Int.J.Curr.Res.Aca.Rev.2020; 8(5): 113-123

International Journal of Current Research and Academic Review

ISSN: 2347-3215 (Online) Volume 8 Number 5 (May-2020)

Journal homepage: http://www.ijcrar.com

doi: https://doi.org/10.20546/ijcrar.2020.805.012

Germination Test and Seed Rate Determination on Pulse Crops

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Abstract

Germination is a process by which the embryo in the seed becomes activated and begins to grow into a new seedling. Therefore, a laboratory experiment was conducted at Hawassa University College of Agriculture in2019. The objectives of the study were to test germination and determine seed rates on pulse crops. The experiment was laid out in complete randomized design (CRD) with three replications having five pulse crop varieties (Broad bean, cow pea, haricot bean, soya bean, and mung bean). The results showed that the highest germination percentage (99.3%) were recorded from Broad bean and cow pea and the other three crop varieties attained more than 97% of germination. On the other hand, seed rates of 102kg/ha,24kg/ha,50.5kg/ha, 43.5kg/ha and 10kg/ha for Broad bean, Cow pea, Haricot bean, Soya bean, and Mung bean were recommended respectively.

Article Info

Accepted: 04 April 2020
Available Online: 20 May 2020

Keywords

Germination, Variety and Seed rate

Introduction

The germination in the seeds of higher plants refers to the protrusion of a root or shoot from the seed coat, while emergence is the visible penetration of the shoot above the soil surface (Hadas and Russo 1974, Hadas 1976, Benech Arnold *et al.*, 1991).

In order that a seed can germinate, it must be placed in environmental conditions favourable to this process (Craufurd *et al.*, 1996). Among the conditions required is an adequate supply of water, a suitable temperature range and, for some seeds, light (Collis George and Williams, 1968; Levitt, 1980; Long and Woodward, 1998). The result is measured in terms of the extent to which seeds have germinated (the final germination percentage attained) and the speed with which the germination process has ended. Frequently, though, other parameters represent significant factors from agronomic, planning or physiological perspectives (Jones and Sanders 1987, Esechie 1994, Kader *et al.*, 1998, Kader 1998, Kader *et al.*, 1999, Kader, 2005).

The length of time elapsed between the first seed to germinate and the last, the variation in germination speed and the timing that the majority of seeds germinate all have impacts on diverse cultural operations like fertilising, harvesting and field maturity of crops (Roberts 1981, Washitani and Saeki 1986, Kader and Jutzi 2001). 'High' (the time at which the majority of seeds germinate) and 'low' (the time at which the minority of seeds germinate) (Kader *et al.*, 1998) germination events are also important indicators of seed vigour and stress resistance (Kader and Jutzi, 2002). These data, from an experimental standpoint, also have a significant impact on statistical analyses (Bland and

Altman 1995, Legendre and Legendre 1998, Johnson 1999).

A large proportion of experiments relating seed germination to time and rate calculations face difficulty in interpreting and analyzing results (Finch-Savage *et al.*, 1998, Trudgill *et al.*, 2000, Grundy *et al.*, 2000).

The methods used to evaluate seed germination and emergence are analytical or graphical (Scott *et al.*, 1984), but germination data have several characteristics that distinguish them from other data frequently collected in plant research. Germination is considered to be a qualitative developmental response of an individual seed that occurs at a point in time, but individual seeds within a treatment respond within different times (Harper and Benton 1966, Orchard 1977, Scott *et al.*, 1984, Kader 1998). This leads to a situation where the final germination percentage alone is not sufficient for reporting results due to the lack of ability to compare two sets of data (one lot of seed may have germinated well before the other, but both attained the same final germination percentage). This has been indicated as a setback in previous work relating seed treatments to the germination pattern of seed lots (Timson, 1965; Todd and Webster, 1965; Harris and Wilson, 1970; Thompson, 1974) leading to the development of a number of germination measurement techniques (Heydecker, 1966; Scott *et al.*, 1984; Carberry and Campbell, 1989).

This research work was compares germination of varies pulse crop varieties and analyzed, represented and interpreted germination data.

A seed that has been damaged will produce an abnormal seedling –the shoot, the root, or both may be damaged. If the root is damaged the seedling will germinate, emerge and then generally die. This is because the taproot is weak and cannot grow normally. If the shoot is damaged the seedling will germinate and may emerge.

