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(Research Article)

Impact of organic and inorganic growth regulators with two soaking time duration on germination indices and seedling vigor of Pigeon pea (*Cajanus Cajana* (L) Millspaugh) seeds

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Abstract

A two factor pots experiment was conducted during winter season of 2018/2019 investigate effects of two growth regulator and soaking time on germination indices and seedling vigor of Pigeon pea seeds. The experiment was laid out according RCBD with three replications. Parameters studied include germination indices; Final germination percentage FGP, Mean daily germination MDG, Daily germination speed DGS and vigor index. Also, seedling dry weight, length and root length were measured. The results indicated that soaking seeds of pigeon pea enhanced germination behaviors and seedling characters. Application of GA or lemon at medium level concentration increased all characters measured in this study particularly under longer time of soaking. The positive effected of soaking with water with combination of GA significantly increased germination indices and seedlings growth characters. In conclusion, as a result, soaking seeds of pigeon pea with application of medium growth regulator concentrations could increase the seed germination indices and seedling growth characters.

Keywords: Pigeon pea; Gabralline; Lemon growth regulators; Germination indices; Seedling vigor

1. Introduction

Poor germination and subsequent establishment of different pulse seed is a general problem in grain pulse production. Pigeon pea (*Cajanus cajana (L)Millspaugh*) of family Fabaceae beans).[1] reported that, Pigeon pea plant is a short lived perennial shrub. Pigeon pea beans contain 20-22% protein, 1.2% fat, 65% carbohydrate, and 3.8% ash and the following minerals such as phosphorus 28.2%, potassium 17.2%, zinc 14.7%, copper 20.9%, iron 14.7%, calcium more than 19.2%, and manganese more than 10.8% [2]. Pulses (Pigeon peas)are major source of proteins for vegetarians in India and compliment the cereals in diet with proteins, essential amino acids, vitamins and minerals[3]. Water is necessary to hydrate protoplasmic metabolism activities, provide dissolved O_2 to the seed embryo, soften the seed's outer coat, and improve seed permeability [4-5]. Water stress lowers enzymatic activity, which has a detrimental impact on carbohydrate metabolism, decreases water potential and soluble calcium and potassium, and alters the hormones of seeds [5-7]. Seed Germination is the sum of events beginning with hydration and culminating with root emergence [8]. Among the stages of the plant life cycle, seed germination, seedling emergence and establishment are key processes in the survival and growth of plant [9]. The term plant growth regulators (PGRs) cover the broad category of organic compounds other than nutrients.[10] reported that, pulse crops have inherent limitations such as poor in germination, indeterminate growth habit, decrease in nodule activity, slow dry matter accumulation and reduced sink activity these

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leads to lower yield and productivity. These limitations can be managed with application of plant growth regulators (PGRs). Plant growth regulators (PGRs) show diverse functions in plants under various stress conditions [11-14]. These are chemical messengers are produced in plants in small concentrations and control several morphophysiological and biochemical attributes of plants [15-17].

