

Effect of Priming on Yield and Yield Components of Soybean [Glycine max (L.)Merrill] Varieties at Assosa, Western Ethiopia

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Abstract

The use of low quality soybean seed is a major limiting factor for yield reduction under tropical and subtropical conditions. Field experiment was carried out at Assosa Agricultural Research Center to determine the effect of priming on yield and yield components of soybean varieties. The experiment had three varieties (Belessa95, Wello and Gishama), three priming types [GA_3 (100PPM), KH_2PO_4 (50 PP) and water] and three priming durations (0, 6, 12hr) were evaluated using a randomized complete block design (RCBD) in four replications. Highly significant ($P \leq 0.01$) difference between interaction of varieties by, priming type and soaking durations for plant height at maturity, number of pods per plants, number of primary branches per plants, yield per hectare, and Varieties by priming type interaction showed highly significant ($P \leq 0.01$) difference for day to 50% flowering, plant height at maturity, number of pods per plants, number of primary branches per plants, harvest index, thousand seed weight and significant ($P \leq 0.05$) for number of seed per pod and stand count at harvest. The tallest plant height (87.26cm) was recorded when Belessa95 primed with water for 12hr. Also highest number of pods per plant (46) was observed on Belessa 95 primed with KH_2PO_4 for 12hr, the highest number of seeds per pods (3) was observed when Wello primed with water and highest yield (3418.85 Kg) was recorded for Wello primed with water for 6hr and highest stand count at harvest (119.67) was recorded for Wello primed with water. Hence, Water priming was recommended to user to overcome the problems of poor crop emergence and establishments under this adverse environmental condition.

Keywords: Chemo-priming, Soybean Varieties, Correlation, Germination.

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1. Introduction

Soybean [*Glycine max* (L.) Merrill] is a legume crop taxonomically belongs to the family leguminace, sub family Papilionaceae, tribe phaseolae, Genus Glycine and subgenus *Soja* (Lackey, 1977). Moreover, the Genus Glycine contains two subgenera, namely Glycine and *Soja*. The wild (*G. soja*) and cultivated (*G. max*) annual species are grouped under the subgenus *Soja*. However, the chromosome number of the cultivated soybean species is a diploid tetraploid ($2n = 2x = 40$). The cultivated species; *Glycine max* (L.) has never been found in the wild, therefore its probable ancestor is *G. soja* which is the major gene sources (Hymowitz, 1970). Soybean is considered either a short or a day neutral plant requires 25 to 30°C temperature for growth and proper nodulation. Soybean is a medium altitude crop well adapted to altitude varying from 1300 to 1800 masl receiving annual rainfall of 900 to 1300 mm and it also well at 1900 masl having 550 to 700 mm annual rainfall (Amare, 1987). The crop has a wide range of soil adaptation, but performs well on light textured, loams and medium black clays with pH range of 6.5 to 7 in Ethiopia (IAR, 1982).

In 2015, about 318.8 million metric tons of soybeans were produced in the world. The United States of America accounted for about 33.55% of the soybean production. The other major producers are Brazil (31.36%), Argentina (17.88%), China (3.76%), Canada (1.96%) and others account the rest (11.48%) (USDA, 2016). It is cultivated in Sub-Saharan Africa to a very limited extent (Laswai *et al.*, 2005; Shurtleff and Aoyagi, 2007). During the last decade or so, the African continent accounted for 0.4% to 0.6% of the world's total production of soybean, the main producers being Nigeria, South Africa, Zimbabwe and Rwanda. Overall, 19 African countries appear in the world soybean production. More than 90% of the soybean is produced by Nigeria (48.9%), Uganda (16.8%), South Africa (14.9%), Zimbabwe (8.4%), Ethiopia (2.7%) and Rwanda (2.0%) etc. (Thomas and Erostat, 2008). The economic viability of soybean is determined by commercial utilization of both sub products; oil, and meal, which accounts one and two third of the crop economic value, respectively. Soybean oil is dominant in the world market, accounts about 30% of the total vegetable oils. In global market, its oil share is estimated nearly 44%, and ranked first among the major oil crops such as rapeseed, groundnut, and sesame (Chung and Singh, 2008). Moreover, on the weight basis, soybean protein yield is about twice, four, and twelve times than that of the meat, eggs, and milk, respectively (Anon., 1984). The nutritional value of soybean primarily lies in its quality protein and oil content which is free of cholesterol (Antalina *et al.*, 1999). The crop is a promising pulse proposed for alleviation of acute protein and oil shortage in the world. Soybean is also nutritious and healthy due to proportional composition of carbohydrate, fiber, vitamins, and minerals (Carter and Wilson, 1998). Studies had been showed a reduced risk of cancer, heart, and chronic disease in soybean product consumed populations (Carter

