73	**955.23**
T_8 (150 ppm salicylic acid)	4.12	4.41	**4.27**	13.60	14.67	**14.13**	950.20	993.13	**971.67**
T_9 (2.5 % PEG-6000)	4.13	4.49	**4.31**	14.93	16.40	**15.67**	1066.67	1109.33	**1088.00**
T_{10} (5 % PEG-6000)	4.14	4.49	**4.31**	15.33	16.40	**15.87**	1066.67	1119.00	**1092.83**
T_{11} (7.5 % PEG-6000)	4.14	4.51	**4.33**	15.60	16.80	**16.20**	1097.93	1148.00	**1122.97**
T_{12} (0.5 % KH_2PO_4)	4.13	4.45	**4.29**	14.67	15.60	**15.13**	1017.33	1060.93	**1039.13**
T_{13} (1 % KH_2PO_4)	4.13	4.47	**4.30**	14.80	16.07	**15.43**	1048.67	1094.73	**1071.70**
T_{14} (1.5 % KH_2PO_4)	4.13	4.47	**4.30**	14.87	16.20	**15.53**	1048.73	1099.67	**1074.20**
Variety (Mean)	**4.12**	**4.43**		**14.11**	**15.26**		**991.12**	**1033.92**	

	S.Em. ±	C. D. at 5%	S.Em. ±	C. D. at 5%	S.Em. ±	C.D. at 5%
V	0.03	0.07	0.19	0.54	14.72	41.74
T	0.07	NS	0.50	1.42	38.95	110.43
V X T	0.10	NS	0.71	NS	55.08	NS
C.V. %	**3.97**		**8.35**		**9.42**	

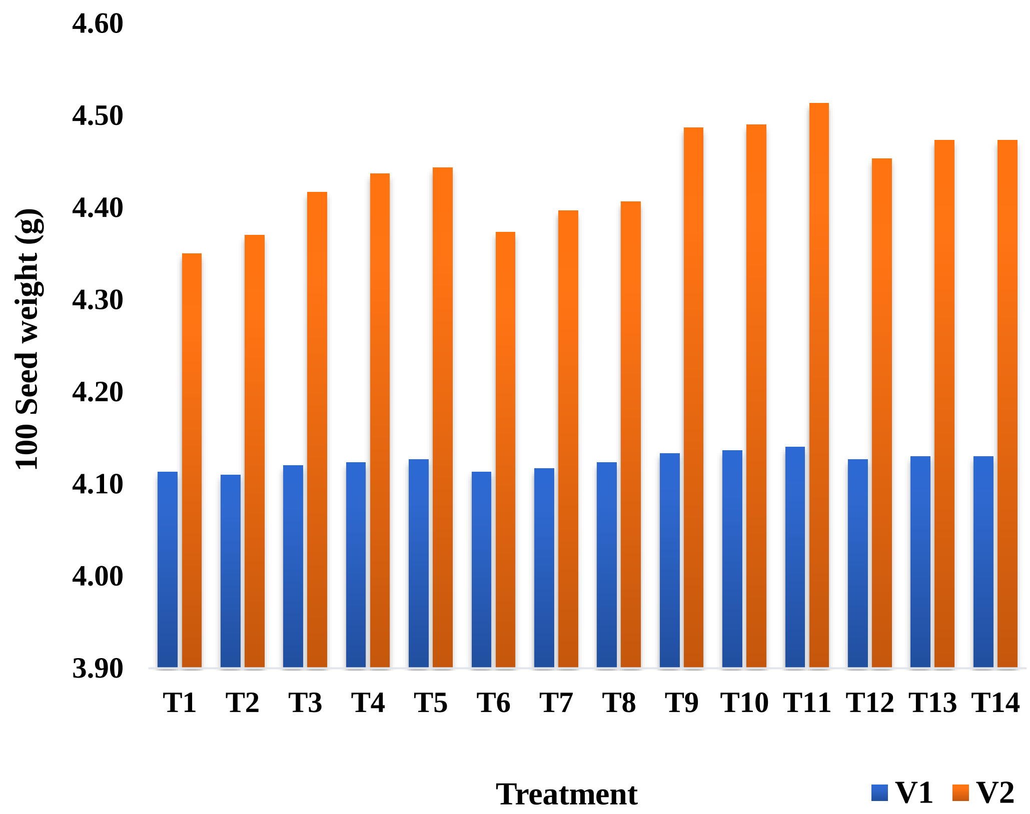


Fig. 4.20: Effect of priming treatments and varieties on hundred seed weight at field level