The impact of PGRs in manipulating physiological processes in crop production include germination, vigor, nutrient uptake from soil, photosynthesis, respiration, partitioning of assimilate, growth suppression, defoliation and postharvest ripening [18]. Plant growth regulators such as GA and mechanical scarification such as soaking in water have been recommended to break dormancy and enhance germination [19]. On the other hand, soaking in water treatments have been reported to enhance germination of hard coated seeds by elevating water and O2 permeability of the testa[20]. Incorporation of plant growth regulators, particularly gibbralic acid GA3, during re-soaking, priming and other pre-sowing treatments in many vegetables crops has improved seed performance [21]. Gibbralic Acid can improve seed germination [22]. The strong inhibitory effect of the seed coat on seed germination may be caused by several possible mechanisms, including mechanical constraint, prevention of water and oxygen uptake, and retention or production of chemical inhibitors [23]. The plant hormones widely took part in determining the physiological state of a seed and regulating the germination process by interacting each other [24]. The growth regulators from organic (Panchgavya,lemon) and inorganic sources (GA3, IAA) increase the germination and vigor of pulse crop seeds The integument breaking or softening, for instance, is needed to remove dormancy imposed by seed coat hardness orim permeability. However, it is very difficult to use mechanical scarification to break the hard seed coat of A. cyclophyllon. There are evidences that different natural and synthetic growth regulators improve seed germination and seedling vigor of many crops [25]. These growth regulators may be of natural origin or synthetic. The growth regulators both from organic (*Emblica officinalis*, lemon, etc.) and inorganic sources along with some traditional growth regulators could be tried to increase the germination and vigor of different pulse seeds. Therefore, chemical scarification (softening the hard seed coat with (citric acid of lemon juice), soaking in water for specific hours and using of GA3will be used to remove exogenous dormancy. Improvement in germination capability and increasing seed vigor might be one option to make the growing pulse seedling more competitive with those of weeds. These growth regulators may be of natural origin or synthetic. Works regarding the effect of growth regulators on pulse seed germination are very limited worldwide and are either lacking or scanty under Sudan condition. However little is emphasized on how plant growth hormones could affect pigeon pea seed germination and seedlings growth. The proposed investigation was undertaken to find out the effect of varying concentrations of different natural and synthetic growth regulators under soaking time to increase the seed germination and evaluate germination indices on Pigeon pea (*Cajanus cajana* (L)Millspaugh. It is also important to study more about the performance of on the germination, vigor and others attributes of pigeon pea.

2. Material and methods

2.1. Experiment layout and treatments

A two-factor experiment was laid out in a randomized complete blocks design (RCBD) during 2018\2019 winter season in Demonstration Farm of Faculty of Agriculture, Kassala University at New Halfa, Sudan to evaluate effect of growth regulator (synthetic and natural) on germination indices and vigor of Pigeon pea seeds under two soaking time A15-cm diameters –sized pots were used in this study filled with soil from the Demonstration Farm's media for germination bed. The growth regulators treatments are:

G_0≡ control without any growth regulators, GA3 wereG_{30} ≡30,G_{45}≡ 45 ,G_{60}≡60 , G_{75}≡ 75,G_{90} ≡ 90 andG_{105}≡105 p.p.m while lemon juice concentrationwereL_2 ≡2, L_4≡ 4and L_6 ≡ 6%.

2.2. Germination Test

Fifteen seeds of pigeon pea were obtained from Agricultural Research corporation station New Halfa randomly selected for each treatment of all experimental units. The seeds were hand dibbled to about three centimeters depth with a spacing of 5centimeters. The seed bed was provided with adequate moisture to get good germination and seedling stand. The seedlings considered germination when emerged above the soil surface. Seed germination was recorded daily at certain time.

2.3. Germination attributes were measured as follows

Final germination percentage (FGP) [%] for every day starting after first day of seedling emerged until last day: was calculated as described by [2] using the following formula:

$$\text{FGP (\%)} = \frac{\text{Final number. Of seedlings emerged}}{\text{Total number. Of seeds sown}} \text{x } 100$$

2.4. Mean daily germination (MDG)

This is an index of daily germination speed and calculated according to formula described by[27] MDG =$\frac{FGP}{d}$

FGP: final germination percent d: test period.

Daily germination speed (DGS)This index is converse of mean daily germination and calculated according to formula described by [27].DGS =$\frac{1}{MDG}$

2.5. Seedling Root length (cm)

On the day of final count (12th day) five randomly selected normal seedlings in each treatment were used to measure root length. The length of root was measured from collar region to the tip of the main root and the average root length was expressed in centimeters.

2.6. Seedling Shoot length (cm)

The shoot length of five randomly selected seedlings were used for measuring shoot length from base to the tip of primary leaf and the average shoot length were expressed in centimeters.

2.7. Seedling Dry weight of ten seedlings (mg)

Five normal seedlings used for root and shoot length measurement from each treatment were kept in blotter paper packet and dried in hot air oven maintained at 750C for 24 hours. The dried seedlings were cooled in a desiccators for 60 minutes, then seedlings was weighed in an electronic balance and the weight was expressed in mg as dry weight of five seedlings.

2.8. Vigor index

The vigor index of seedlings was calculated by adopting the method suggested by [26] and expressed in whole number by using the below formula.