and Wilson, 1998). The crop is also highly important in cropping system thereby enriching soil fertility through biological N fixation in symbiosis with bacteria better than other legume crops. On the average soybean can fix over 75 kg nitrogen per hectare (LaRue and Patterson, 1981).

The success of the soybean industry is attributed to the crop's agronomic performance and composition (Liu, 2000). Soybean can be grown in a wide range of environments, has moderate drought tolerance, and does not require nitrogen fertilization because of symbiosis with the nitrogen fixing bacteria; *Rhizobium*. Roughly 60% of the dry weight of soybean seed is composed of protein and oil, and as a result soybean seed has the highest protein and second highest oil content among cereal and legume species (Liu, 1997). These facts make soybean an important crop for oil manufacturing, animal feed, and food production (Hymowitz *et al.*, 1972; Wilcox and Shibles, 2001). Soybean is important because of its nutritional qualities. It has high percentage of high quality and cheap protein and is a rich source of edible oil. The world production of edible oils consists of 30% soybean (Assefa, 2008). Soybean seed contains about 40-45% protein and 20-22% oil, 20-26% carbohydrate and a high amount of Ca, P and vitamins (Rahman *et al.*, 2011). In Ethiopia, soybean was started in 1950's on introduced genotypes with main emphasis of identifying adapted lines for the potential areas, replacing imported soybean flour, introducing into the existing cropping systems, and diet of the poor farmers (Amare, 1987). It is a crop that can play major role as protein source for resource poor farmers of Ethiopia who cannot afford animal products. In our country, now a day's soybean is highly utilized in nutrition industries for both food and feeds. According to CSA (2015) the area under soybean cultivation in Ethiopia is estimated about 35259.76 hectares (ha) and 72183.75 tons of production with the productivity of 2.04 tons ha⁻¹ which is by far lower than the world's average of 2.3-4.0 tons ha⁻¹ and in Benishangul-Gumuz Region the area under soybean cultivation is 12939.90 hectares and productivity is 1.90 tons ha⁻¹ (Masuda and Goldsmith, 2008). Soybean was introduced into Benishangul -Gumuz during resettlement program. Since then, the farmers grow soybean on small scale as sole crop primarily for its economic merit and home consumption. In Assosa zone, soybean was the most dominant pulse crop with the total production area and productivity of 3617.63 ha and 1.46 tons/ha, respectively (CSA, 2015). Now a day's, soybean production is highly raised in the region due to increased demand of the farmers and investors.

Even if the region is suitable for production the use of soybean seeds of low physical and physiological quality is a common practice under this environment, leading to inadequate plant population which finally reduce the production and productivity in the field. Faster germination and emergence is an important factor for better, more and uniform stand establishment. This poor crop emergence and establishments might have happened due to unpredictable and erratic rain fall, low or inadequate soil nutrients, low quality seeds, hard seed coat, sowing time, low moisture contents of the soil, heat stress, limited access to mechanization and diseases of the crops like soybeans which are mainly grown under such environments all contribute to failures and poor crop stand establishment that may survive the crop poorly under such adverse environmental conditions. Under such conditions seed germinations, seed emergence and seedling establishments can be inhibited and reduced. Therefore, seed priming (seed invigoration) before seed sowing has been a best solution to overcome such adverse environmental effects for better, more and uniform seed germination, seed emergence and seedling establishment. Concerning priming treatments studies on soybean are not adequate but encouraged so more information is required to use this technology in seed production.