Abnormal seedlings which do emerge lack vigor making them vulnerable to the rigours of field establishment. Like temperature, disease, insects, seeding depth and soil crusting are more likely to affect the establishment of weak seedlings. Those that do emerge are unlikely to survive for long, producing little dry matter and making little or no contribution to final yield. So the major objective of this paper is to evaluate Germination and determine seed rate for pulse crop varieties in the growing site.

Pulse crop production in Ethiopia

Legumes, or pulses, are flowering plants in the Leguminosae family. The word legume is derived from the Latin verb *legere* which means to gather.

The term pulse has a more direct lineage. It derives from pulse or porridge, a cooked bean dish which the ancient Romans were fond of eating (Albala 7). This family is also known as Fabaceae, and both terms can be used interchangeably to indicate some 690 genera and 18,000 species therein (Morris 1965).

Pulses rank second among ingredients used in national dishes in Ethiopia and are an integral component of the cooking culture of Ethiopians. However, despite their importance, systematic assessment of pulses use in the Ethiopian diet has not yet been carried out at the household or individual level. A few studies suggest usage is very low (Kebebu *et al.*, 2013; Roba *et al.*, 2015).

From a community perspective, caloric intake from consumption of pulses and oilseeds combined was reported at 9% for rural and 14% for urban communities (IFPRI, n.d). Of a total of 12.4 million hectares of farmland in Ethiopia, the majority is used for production of cereals (9.16 million hectares); a relatively small area is seeded to pulses (1.41 million hectares) (FAO, 2010).

The diverse and important roles played by pulses in farming systems and in the diets of people make them ideal crops for achieving the Sustainable Developmental Goals of reducing poverty and hunger, improving human health and nutrition, and enhancing ecosystem resilience. Moreover, some pulses (chickpeas, peas) have certain qualities that enhance soils and improve productivity (Campbell, *et al.*, 1992 and Schwenke, *et al.*, 1998).

Germination

Seed germination is a parameter of the prime significance, and fundamental to total biomass and yield production and consists of a complex phenomenon of many physiological and biochemical changes leading to the activation of embryo. Germination begins with water uptake by the seed and ends with the start of elongation by the embryonic axis, usually the radicle.

Requirements for germination

The basic requirements for germination of seed are moisture, a favorable temperature, and oxygen (Uhvits, 1946).

Moisture

Moisture is required for rehydration of the seed to levels that can support greatly increased respiratory activity, the breakdown of complex reserve materials such as starch, fats and oils, and proteins into simple, mobile, and usable forms, and the synthesis of new materials for growth. The moisture or water must be available in the liquid phase. Seed cannot absorb enough water vapor to bring moisture content high enough to support completion of the germination process (Uhvits, 1946). The liquid water required for germination is normally supplied by the media in or on which the seed are planted soil, peat, blotters, etc. The absorption of water by a seed essentially involves a special type of diffusion called imbibition. Water or other mobile material move from a place or area where it is high in concentration (purer) to an area where it is lower in concentration (less pure) by diffusion until an equilibrium is established, assuming, of course, there are no barriers to such movement. The water in a seed at 10-13% moisture content is not very concentrated it is very impure. It is much lower in concentration than the water in a moist blotter, damp peat, or even relatively "dry" soil. The net movement of water, therefore, is from the media (soil, peat, blotter, etc.) into the seed (Bargali, 2015).

Oxygen

A second general requirement for germination of seed is a supply of oxygen. Oxygen is needed for a great increase in respiratory activity to provide energy to drive the germination process. Since the atmosphere has an abundance of oxygen, it becomes limiting for germination only when its availability to the seed is blocked or impeded by some environmental factor or seed condition (Selamat *et al.,* 2010). Excessive moisture in the soil or other media displaces oxygen in the pore spaces and can reduce its availability to the seed below the threshold level. Many kinds of seed die and ferment in soil that is water logged for more than 2 or 3 days. The covering or coat of some kinds of seed imposes dormancy on the seed because it restricts absorption of oxygen. A few kinds of seed such as those of rice and some aquatic plants can germinate submerged in water a condition that severely limits or excludes oxygen (Selamat et al., 2010).

Favorable temperature

For each kind of seed there is a range of temperature within which the germination process can proceed to completion in a reasonable period of time if it is not blocked by dormancy. The classical work on seed germination defines three cardinal points along the temperature range for germination of a species. These cardinal points are the minimum or base, optimum, and maximum or ceiling temperatures. They differ among the different kinds of seed (Uhvits, 1946). The minimum or base temperature is the temperature below which the processes of germination do not proceed to the point of visible growth of the embryonic axis within a "reasonable" period of time. For many seed kinds the minimum temperature is difficult to establish because of its dependence on time. Since the main effect of a lower temperature on germination is - up to a point a slowing down of the germination process, the minimum temperature established in a 10-day germination period is usually higher than when a 15- or 20-day period is allowed (Ahmed, 1981).