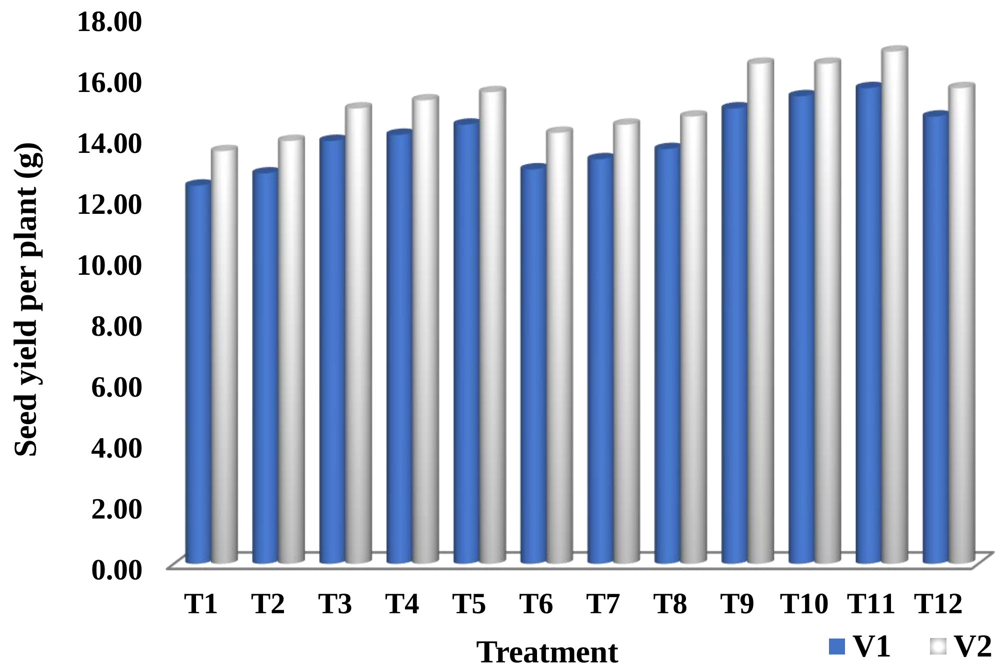


Fig. 4.21: Effect of priming treatments and varieties on seed yield per plant at field level