Hence, objectives of this study were:-

- To determine the effect of priming on yield and yield components of soybean varieties.

2. Materials and methods

2.1. Description of the Study Sites

The field experiment was conducted in Benishangul-Gumuz Regional State, at Asossa Agricultural Research Center (AARC) on station in the 2015 main cropping season under rain fed field conditions. Benishangul- Gumuz Regional State is geographically located at the latitude of 9°30' to 11°39' N and longitude of 34° 20' to 36° 30' E covering a total land area of 50,000 square kilometer. The study site is located at 10° 02' 05" N latitude and 34° 34' 09" E longitudes and situated east of Assosa town and west of Addis Ababa about 14 km and 653 km distance, respectively. The area experiences a unimodal rainfall pattern and has annual rainfall of about 1118 mm out of which 936.3 mm rain was recorded during the growing season of the crop. The rainy season occurs from March to December and the maximum rain is received in August. The minimum and maximum temperatures are 11.9°C and 32.7°C, respectively. The soil type of the area is Nitosol which is dark reddish brown to dark red in colour and the crops mainly cultivated in the area are sorghum, maize, soybean and finger millet (AARC, 2007).

2.2. Treatments and Experimental Design

The treatments consist of three varieties of soybean namely Belessa- 95, Wello and Gishama and priming treatments GA₃ (100PPM), KH₂PO₄ (50PPM) and water at timings of 0, 6 and 12hr. The size of each plot was 4x3m (12m²). The space between blocks was 1m, the space between rows in each plot was 60cm and spacing between plants was 5cm. The rate of fertilizer used was 100kg DAP which contains 18%N and 46%P₂O₅ as a source of

Nitrogen and Phosphorus. The experiment was laid out in factorial arrangement using Randomized Complete Block Design (RCBD) in four replications.

2.3. Experimental Procedure and Field Management

The land was prepared for planting by tractor, disked and harrowed. The seeds of all the three varieties were soaked in GA₃ (100 PPM), KH₂PO₄ (50 PPM) and water for 0, 6 and 12 hr. The seeds of all the varieties were used as control where Hydro priming and osmo priming treatments were not applied. After giving treatment for 0, 6 and 12 hours the seed was removed from water and solutions then it was kept in filter paper to remove the remaining solution. All the primed seeds were again re-dried at room temperature until they gain their original seed moisture content. Seed was sown in last week of June 2015 in rows by placing the seeds at an appropriate distance as per the treatments with the help of tape meter and then covered it manually with the soil. All cultural practices such as weeding fertilizer application etc were applied uniformly to all plants. The crop was harvested manually when the crop reached physiological maturity and sun dried for up to 14 days to adjust the moisture contents of the seed to 10%.

2.4. Data Collected

2.4.1. Growth phenology, yield component and yield

Days to 50% flowering: The number of days taken from the date of sowing to flowering were calculated and expressed in number as days taken for 50 per cent of plants showed flowers.

Plant height: The plant height on five randomly selected and tagged plants were measured from the base of the plant to the tip of the shoot apex at physiological maturity and the average height of five plants was worked out and expressed in centimeters.

Days to Physiological maturity: were recorded as the number of days from sowing to 90% plants per plot attains maturity (the seed as well as pod turn yellow).

Number of pods per plant: The number of pods from five randomly selected and tagged plants and average was taken.

Number of seeds per pod: The number of seeds per plant was counted from five randomly selected plants and the average was taken.

Number of Primary branches per plant: The number of primary branches on the main stem per plant harvested at maturity was obtained by counting the branches from five randomly selected and average was taken.

Stand count at harvest: the number of plants per net plot at harvest.

Harvest index was determined as the ratio of grain yield to the total above ground dry biomass yield.

Thousand seed weight: determined by weighing 1000 seeds sampled from each plot using an electronic sensitive balance.

Yield per hectare: The matured pods harvested from the net plot in each treatment were sun dried and the seed was separated. The weight of the seeds harvested from net plot area was recorded and converted to yield per hectare after adjusting to 10% moisture content.