Seed rate

The correct plant density is an important factor in maximizing yield of crops. To obtain the targeted density it is necessary not only to have quality sowing seed but also be able to accurately calculate seeding rates. It is surprising the difference as light variation in seed size or germination makes to the seeding rate required to achieve a target plant density (Bewley and Black, 1994). High seed weight, efficient utilization of reserve food material, development of secondary roots and lower SLA are desirable agronomic traits in crop cultivation, but it varies with crops and genotypes. Large seeds produced more vigorous plants having more shoot and root biomass at initial growth stages and more large seeds at harvest than those produced from small and medium seeds. However, at maturity the plant produced by various seed categories did not differ in height, pod yields, 100-seed weight and shelling. These suggest that small and medium seeds, which germinate better and require 50 and 25 percent lesser amount of seeds, respectively, than those of large one, should be used for sowing, the large and handpicked seeds should be used as food or other edible purposes However, studies on utilization of reserve food material in 10 cultivars of different seed weight indicated that both medium and higher seed-weight groups are efficient in utilization of reserve food material from cotyledons to establish

vigorous seedlings than that of lower seed-weight group (Singh *et al.*, 1997; Singh *et al.*, 1998).

Description of the study area

The laboratory experiment was conducted at Hawassa University, College of Agriculture in 2019. The area is situated in SNNPR, of Ethiopia which is located at 7.04^0 N latitude and 38.3^0 E longitudes and the altitude of 1750m.a.s.l. The area receives an annual rainfall of 900-1000 mm. The maximum and the minimum temperature of the area is 28^0 C and 13^0 C, respectively.

Experimental materials

The main experimental materials used during this study were Petri dish, filter paper(soft), pulse crop varieties, water dropper, sensitive balance and ruler.

Experimental design and treatment

The field experiment was laid out in Randomized Complete Design (CRD) with three replications and five treatments. The treatments of pulse crop varieties were (broad bean, cow pea, soy bean, haricot bean and mung bean varieties). The seed spacing during planting was not less than 1 to 5 times with the width or diameter of each seeds.

Purity analysis for working sample

Based on the International Rules for Seed Testing (ISTA. 2005)purity is an expression of how 'clean' the seed lot is. Information on actual seed lot composition is important; purity analysis serves as a guideline to determine the necessity of further cleaning. During purity analysis, each 'pure' seed fraction from the working sample is separated from the inert matter and other seeds. Purity should be attributed to samples that are not only free from seeds of weeds and other crop species, debris and inert material, but from empty, immature, damaged and infected seeds. Gene banks should aim for absolute purity – it is important to set standards as high as 98% for the proportion of pure seeds in accessions. If an accession fails to meet this target after the initial cleaning, it should then be re-cleaned as many times as necessary for absolute purity.

- Weigh out a working sample of given weight (for example 400 g) of the total seed lot randomly used an electronic balance.
- Spread the sample on table and separate out all pure seeds manually with tweezers or remove impurities by blowing, sifting or letting seeds roll down a slanting surface.
- Weighed the 'pure' seed fraction and express purity as the percentage weight of pure seed over the total weight of the working sample, as shown below.

Purity (%)

$$= \frac{\text{Weight of pure seeds (g)}}{\text{Total weight of working sample (g)}} x100$$

For instance: Total weight of working sample of mung bean = 400 g Weight of pure seeds = 392.4g Inert matter = 5.52 g Other seeds = 2.08g Purity (%) = $\frac{392.4}{400} x100$ = 98.1% of 400. Therefore purity of our working sample seen below the table.