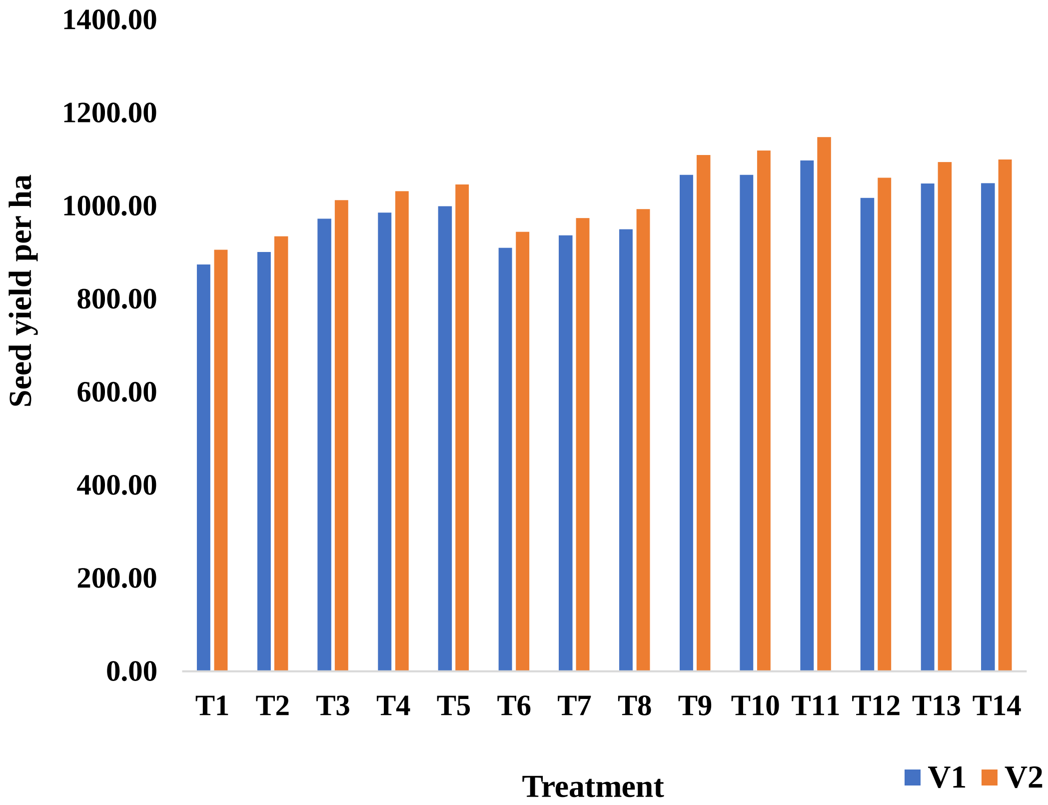


Fig. 4.22: Effect of priming treatments and varieties on seed yield per ha at field level

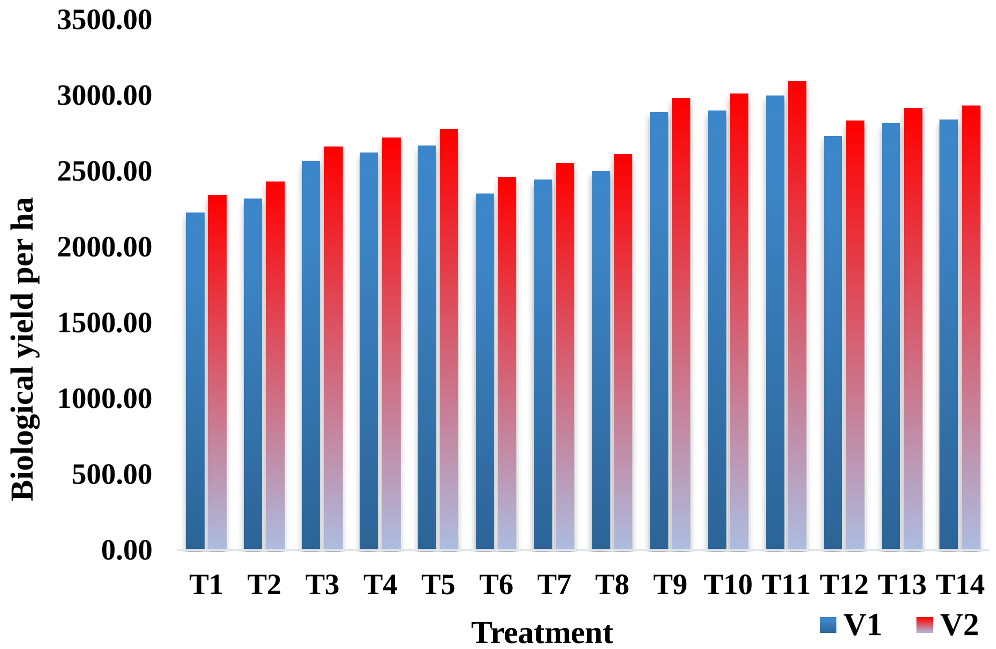


Fig. 4.23: Effect of priming treatments and varieties on biological yield per ha at field level

Data related to seed yield per hectare were critically reviewed which revealed that the seed priming effect on seed yield differed in both varieties. Maximum seed yield (1033.92 kg/ha) was recorded by variety GM-6 (V_2), whereas, the lowest seed yield (991.12 kg/ha) was recorded by variety GM-4 (V_1).

Seed priming effect on seed yield per hectare shown highly significant difference among all the treatments. Highest seed yield was recorded by treatment 7.5% PEG-6000 (T_{11}) (1122.97 kg/ha) which was at par with treatments *viz*., T_{10}, T_9, T_{14}, T_{13}, T_{12} and T_5. However, lowest seed yield was observed in control (T_1) (890.00 kg/ha). The interaction effect between varieties and treatments was found non-significant.

Increase in seed yield due to priming treatment with PEG was attributed to the faster emergence and better growth of plants which increases number of leaves resulting in higher photosynthetic activity, triggering the synthesis of hormones involved in flowering behaviour and their active role in various physiological and bio-chemical processes of the plants. The results were supported by the findings of Lamichaney *et al.* (2018) in chickpea. Similarly, Arif *et al.* (2008) in soybean.

4.3.2 Effect of seed priming treatments on biological yield

The data related to biological yield as influenced by seed priming treatments and varieties presented in Table 4.9 and Fig. 4.23.