2.5. Data Analysis

Data were subjected to Analysis of Variance (ANOVA) using Gomez and Gomez (1984) with computer software SAS statistical package, Version 9.1 (SAS, 2000). Whenever the effects of the factors were found to be significant, the means were compared using the Tukey's Studentized Range (HSD) test at 5% level of significance.

3. Results and discussions

3.1. Field Experiment

3.1.1. Days to 50% flowering

There was a highly significant ($P \leq 0.01$) difference among varieties, seed priming type and their interaction effect for days to 50 per cent flowering. *Wello(2)* variety which is primed with GA₃(B) took significantly lesser days (82) to 50 per cent flowering followed by *wello(2)* primed with KH₂PO₄(C) and unprimed(A) *Wello* variety which took (85.33) days to 50 per cent flowering. Significantly delayed flowering was exhibited on unprimed (A) *Belessa95* (1) variety which took (93 days) and was at par with *Belessa 95*(1) variety primed with GA₃ (B) and KH₂PO₄(C) which took (91 days) whereas the other combination showed an intermediate values (Table 1). The results agreed with Khairul, *et al.* (2015) who reported that chickpea seed primed with GA₃ took minimum number of (70) compared to hydro primed chickpea seed which took (82.33) days to 50% flowering. Similarly, Punjabi *et al.* (1992) reported that soybean variety applied with GA₃(100 ppm) initiated flowering and increased number of flower per plants (35.44) as compared to control (16.78). On the other hand, Harris *et al.* (2007) found that the priming in maize led to better crop establishment and growth, earlier flowering and greater yields. The accelerated flowering in case of GA₃ might be due to their effect in the fast emergence of the seeds at the beginning and the variation in case of the three different unprimed soybean varieties might be due to early and late flowering of the varieties. In addition to better establishment, farmers reported that primed crops grew more vigorously, flowered

earlier and yielded higher (Farooq *et al.*, 2008).

Table 1. Interaction effects of Soybean varieties and priming types on days to 50% flowering, number of seed per pod, stand count at harvest, harvest index and thousand seed weight.

Interaction	D50%F	NSPP	SCAH	HI	1000SW
1 A	93.00 ^a	2.47 ^{fg}	116.67 ^{ghi}	31.00 ^a	150.00 ^{cdef}
1 B	91.00 ^b	2.87 ^{abc}	119.44 ^{ab}	27.00 ^{cd}	157.20 ^{abcde}
1 C	91.00 ^b	2.87 ^{abc}	118.67 ^{bcd}	27.00 ^{cd}	145 ^{efghi}
1 D	90.00 ^{bc}	2.93 ^{ab}	120.00 ^a	25.00 ^{de}	152.80 ^{bcdef}
2 A	85.33 ^f	2.53 ^{efg}	117.33 ^{efgh}	27.00 ^{cd}	140.00 ^{ghi}
2 B	82.00 ^g	2.80 ^{abcd}	119.33 ^{ab}	23.00 ^{de}	136.70 ^{hi}
2 C	85.33 ^f	3.00 ^a	118.67 ^{bcd}	30.00 ^{ab}	146.10 ^{efghi}
2 D	87.00 ^{ef}	3.00 ^a	119.67 ^{ab}	27.00 ^{bcd}	153.10 ^{bcdef}
3 A	90.00 ^{bc}	2.33 ^g	116.00 ⁱ	31.00 ^a	148.30 ^{defgh}
3 B	87.33 ^{de}	2.73 ^{bcde}	117.33 ^{efgh}	27.00 ^{cd}	155.00 ^{abcde}
3 C	89.00 ^{cd}	2.71 ^{bcde}	117.00 ^{fghi}	28.00 ^{abcd}	163.90 ^{ab}
3 D	89.00 ^{cd}	2.6 ^{def}	118.67 ^{bcd}	30.00 ^{abc}	166.30 ^a
LSD	1.85	0.22	1.21	2.40	11.80
CV	1.24	4.71	4.62	4.76	5.74

Where, D50%F= Day to 50% flowering, NSPP=Number of seed per plant, SCAH= Stand count at harvest, HI= harvest index, 1000SW= Thousand seed weight 1=*Belessa 95*, 2= *Wello*, 3= *Gishema*, A=Control B=Gibberellic acid, C=Potassium dihydrophosphate and D= Water. Means followed by the same letter(s) at each column and row are not significantly different from each other at 0.05 level of probability.