Vigor index = (FGP (%)) x[shoot length + root length (cm)]

Data was statistically analyzed according to RCBD of factorial trail using computer software package Statistics version10. Mean separation was worked out by the least significant differences at 5% level.

3. Results and discussion

Increasing gibraline (G)level until 105 p.p.m significantly increased the FGP of Pigeon pea as compared to other G and L treatments (table1). Soaking time showed significant differences on FGP for Pigeon pea seeds which gave maximum% for H12 treatment particularly with addition of G90,G105 and L6 growth regulators treatments (Table1). The higher DGS values (0.18)was recorded due to application G75, G90 treatments as compared to other growth regulator treatments. Soaking time did not significantly differences in DGS (Table1). The greater values of DGS were recorded in G75H12, G90 H12and L65H12 treatments relative to the all treatments (Table1).

In table1, the highest MDG value (9.92) was recorded in L4H12 followed by (G45H12, G60H12 which recorded 8.27,8.08,respectively. The higher vigour indices were recorded in treatment with lower levels of growth regulators particularly longer period of soaking time. In this regard, soaking pigeon pea seeds for 12 hours with application ofG30,L4 growth regulators level significantly gave the higher vigour index values as compared to their relative treatments(Table1). Increasing growth regulators levels until G60 under longer time resulted in taller seedlings of pigeon pea. The longest seedling (12.70 cm) was observed in G45H12.The higher seedling dry weight (0.41,0.31 g) were recorded in L4H6, G75H6 and G90H6 treatments (Table2). Also, the longer roots were recorded in (L6H6,G45H12 and G60H12)treatments(Table2).

The impact of plant growth regulators (PGRs) in manipulating physiological processes in crop production include germination vigour and growth suppression was well documented in corporation of plant growth regulators

,particularly gibbralic AcidGA_3during re-soaking and other pre soaking treatment in many vegetables crop has improved seed performance. The increased of all germination indices resulted in this study due to application of GA growth regulator might be due to positive role of GA in activation of cytological enzymes which stimulates α -amylase enzyme that converts in soluble sugars and leaching out of the inhibitors as which in turn helps in breaking the seed dormancy as reported by[28] . Also, gibberellins are associated with various plant growth and development processes such as stem, and root elongation and dry matter accumulation. Due to its role in increasing cell division, cell elongation and cell multiplication which might have replicated in to maximum seedling growth. This might explained the increased in seedling characters observed in this study due to application of GA. These result are in accordance with those reported by [29-30]. The increase in root length at lower concentration of GA observed in this study agreed the past study reported by [31] who reported that GA3 at lower concentration initiate the growth of root where as higher concentration has little effect on root growth. The increase in vigor index obtained in this study might be due to increase aforementioned characters as result of application of GA because the vigor index of seedling is directly dependant on germination percentage and seedling length so, the later characters were higher and consequently increased vigor index reported by [32]. The role of natural growth regulators such as lemon juice as chemical scarification to break the hard seed coat case softening the coat was reported by[32]. This might explained the result obtained in this study while lemon juice at higher level of concentration increased the germination indices. Also this result confirmed by those resulted by [33] .

The increased in the all germination characters observed in this study due to soaking seeds in water might be attributed to role of positive effect of water in enhancing germination of these seeds by either elevating water and oxygen permeability of testa as reported [20]. The maximum speed of germination with GA3 might be due to its influence in early germination and increased percent germination. The results are in conformity with findings of [34]. Also, increased in germination percentage resulted in increase of other growth parameters because these characters were associated with each other's. The maximum vigor index with GA3 pre-soaking seed treatment might be due to cumulative effect of seedling dry weight and germination percentage which were greatly influenced by GA3 in chickpea seed at laboratory conditions. The results are in line with the findings of [29]. Hence, it can be stated that increase in overall growth of the seedling has led to the overall assimilation and redistribution of food material to give seedling with maximum dry weight. seeds treated with growth regulator and soaking in water helped to increase germination behavior indices and great vigor seedling of pigeon pea.