Perusal of the data showed that the seed priming effect on biological yield differed significantly with in varieties. Higher value (2736.91 kg) of biological yield was recorded with variety GM-6 (V_2) are compared to variety GM-4 (2633.11 kg) biological yield. Seed priming effect on biological yield differed significantly among all the treatments.

The highest biological yield (3044.27 kg) was recorded by treatment 7.5% PEG-6000 (T_{11}), which was at par with treatments *viz*., T_{10}, T_9, T_{14} and T_{13}, whereas, the lowest biological yield (2283.50 kg) was reported in control (T_1). The interaction effect between varieties and treatments was found non-significant for biological yield.

These results were consistent with the results obtained by Khan *et al.* (2008) in mung bean and Toklu (2015) in lentil. Arif *et al.* (2014).

4.3.3 Effect of seed priming treatments on harvest index

The results regarding harvest index only numerically varied by seed priming treatments and varieties presented in Table 4.9 and Fig. 4.24.

Table 4.9: Influence of different priming treatments and varieties on biological yield per hectare and harvest index

Priming Treatments	Biological yield per hectare (kg)			Harvest Index (HI)		
	GM-4 (V_1)	**GM-6 (V_2)**	**Treatment (Mean)**	**GM-4 (V_1)**	**GM-6 (V_2)**	**Treatment (Mean)**
T_1 (Control)	2226.47	2340.53	**2283.50**	39.24	38.79	**39.02**
T_2 (Hydro priming)	2318.87	2430.60	**2374.73**	38.92	38.58	**38.75**
T_3 (5 ppm GA_3)	2565.40	2660.93	**2613.17**	37.98	38.22	**38.10**
T_4 (7.5 ppm GA_3)	2622.53	2721.00	**2671.77**	37.70	37.97	**37.83**
T_5 (10 ppm GA_3)	2668.80	2776.20	**2722.50**	37.46	37.65	**37.56**
T_6 (50 ppm salicylic acid)	2349.73	2460.80	**2405.27**	38.68	38.40	**38.54**
T_7 (100 ppm salicylic acid)	2442.20	2550.87	**2496.53**	38.28	38.20	**38.24**
T_8 (150 ppm salicylic acid)	2499.27	2611.00	**2555.13**	37.86	38.07	**37.96**
T_9 (2.5 % PEG-6000)	2888.93	2981.80	**2935.37**	36.97	37.16	**37.06**
T_{10} (5 % PEG-6000)	2899.80	3011.87	**2955.83**	36.72	37.15	**36.93**
T_{11} (7.5 % PEG-6000)	2996.67	3091.87	**3044.27**	36.58	37.14	**36.86**
T_{12} (0.5 % KH_2PO_4)	2730.33	2831.60	**2780.97**	37.18	37.42	**37.30**
T_{13} (1 % KH_2PO_4)	2816.33	2916.27	**2866.30**	37.25	37.57	**37.41**
T_{14} (1.5 % KH_2PO_4)	2838.27	2931.47	**2884.87**	37.00	37.55	**37.27**
Variety (Mean)	**2633.11**	**2736.91**		**37.70**	**37.85**	
	S.Em. ±		**C.D. at 5%**	**S.Em. ±**		**C.D. at 5%**
V	27.20		77.12	0.42		NS
T	71.97		204.05	1.11		NS
V X T	101.78		NS	1.57		NS
C.V. %	**6.57**			**7.19**		