3.1.2 Plant height

There was a highly significant ($P \leq 0.01$) difference among varieties, duration of priming, seed priming type and interaction effect for plant height at maturity. The tallest plant height was recorded for *Belessa 95* variety (87.27cm) hydro primed for 12 hour which was at par with *Gishama* hydro primed for 6 hr (86.57cm) and for 12hr (85.23cm) (Table2). *Gishama* variety which was primed with GA₃ for 0, 12 and 6 hours has also the highest plant height (84.54cm), (83.80cm) and (83.67cm) respectively. This result was agreed with Punjabi *et al.* (1992) who reported that Soybean seed primed with GA₃(100ppm) records the tallest plant height (57.10cm) as compared to control (25.11cm). This might be due to the importance of priming treatments for stimulations of genes that are important for enhancement of cell division which leads to increase plant height at maturity. Basically, plant height is a genetically controlled character, but several studies have indicated that the plant height can be increased or decreased by different seed quality enhancement practices Ali, (2009). The beneficial effect of exogenous application of GA₃ to seeds might be due to the translocation of GA₃ to the aerial part of plants, and this perhaps occurs to an extent that is enough to increase hypocotyls size and the consequent increase in first node height hence sufficient to positively affect plant height (Chavan *et al.*, 2014)

Bensen *et al.* (1990), demonstrate the hypocotyls growth rate is directly associated with the amount of GA₃. *Belessa 95* variety which was primed with KH₂PO₄ for 12hr records (79.4cm) plant height which is at par with *Wello* and *Belessa 95* variety primed with KH₂PO₄ for 12hr which records (79.2cm) and (79.4cm) respectively. The result is in agreement with Mohammadi(2009) who reported that soybean seed primed with potassium nitrate showed the highest plant height(43.4%) as compared to control. The enhanced plant height may also be due to the improved and faster plant emergence in GA₃, Water and KH₂PO₄ primed varieties which created cooperative competition among the plants for light and resulted in taller plants. The results agree with Harris *et al.* (2000) who reported that seed priming of ten rice varieties resulted in taller plants (108 cm and 94 cm) in two years. The shortest plant height was observed on the unprimed *Wello* variety (68.13cm), *Belessa 95* variety(72cm), *Wello* primed with GA₃ for 0 hr (72.20cm) which is at par with *Wello* primed with KH₂PO₄ for 0hr (73.20cm) and *Wello* primed with GA₃ for 0hr(73.72cm).

Table 2. Interaction effects of priming, soaking duration and varieties on Plant height

Variety	PT	Priming durations		
		0	6	12
<i>Belessa 95</i>	GA ₃	76.40 ^{efghi}	74.07 ^{fghi}	76.73 ^{efghi}
	KH ₂ PO ₄	75.20 ^{fghi}	75.00 ^{fghi}	79.40 ^{cdef}
	Water	75.88 ^{efghi}	81.33 ^{bcde}	87.27 ^a
	Control	72.00 ^{ij}	72.00 ^{ij}	72.00 ^{ij}
<i>Gishema</i>	GA ₃	84.54 ^{abc}	83.67 ^{abcd}	83.80 ^{abcd}
	KH ₂ PO ₄	73.27 ^{ghij}	75.32 ^{fghi}	76.33 ^{efghi}
	Water	76.33 ^{efghi}	86.57 ^{ab}	85.23 ^{ab}
	Control	74.47 ^{fghi}	74.47 ^{fghi}	74.47 ^{fghi}
<i>Wello</i>	GA ₃	72.20 ^{hij}	74.67 ^{fghi}	73.78 ^{fghij}
	KH ₂ PO ₄	73.20 ^{ghij}	75.68 ^{efghi}	79.20 ^{cdef}
	Water	73.72 ^{fghij}	78.13 ^{defg}	77.87 ^{efgh}
	Control	68.13 ^j	68.13 ^j	68.13 ^j
LSD	5.78			
CV	2.32			

Where, PT= Priming type GA₃=Gibberellic acid, KH₂PO₄=Potassium dihydrophosphate. Means followed by the same letter(s) at each column and row are not significantly different from each other at 0.05 level of probability.