Crops	Submitted sample(gm)	Working sample(gm)	Purity %
Broad bean	1000	400	99.6
Cow pea	1000	400	100
Haricot bean	1000	700	98.4
Soya bean	1000	500	98.7
Mung bean	1000	400	98.1

Experimental procedures

Top-of-paper method

1. prepared the right Petri dish and filter paper(soft)
2. Counted 50 seeds in three replications
3. Moisten the petri dish of filter paper(soft) up to the optimum
4. Placed the seeds on the Petri dish
5. Sown seeds on the petri dish at optimum spacing
6. Labeled the test as to group number
7. Visited the test frequently
8. Counted the germinated seeds on the prescribed dates
9. Calculated the germination

$$\text{Percentage of germination} = \frac{\text{No. of normal seedlings}}{\text{No. of seeds set for the test}} \times 100$$

Evaluation of seedlings

A. Normal seedling

1. A well developed root-system including a primary root except for those plant normally producing seminal roots.
2. A well developed and intact hypocotyle and epicotyle without damage to the tissues and normal plumule.
3. In the poaceae (gramineae), a well developed primary leaf within or emerging through the coleoptile.
4. One cotyledon for seedlings of monocots and two cotyledons for seedlings of dicot.

B. Abnormal seedling

1. Seedling which was lacking in any one of its essential structures or the structures grown were not balanced.
2. All damaged, deformed and decayed seedlings.
3. Seedlings short and weak or spindly or watery.
4. Seedling which fails to develop a green color.

C. Hard seed

Seeds of Fabaceae (Leguminosae) and Malvaceae, which remain hard at the end of the prescribed test period because they have not absorbed water due to an impermeable seed coat, are classified as hard seeds.

D. Dead seed

Seeds which at the end of the test period are neither hard nor fresh and have not produced seedlings are classified as dead seed.

Data collection

Data collected consists of germinated seed from first date of germination up to final date of germination, normal seedlings, abnormal seedlings, un germinated seeds and hypocotyl and epicotyl length from 10 seedlings at randomly.

Data analysis

The parameters used to compare the germination data for representation and accuracy were as follows.

1. Final Germination Percentage (FGP)
2. Mean Germination Time (MGT)
3. Germination Index (GI)
4. Coefficient of Velocity of Germination (CVG)
5. Germination Rate Index (GRI)
6. First Day of Germination (FDG)
7. Last Day of Germination (LDG)
8. Time Spread of Germination (TSG)

The details, measurement units and calculation methods of each parameter are shown in Table 1, with a base germination period of 1- 14 daysbut days were varied depending on varieties being used and applied.

Results and Discussions

Germination parameter

First day, last day and time spread of germination are good measures of when the first germination event started, when the last event occurred and the time between the two, but, again,the results of Table-2 reveal a variation between germination data based on the time spread of germination as well as a final percentage. FGP only reflects the final percentage of germination attained and provides no picture of the speed or uniformity of germination. Table 2 shows that the crop varieties tested all attained the FGP of more than 97%, but had varying time spreads of germination.

MGT is an accurate measure of the time (days) taken for a seed to germinate, but does not correlate this well with the time spread or uniformity of germination. It focuses instead on the day when most germination events occurred. As seen from Table-2, all crop varieties started germination on the same day and attained the near to the same FGP, but had varying MGT values. Table 2, on the other hand, shows the same TSG value had a different FGP, yet the same MGT. This means that crop varieties can germinate across a different spread and attain a different final germination percentage, yet have the same mean germination time.

GRI calculations merely show the percentage of germination per day, so the higher the percentage and the shorter the duration, the higher the GRI. CVG does not focus on the final percentage of germination, but places emphasis on the time required for reaching it. The details of time (first day, last day and time spread) are not taken into account as the time is averaged. Table 2 shows seed of varieties with the same FDG, LDG and TSG, but different CVG values. This means that time-based measurements, not correlated with the FGP, are not a very useful representation of the overall seed germination activity. Starting germination and ending it at the same time is not sufficient enough to produce a uniform CVG. The GI appears to be the most comprehensive measurement parameter combining both germination percentage and speed (spread, duration and 'high/low' events). It magnifies the variation among seed of varieties in this regard with an easily compared numerical measurement.

Hypocotyl and epicotyl length

The result of table-4 below showed that theBroad bean seedling length of hypocotyl was zero but the length of epicotyl was 1.72. It implies that during the hypogeal germination the cotyledons stay below the ground. The epicotyl (part of the stem above the cotyledon) grows, while the hypocotyl (part of the stem below the cotyledon) remains the same in length.