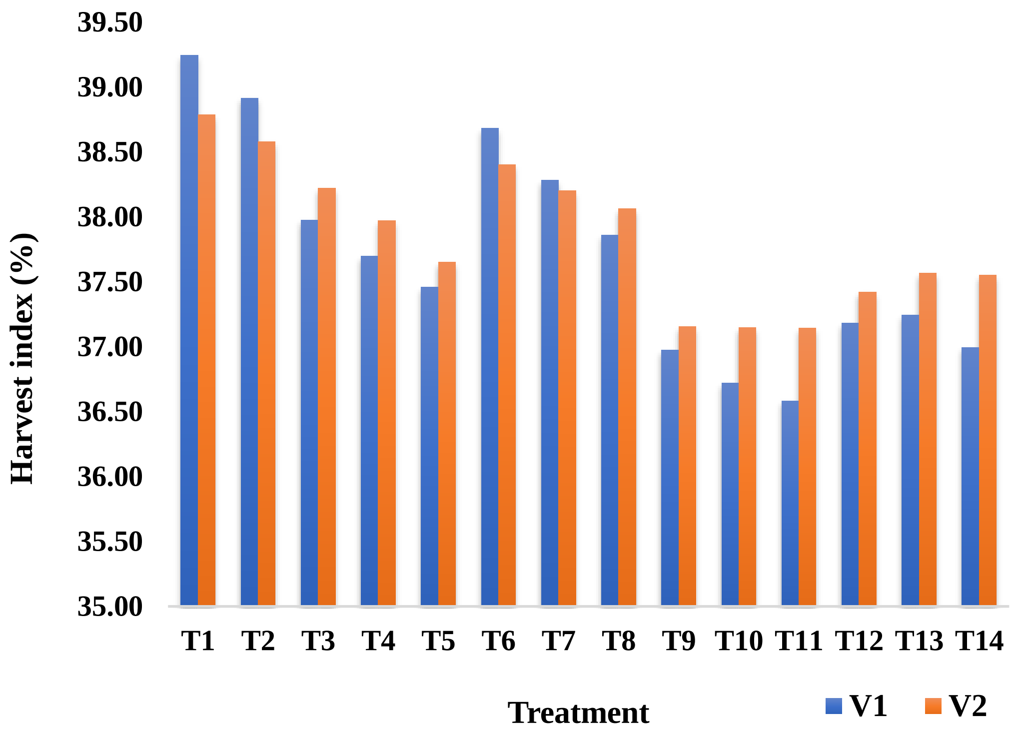


Fig. 4.24: Effect of priming treatments and varieties on harvest index at field level

From the data it was obtained that the seed priming effect on harvest index was found non-significant. However, numerically higher value of harvest index (37.85) was recorded by variety GM-6 (V_2) over to (37.70) variety GM-4 (V_1).

Seed priming effect on harvest index was also not found significant among all the treatments, though, higher harvest index (39.02) was observed in control (T_1) and lower (36.86) harvest index in 7.5% PEG-6000 (T_{11}).

The interaction effect between varieties and treatments was found non-significant for harvest index.

Similar findings were also reported by Khan *et al*. (2008) in mung bean, Arif *et al*. (2014) in soyabean.

SUMMARY AND CONCLUSIONS

V. SUMMARY AND CONCLUSIONS

The present investigation entitled, "**Responses of Green gram (*Vigna radiata* L.) to different priming treatments on germination, growth and yield**", was conducted in Seed Science and Technology Laboratory, Department of Genetics and Plant Breeding, and field experiment was carried out at Agronomy Instructional Farm, Chimanbhai Patel College of Agriculture, Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar during *kharif* 2021 to study the effect of seed priming treatments on germination, seedling vigour and yield attributing characters of green gram.

The seeds of green gram were primed for 1 hrs. with water (T_2), and solution of GA_3 (5.0 ppm) (T_3), GA_3 (7.5 ppm) (T_4), GA_3 (10.0 ppm) (T_5), Salicylic acid (50.0 ppm) (T_6), Salicylic acid (100 ppm) (T_7), Salicylic acid (150 ppm) (T_8), PEG-6000 (2.5 %) (T_9), PEG-6000 (5.0 %) (T_{10}), PEG-6000 (7.5 %) (T_{11}), KH_2PO_4 (0.5 %) (T_{12}), KH_2PO_4 (1.0 %) (T_{13}) and KH_2PO_4 (1.5 %) (T_{14}) then drying all the primed seed up to original moisture content.

Laboratory data were analyzed by using Factorial Completely Randomized Block Design (FCRD). The observations related to germination studies *viz*., germination percentage, coefficient of velocity of germination, shoot length (cm), root length (cm), seedling length (cm), root dry weight (mg), shoot dry weight (mg), seedling fresh weight (mg), seedling dry weight (mg), vigour index-I and vigour index-II were recorded.

The field experiment data were analyzed by using Factorial Randomized Block Design (FRBD) with three replications. Field observations on growth, seed yield and yield contributing characters *viz*., field emergence (%), days taken to 50% flowering, number of pod per plant, number of seed per pod, pod length (cm), days to maturity, plant height at maturity (cm), number of primary branch per plant, hundred seed weight (g), seed yield per plant (g), seed yield per hectare (kg), biological yield per hectare (kg) and harvest index (HI) were recorded.

5.1 Summary

5.1.1 Effect of seed priming and varieties on seed germination and its related parameter

5.1.1.1 Effect of varieties

Green gram varieties significantly differed in most of characters except germination percentage and coefficient of velocity. Variety, GM-4 recorded higher in root length (6.58 cm), shoot length (9.77 cm), seedling length (16.35 cm), root dry weight (7.88 mg) and vigour index I (1532.20) as compared to variety GM-6. while, GM-6 recorded significantly higher value in case of shoot dry weight (24.05 mg), seedling fresh weight (373.26 mg), seedling dry weight (31.71 mg) and vigour index II (2969.41) over to variety GM-4.