Table 1 Final Germination %(FGP), Mean Daily Germination(MDG)Daily Germination Speed(DGS) and Vigor index of pigeon pea seedling

treatment	FGP	MDG	DGS	Vigor index
G_0	61.0	6.50	0.16	523.2
G_{30}	75.0	6.63	0.15	606.7
G_{45}	67.0	7.38	0.14	766.6
G_{60}	70.0	7.38	0.14	923.4
G_{75}	78.0	5.66	0.18	895.1
G_{90}	80.0	5.82	0.18	980.6
G_{105}	90.0	6.25	0.16	927.7
L_2	73.1	6.46	0.16	1113.6
L_4	79.6	6.59	0.15	1075.3
L_6	78.5	7.01	0.18	1135.9
$LSD_{0.05}$	21.2	0.28	0.03	3.50
H_6	75.8	6.38	0.16	1142.0
H_{12}	81.7	6.75	0.16	1244.0
$LSD_{0.05}$	7.7	1.08	0.01	0.94
G_0H_6	63.0	5.25	0.19	1403.1

G_0H_{12}	65.0	7.75	0.13	1643.4
$G_{30}H_6$	78.0	5.42	0.18	1475.2
$G_{30}H_{12}$	80.0	7.83	0.13	1738.1
$G_{45}H_6$	73.0	6.50	0.15	919.7
$G_{45}H_{12}$	74.0	8.27	0.13	613.6
$G_{60}H_6$	81.0	6.67	0.15	1087.3
$G_{60}H_{12}$	82.0	8.08	0.12	759.6
$G_{75}H_6$	83.0	6.08	0.16	940.3
$G_{75}H_{12}$	84.0	5.23	0.20	850.0
$G_{90}H_6$	93.0	6.17	0.16	1104.5
$G_{90}H_{12}$	94.0	5.46	0.19	856.8
$G_{105}H_6$	96.0	6.75	0.15	1006.1
$G_{105}H_{12}$	97.0	5.75	0.17	849.3
L_2H_6	60.0	6.83	0.15	1181.7
L_2H_{12}	64.0	6.08	0.17	1245.5
L_4H_6	69.0	6.25	0.14	1077.6
L_4H_{12}	73.0	9.92	0.16	1037.0
L_6H_6	75.0	7.20	0.14	225.0
L_6H_{12}	81.0	7.20	0.23	1046.8
$LSD_{0.05}$	14.2	0.45	0.08	5.59

Table 2 Mean seedling length(cm)root length(cm)and seedling dry weight(g) of pigeon pea seedling

treatment	**Seedling length**	**root length**	**dry weight**
G_0	9.49	2.99	0.10
G_{30}	10.06	3.66	0.12
G_{45}	11.03	3.59	0.17
G_{60}	11.52	4.07	0.10
G_{75}	10.76	2.82	0.19
G_{90}	11.41	2.93	0.19
G_{105}	9.99	2.43	0.10
L_2	10.71	3.66	0.17
L_4	10.22	3.38	0.24
L_6	10.24	3.52	0.09
$LSD_{0.05}$	0.40	0.38	0.12
H_6	9.88	3.01	0.22
H_{12}	11.21	3.59	0.09
$LSD_{0.05}$	0.11	0.10	0.06

G_0H_6	7.61	2.25	0.09
G_0H_{12}	11.38	3.73	0.11
$G_{30}H_6$	8.44	3.32	0.16
$G_{30}H_{12}$	11.68	4.01	0.08
$G_{45}H_6$	9.43	2.36	0.03
$G_{45}H_{12}$	12.63	4.82	0.09
$G_{60}H_6$	10.33	3.26	0.12
$G_{60}H_{12}$	12.70	4.89	0.08
$G_{75}H_6$	10.76	2.13	0.31
$G_{75}H_{12}$	10.76	3.51	0.08
G90H6	11.75	3.13	0.31
G90H12	11.06	2.73	0.07
G105H6	9.56	2.64	0.10
G105H12	10.42	2.22	0.08
L2H6	10.54	3.87	0.24
L2H12	10.88	3.44	0.09
L4H6	9.83	3.22	0.47
L4H12	10.61	3.53	0.07
L6H6	10.56	4.02	0.09
L6H12	9.92	3.01	0.10
LSD0.05	0.64	0.61	0.05

4. Conclusion

In conclusion, as a result, soaking seeds of pigeon pea for longer time with application of GA could increase the seed germination indices and seedling growth characters.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

References

[1] Pambo, K.O. 2014. Application of the commodity approach to pigeonpea value-chain analysis in Kenya. A paper submitted for presentation at the FAO Hosted Session at the IFAMA World Forum 2014 Cape Town, South Africa, June 18, 2014. http:// purl. umn.edu/173485

[2] Gitiara, E.W.; E Yuniastuti2and,E and Ariyah, N(2019) Growth and development of pigeon pea (Cajanus cajan) on the differences of Fitosan conc.IOP Conf. Ser.:Earth Environ. Sci. 250:8-14.