3.1.3. Physiological maturity

There was a highly significant difference among varieties and significant (P≤0.05) difference among priming types for hastening Physiological maturity. Among variety *Wello* variety took significantly lesser days (120.8) to Physiological maturity as compared to *Belessa 95* and *Gishema* which took (123.2) and (125) days respectively (Table 3). Among priming types there was significance Soybean varieties which was primed with GA₃ took significantly lesser days (122) to Physiological maturity compared to Water and KH₂PO₄ which took (123.11) and (123.56) days respectively (Table 3) this might be due to the faster germination of seed as the results of gibberellic whereas the variation between varieties to accelerated or delayed physiological maturity might be due to genetic variations among them.

Table 3. Main effect of priming types and soybean varieties on physiological maturity.

Variety	physiological maturity
<i>Gishema</i>	125.00 ^a
<i>Belessa</i>	123.20 ^b
<i>Wello</i>	120.80 ^c
LSD (0.05)	0.53
Priming type	
GA ₃	122.00 ^b
KH ₂ PO ₄	123.56 ^a
Water	123.11 ^a
LSD (0.05)	0.94
CV(%)	0.80

Where, GA₃=Gibberellic acid, KH₂PO₄=Potassium dihydrophosphate. Means followed by the same letter(s) at each column and row are not significantly different from each other at 0.05 level of probability.

3.1.4. Number of pods per plant:

There was a highly significant (P≤0.01) difference among varieties, priming type, priming durations and their interactions for number of pods per plant. The highest number of pods per plant was observed on *Belessa 95* variety primed with KH₂PO₄ for 12hr (46.00) and 6hr (45.33) followed by *Wello* variety primed with KH₂PO₄ for 12hr (45.13) and 6hr (44.87) whereas the lowest number of pods per plant was observed for *Gishema* varieties primed with GA₃ for 0hr (22.73), unprimed *Belessa 95* (30.27), *Wello* (31.40) and *Gishema* (24) varieties (Table 4). These results are similar with the finding of Shahram (2015) who reported that soybean seed primed with KH₂PO₄ and water records (132.8) and (124.5) number of pods per plant respectively compared to control (85.91). Similarly, Mohammadi (2009) reported that soybean seed primed with potassium nitrate showed the highest value of number of pods per plant (56.5%) as compared to control. *Wello* variety primed with GA₃ for 12 hr gave 43.53 pods per plant which was at par with *Belessa 95* primed with water for 12hr (43.20) and 6hr (41.93) and *Wello* variety primed with water for 12hr (41.27) and 6hr (40.40) (Table 4). These results are in line with the report of (Khairul, et al., 2015) who reports that chickpea seed primed with GA₃ 225ppm and GA₃ 300ppm resulted in (55.50) and (52.38) number of pods per plants respectively compared to hydro primed chickpea seeds. Similarly, Aldesuquy and Ibrahim (2000) reported that the seed treatment with shikimic acid improved yield and yield components of cowpea plants by increasing the number of pods per plant and number of seeds per pod.

Table 4 .Interaction effects of priming types, durations and varieties on number of pods per plant.