5.1.1.2 Effect of treatments

Among the all priming treatments, seed primed with 7.5 % PEG-6000 recorded higher value in germination percentage (97.00%), root length (6.67 cm), shoot length (10.77 cm), seedling length (17.43 cm), root dry weight (9.10 mg), shoot dry weight (26.53 mg), seedling fresh weight (424.77 mg), seedling dry weight (35.63 mg), vigour index I (1690.60) and vigour index II (3457.20).

5.1.2 Effect of seed priming treatments and varieties on yield and yield attributing characters

5.1.2.1 Effect of varieties

Green gram varieties differed significantly in most of characters except field emergence, days to 50% flowering, number of seeds per pod, number of primary branches per plant and harvest index. Variety, GM-6 recorded superior value of number of pod per plant (25.51), plant height (57.98 cm), pod length (9.00 cm), 100 seed weight (4.43 g), seed yield per plant (15.26 g), seed yield per ha. (1033.92 kg) and biological yield per ha. (2736.91 kg) as compared to variety GM-4.

5.1.2.2 Effect of treatments

The priming treatments differed significantly in most of characters except 100 seed weight and harvest index. Seed primed with 7.5% PEG-6000 showed superiority in field emergence (90.50%), days to 50% flowering (32 days), number of pod per plant (27.60), number of seed per pod (13.23), pod length (9.73 cm), plant height (62.53 cm), number of primary branch per plant (6.97), days to maturity (62.66 days), seed yield per plant (16.20 g), seed yield per ha. (1122.97 kg) and biological yield per ha. (3044.27 kg).

5.2 Conclusion

On the basis of experiment, it can be concluded that seed primed with 7.5% PEG-6000 found best treatment among all the treatments in case of germination and its related parameters as well as yield and its components characters.

Both the varieties GM-4 and GM-6 is studied during the investigation and it can be concluded that GM-6 proved superior over to variety GM-4 in field condition.

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APPENDICES

APPENDICES

Appendix A: Mean weekly weather parameters recorded during crop growth period of *kharif* 2021

Month and year	Std. Weeks	Temperature (°C)		Relative Humidity (%)		Rainfall (mm)	Bright sunshine (hrs./day)	Wind velocity (km/hr)	Pan Evaporation (mm/day)
		Max.	Min.	Morn.	Even.				
July 2021	26	37.2	25.6	79	65	9.0	6.0	7.9	6.0
	27	38.0	26.8	76	65	0.0	8.4	11.1	7.3
	28	39.1	26.0	81	63	47.0	5.7	6.7	7.1
	29	36.1	26.2	82	75	8.0	3.8	7.4	7.0
	30	31.6	24.8	85	90	65.5	0.7	10.2	4.6
	31	29.0	24.3	84	85	17.5	0.0	8.6	3.5
August 2021	32	33.5	25.9	80	74	0.0	6.8	5.4	6.1
	33	36.5	25.7	73	68	0.0	9.5	5.9	7.5
	34	36.9	26.0	76	67	2.0	7.6	4.9	7.3
	35	35.6	24.7	82	66	36.5	6.6	5.3	6.0
September 2021	36	34.4	24.9	88	83	41.0	4.1	5.7	5.5
	37	32.9	24.2	85	83	109.5	3.6	3.3	4.4
	38	33.5	23.6	80	77	6.0	5.2	4.7	5.6
	39	33.1	24.9	81	77	87.5	4.4	5.1	5.8
October 2021	40	34.7	25.0	78	70	0.0	7.7	3.9	7.0
	41	37.4	25.8	77	62	0.0	9.8	2.1	7.9
	42	36.9	21.1	69	62	0.0	9.7	2.2	7.3
	43	36.2	18.0	66	59	0.0	9.9	4.7	6.8
	44	33.3	15.9	69	50	0.0	9.7	2.3	5.8

CERTIFICATE

This is to certify that I have no objection for supplying to any scientist only one copy or any part of this thesis at a time through reprographic process, if necessary for rendering reference service in a library or documentation centre.

Place : SARDARKRUSHINAGAR.
Date : 15th SEPTEMBER, 2022.

(BHANKHAR PRATIK D.)