[3] Elias,S.M., Hossain,M. S.,Sikder, F. S.,Ahmed, J. and Karim, M. R.(1986).Identification of constraints to pulse production with special reference topresent farming systems. Annual Report of the Agricultural EconomicDivision, BARI, Joydebpur. p. 1-4.

[4] Prerna, D.I... Govindaraju, K. Tamilselvan, S. Kannan, M.Vasantharaja, R. Chaturvedi, S. Shkolnik, D. (2021). Influence of nanoscale micro-nutrient α-Fe2O3 on seed germination, seedling growth, translocation, physiological effects and yield of rice (Oryza sativa) and maize (Zea mays). Plant Physiol. Biochem. 162, 564–580

[5] Khalid, N.; Tarnawa, Á.; Kende, Z.; Kassai, K.M.; Jolánkai, M. (2021). Viability of maize (Zea mays L.) seeds influenced by water, temperature, and salinity stress. Acta Hydrol. Slovaca, 22, 113–117

[6] Abido,W.A.E.; Zsombik, L. (2020). Effect of water stress on germination of some Hungarian wheat landraces varieties. Shengtai Xuebao/Acta Ecol. Sin., 38, 422–428.

[7] Karimmojeni, H.; Rahimian, H.; Alizadeh, H.; Yousefi, A.R.; Gonzalez-Andujar, J.L.; Mac Sweeney, E.; Mastinu, A. (2021). Competitive ability effects of datura stramonium l. And xanthium strumarium l. on the development of maize (Zea mays) seeds. Plants, 10, 1922.

[8] Bewley, J.D. and M. Black. 1985. Seeds: Physiology ofDevelopment and Germination. Plenum Press, New York. 445p

[9] Hadas, A. 2004. Seedbed preparation: the soil physical environment of germinating seeds. p. 3–36. In: Handbook of Seed Physiology: Applications to Agric. R.L. Benech-Arnold and R.A. Sanchez (eds.). Food Product Press, New York, USA.

[10] Vishnu ,K.and. Brar,BS.(2020). Role of plant growth regulators in pulse production: A review International Journal of Chemical Studies; 8(5): 2736-2742

[11] Sabagh A. E, Mbarki S, Hossain A, Iqbal MA, Islam MS. (2021). Potential role of plant growth regulators in administering crucial processes against abiotic stresses. Frontiers in Agronomy 3: 648694. DOI 10.3389/fagro .648694

[12] Mir R. A, Bhat BA, Yousuf H, Islam ST, Raza A, Rizvi MA, Charagh S, Albaqami M, Sofi PA, Zargar SM (2022). Multidimensional role of silicon to activate resilient plant growth and to mitigate abiotic stress. Frontiers in Plant Science 13: 819658. DOI 10.3389/fpls 2022, 819658.

[13] Dai F, Rong Z, Wu Q, Abduallah EF, Liu C, Shengrui L (2022). Mycorrhiza improves plant growth and photosynthetic characteristics of tea plants in response to drought stress. BIOCELL 46: 1339–1346. DOI 10.32604/biocell. 018909.

[14] Corpas F.J, González-Gordo S, Rodríguez-Ruiz M, Munoz-Vargas M.A, Palma Martínez J.M (2022). Nitric oxide and hydrogen sulfide share regulatory functions in higher plant events. BIOCELL 46: 1–5. DOI 10.32604/biocell. 017300.

[15] Ahmad N, Virk AL, Hussain S, Hafeez MB, Haider FU, Rehmani MIA, Yasir TA, Asif A (2022). Integrated application of plant bioregulator and micronutrients improves crop physiology, productivity and grain biofortification of delayed sown wheat. Environmental Science and Pollution Research 29: 52534–52543. DOI 10.1007/s11356-022-19476-5.