Table.1 Description of various parameters used to study seed germination

Germination Parameter	Symbol	Unit	Formula for Calculation	Description of Formula	Notes & Reference
Final Germination Percentage	FGP	%	FGP=ratio final no. of seeds germinated in a seed lot to total seed planted × 100		The higher the FGP value, the greater the germination of a seed population. Scott *et al.*, (1984)
Mean Germination Time	MGT	Day	MGT=P*f·x*/P*f*	f=Seeds germinated on day x	The lower the MGT, the faster a population of seeds has germinated. Orchard (1977)
First Day of Germination	FDG	Day	FDG=Day on which the first germination event occurred		Lower FDG values indicate a faster initiation of germination. Kader (1998)
Last Day of Germination	LDG	Day	LDG=Day on which the last germination event occurred		Lower LDG values indicate a faster ending of germination. Kader (1998)
Coefficient of Velocity of Germination	CVG	—	CVG=$N_1 + N_2 + \cdots +$ *Nx*/100 × $N_1T_1 + \cdots +$ *NxTx*	N=No. of seeds germinated each day, T=No. of days from seeding corresponding to N	The CVG gives an indication of the rapidity of germination. It increases when the number of germinated seeds increases and the time required for germination decreases. Theoretically, the highest CVG possible is 100. This would occur if all seeds germinated on the first day. Jones and Sanders (1987)

Germination Rate Index	GRI	(%/day)	GRI=G1/1 + G2/2 +⋯+ Gx/x	G1=Germination percentage × 100 at the first day after sowing, G2=Germination percentage × 100 at the second day after sowing	The GRI reflects the percentage of germination on each day of the germination period. Higher GRI values indicate higher and faster germination. Esechi (1994) after modification.
Germination Index	GI	—	GI=(10×n1) + (9×n2) + ⋯ + (1×n10)	n1, n2 ...n10 = No. of germinated seeds on the first, second and subsequent days until the 10th day; 10, `... and 1 are weights given to the number of germinated seeds on the first, second and subsequent days, respectively	In the GI, maximum weight is given to the seeds germinated on the first day and less to those germinated later on. The lowest weight would be for seeds germinated on the 10th day. Therefore, the GI emphasizes on both the percentage of germination and its speed. A higher GI value denotes a higher percentage and rate of germination. Bench Arnold *et al.*, (1991)
Time Spread of Germination	TSG	Day	TSG=The time in days between the first and last germination events occurring in a seed lot		The higher the TSG value, the greater the difference in germination speed between the 'fast' and 'slow' germinating members of a seed lot. Kader (1998)

Table.2 Germination parameters

Day	Broad bean	Caw pea	Haricot bean	Soy bean	Mung bean
1	0	0	0	0	0
2	0	0	0	0	0
3	0	0	0	0	0
4	20	28	16	22	35
5	111	119	101	120	111
6	9	1	18	1	0
7	8	0	9	2	0
8	0	1	2	1	0
9	1	0	0	0	0
14	0	0	0	0	0
Parameters					
FGP (%)	99.3	99.3	97.3	97.3	97.3
MGT (day)	2.06	1.83	2.17	1.9	1.76
GI	16.72	19.86	19.46	19.46	48.66
CVG	48.5	54.4	45.91	52.6	56
GRI (%/day)	16.8	20	20	20	50
FDG (day)	4	4	4	4	4
LDG (day	9	8	8	8	5
TSG (day)	5	4	4	4	1

(Olisa, 2010)

Table.3 Mean data for normal seedling, Abnormal seedling, and Un germinated seed in 100%

Crops	Purity %	Germination%	Normal seedling (%)	Abnormal seedling (%)	Un germinated seed (%)
Broad bean	99.6	99.3	83.3	16	0.7
Cow pea	100	99.3	80.6	18.7	0.7
Haricot bean	98.4	97.3	78.7	18.6	2.7
Soya bean	98.7	97.3	89.3	8	2.7
Mango bean	98.1	97.3	92.3	5	2.7

Table.4 Mean data for hypocotyl and epicotyl length.

Crops	Hypocotyl length(cm)	Epicotyl length(cm)
Broad bean	0	1.72
Cow pea	6.09	o.35
Haricot bean	8.93	0
Soya bean	8.84	0
Mung bean	6.77	0.7

Table.5 Seed rate calculation

Crops	1000seed weight (gm)	Germination%	Purity %	Seeds/hill (number)	Spacing (cm)	Seed rate kg/ha
Broad bean	201.2	99.3	99.6	2	40*10	102
Cow pea	47.6	99.3	100	2	40*10	24
Haricot bean	96.6	97.3	98.4	2	40*10	50.5
Soya bean	83.6	97.3	98.7	2	40*10	43.5
Mung bean	19	97.3	98.1	2	40*10	10

In this way, the epicotyl pushes the plumule above the ground. In this kind of germination, the cotyledons do not come out of the soil surface. In such seeds the epicotyl (i.e., part of embryonic axis between plumule and cotyledons) elongates pushing the plumule out of the soil.