[16] Mubarik M.S, Khan S.H, Sajjad M, Raza A, Hafeez M.B, Yasmeen T, Rizwan M, Ali S, Arif M.S (2021). A manipulative interplay between positive and negative regulators of phytohormones: A way forward for improving drought tolerance in plants. Physiologia Plantarum 172: 1269–1290. DOI 10.1111/ppl.13325

[17] Raza A, Salehi H, Rahman MA, Zahid Z, Madadkar Haghjou M. (2022b). Plant hormones and neurotransmitter interactions mediate antioxidant defenses under induced oxidative stress in plants. Frontiers in Plant Science 13: 961872. DOI10.3389/fpls. 961872

[18] Kathiresan, G. and Balasubramanian, T. N. (1995). Influence of growth regulatory substance on the germination of clip and single budded sets of different age cane. Cooperative Sugars. 26: 695-699.

[19] Hermansen A,Brodal G, Balvoll G (1999). Hot water treatments of carrotseeds, effects on seed- orne fungi, germination, emergence and yield. SeedSci. Technol. 27: 599-613

[20] Aydın I.and Uzun, F (2001). The effects of some applications on germination rate of Gelemen Clover seeds gathered from natural vegetation in Samsun.Pak. J. Biol. Sci. 4: 181-183.

[21] Turkyilmaz B., 2012 - Effects of salicylic and gibberellic acids on wheat (Triticum aestivum l.) under salinity stress. Bangladesh J. Bot., 41(1):29-34.

[22] Taiz L, Zeiger E (2002). Plant Physiology, Chapter 23. Abscisic Acid: ASeed Maturation and Antistress Signal, 3rd ed . Sinauer Associates, Inc.,Sunderland, MA, pp. 538-558

[23] Zhang C, Luo W, Li Y, Zhang X, Bai X, Niu Z. (2019). Transcriptomic analysis of seed germination under salt stress in two desert sister species (Populus euphratica and P. pruinosa). Frontiers in Genetics. 10:1-16

[24] Mohanty, S. K. and Sahoo, N. C. (2006). Effect of soaking period, seed size and growth regulators on imbibition and germination of seeds of some field crops. Orissa J. Agric. Res. Retrived from cababstractsplus.org.

[25] Basra, S.M.A., M.N. Iftikhar and I. Afzal. 2011. Potential of moringa (Moringa oleifera) leaf extract as priming agent for hybrid maize seeds. International Journal of Agriculture and Biology 13: 1006–1010.

[26] Farooq, M., S.M.A. Basra, M. Khalid, R. Tabassum and T. Mehmood. 2006. Nutrietn homeostasis, reasrvers metabolism and seedling vigor as affected by seed priming in coarse rice. Candadian Journal of Botany 84: 1196–1202.

[27] Babu KD, Patel RK, Singh A, Yadav DS, De LC, Deka BC. Seed germination, seedling growth and vigour of papaya under North east Indian condition. Acta Horticulturae. 2010; 851:299-306.

[28] Gawade US. Seed viability, (2008). Germination and seedling growth studies in custard apple M.Sc. (Ag.) Thesis, Dr.Panjabrao Deshmukh Krishi Vidyapeeth, Akola MS, (INDIA).

[29] Gholap SV, Dod VN, Bhuyar SA, Bhard SG. (2000) Effect of plant growth regulators on seed germination and seedling growth in Aonla (Phyllanthus emblica L.) under climatic condition in Akola. Crop Research. 2000; 20(3):546-548.

[30] Wittwer SH, Bukovac MJ. The effects of gibberellins on economic crops. Econ. Bot. 1958; 12:213-255

[31] Anburani A, Shakila A.(2010). Influence of seed treatment on the enhancement of germination and seedling vigour of papaya. Acta Horticulturae. 2010; 851:295-298.

[32] PulokM.A,Hossain,M..Haque,K.Poddar,S.Partho and M S.H.khan(2014)effect of organic and inorganic Growth regulators on Germination and vigour of pigeon pea seed.int.j.Bus.soc.sciRe2(2):116-120