The remaining crop varieties seen below table-4 showed that during epigeal germination the cotyledons are pushed above ground. The hypocotyl elongates while the epicotyl remains the same in length. In this way, the hypocotyl pushes the cotyledon upward. In seeds with epigeal germination, the cotyledons are brought above the soil due to elongation of the hypocotyl. In cow pea, haricot bean, soya bean, and mange bean, flat green leaf like cotyledons can be seen in the young seedlings.

Seed rate

The result of table-5 showed that during seed rate calculation 1000 seed weight, germination%, purity%, seed/hill, and spacing between row and between pants were mandatory. Based in our laboratory research results large seed size varieties (Broad bean seen table-5) have higher seed rate than smaller seed size (Mung bean seen table-5) because of large seed size have more 1000 seed weight than small sized seeds.

Germination and purity percentage also have a great role in seed rate calculation. When high percentage of germination and purity seeds have small seed rate as compered to low germination and purity percentage. During planting of seeds per hill was depend on purity and germination percentage of seeds. Therefore, we used two seeds per hill during seed rate calculation because seeds were not 100% pure and germinated 100% and it will be thinning.

Formula for Seed Rate Calculation

1. Area = length(m)*width(m)
2. Number of seed per meter square $= \frac{\text{Number of seed per hill}}{\text{spacing in meter square}}$
3. Seed weight (SW)/kg $= \frac{\text{Number of seed per meter square} * 1000\text{seed weight}}{100}$
4. Economic value(EV)= $\frac{\text{Purity\%} * \text{Germination\%}}{100}$
5. Seed rate kg/ha = $\frac{SW(100-EV)}{100}$ +S

Source(WSU, Seed Science and Technology Manual,2017)

Summary and conclusion are as follows:

Germination is a process by which the embryo in the seed becomes activated and begins to grow into a new seedling. Germination is usually the growth of a plant contained within a seed; it results in the formation of the seedling; it is also the process of reactivation of metabolic machinery of the seed resulting in the emergence of radicle and plumule. The result is measured in terms of the extent to which seeds have germinated and the speed with which the germination process has ended. Frequently, though, other parameters represent significant factors from agronomic, planning or physiological perspectives. Therefore, first day, last day and time spread of germination are good measures of when the first germination event started, when the last event occurred and the time between the two. FGP only reflects the final percentage of germination attained and provides no picture of the speed or uniformity of germination. Crop varieties tested all attained the FGP of more than 97%, but had varying time spreads of germination and all crop varieties started germination on the same, but had varying MGT values. In conclusion, the use of germination data analysis methods is prone to misinterpretation if germination percentage, speed, and

concentration are not taken into account in one measurement. In the context of the parameters tested in this investigation, it appears that the GI is the most accurate in this regard.

When we used more than 98% pure seeds during seed germination test and all crop varieties attained(germinated) more than 97%, but normaly, and abnormally grown seedlings were varies from varieties to varieties. The result of test showed that the mung bean crop varieties used the purity percentage was least as compere to other but attained the higher percentage of seedlings grown normally. Based on epicotyl and hypocotyl length the result showed that Broad bean have taken place hypogeal germination because the length of hypocotyl was zero but the length of epicotyl was 1.72. The other four crop varieties were takes place epigeal germination the cotyledons are pushed above ground and the hypocotyl elongates while the epicotyl remains the same in length. In this way, the hypocotyl pushes the cotyledon upward. In seeds with epigeal germination, the cotyledons are brought above the soil due to elongation of the hypocotyl. In cow pea, haricot bean, soya bean, and mange bean, flat green leaf like cotyledons can be seen in the young seedlings.

Lastly, for seed rate calculation we used 1000 seed weight, germination%, purity%, seeds/hill, and spacing between row and between pants and calculated 102kg/ha for Broad bean, 24kg/ha for Cow pea, 50.5kg/ha for Haricot bean, 43.5kg/ha for Soya bean, and 10kg/ha for Mung bean seeds.

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How to cite this article:

Desta Abayechaw and Kedir Wulchafo. 2020. Germination Test and Seed Rate Determination on Pulse Crops. *Int.J.Curr.Res.Aca.Rev.* 8(5), 113-123. doi: https://doi.org/10.20546/ijcrar.2020.805.012