Variety	PT	Priming durations		
		0	6	12
<i>Belessa 95</i>	GA ₃	36.53 ^{bcdefgh}	35.33 ^{cdefghi}	35.60 ^{cdefghi}
	KH ₂ PO ₄	33.33 ^{defghij}	45.33 ^{ab}	46.00 ^a
	Water	32.13 ^{fghijk}	41.93 ^{abcd}	43.20 ^{abc}
	Control	30.27 ^{hijklm}	30.27 ^{hijklm}	30.27 ^{hijklm}
<i>Gishema</i>	GA ₃	22.73 ^m	26.73 ^{ijklm}	27.20 ^{ijklm}
	KH ₂ PO ₄	23.47 ^{lm}	27.60 ^{ijklm}	30.27 ^{hijklm}
	Water	24.27 ^{klm}	26.07 ^{ijklm}	26.07 ^{ijklm}
	Control	24.00 ^{klm}	24.00 ^{klm}	24.00 ^{klm}
<i>Wello</i>	GA ₃	39.27 ^{abcdefg}	37.73 ^{abcdefgh}	43.53 ^{abc}
	KH ₂ PO ₄	34.87 ^{cdefghij}	44.87 ^{ab}	45.13 ^{ab}
	Water	32.67 ^{efghijk}	40.40 ^{abcdef}	41.27 ^{abcd}
	Control	31.40 ^{ghijklm}	31.40 ^{ghijklm}	31.40 ^{ghijklm}
LSD	8.92			
CV	8.05			

Where, PT= Priming types GA₃=Gibberellic acid, KH₂PO₄=Potassium dihydrophosphate. Means followed by the same letter(s) at each column and row are not significantly different from each other at 0.05 level of probability.

3.1.5. Number of seeds per pod

There was highly significance difference among varieties ($P \leq 0.01$) and significant interaction ($P \leq 0.05$) effect between varieties by priming type for number of seeds per pod. The highest number of seed per pod was recorded on *Wello*(2) variety primed with KH₂PO₄(C)(3)and water(D) (3) which are at par with *Belessa 95*(1)variety primed with water(D)(2.93), with KH₂PO₄(C)(2.87), withGA₃(B)(2.87) and *Wello*(2) variety primed withGA₃ (B)(2.8). (Table 2).The three unprimed (A) soybean varieties show the lower number of seeds per pod *Gishema* (3) (2.33), *Belessa95* (1) (2.47) and *Wello*(2) (2.47) compared to the primed soybean varieties (Table 1).These results are similar with the report of Mohammadi (2009) who reported that soybean seed primed with potassium nitrate showed the highest number of seeds per pod (23.8%) as compared to control. Similarly, Shahram (2015) reported that soybean seed primed with water and KH₂PO₄ gave the same seed number seed per pods which is (2.59) and (2.52) respectively compared to control (1.94). Similarly, results were also reported by Rashid *et al.* (2004) in mungbean reported that the primed seed plants produced more seed per pod.

3.1.6. Number of Primary branches per plant

There was highly significance difference ($P \leq 0.01$) among varieties, priming type, durations of priming and their interaction effect on number of primary branches per plant. The highest number of primary branches per plant was observed on *Wello* and *Belessa95*variety primed with KH₂PO₄for 12hr (6.60) and for 6hr (6.54) respectively which was at par with *Gishema* and *Belessa95* primed with KH₂PO₄ for 12hr (6.53) and for 6hr (6.47) respectively. Similarly, the highest number of primary branches per plant was also observed on hydro primed *Belessa95*variety for 6hr (6.47) and for 12hr (6.27) and *Gishema* hydro primed for 6hr (6.40) and for 12hr (6.13).The lowest number of primary branches per plant was recorded on *Gishema* variety primed with GA₃ for 6hr (2.47) whereas the other showed an intermediate value (Table 5). Unprimed soybean varieties gave lower number of primary branches per plant. The results are in agreement with those obtained by Kaur *et al.* (2002) who reported that primed chickpea seeds increased number of branches 30-40% than unprimed seeds. Similarly, Punjabi *et al.*(1992) found that Soybean seed primed with GA₃(100ppm) records the highest number of branches per plant (5.11) as compared to control (3.89).The variation in the number of branches might be due to the vigorous growth of the plants due to the priming effects.

Table 5. Interaction effects of priming types, duration and varieties on number of primary branches per plant.

Variety	PT	Priming durations		
		0	6	12
<i>Belessa 95</i>	GA ₃	3.27 ^{bcd}	3.87 ^{bc}	3.33 ^{bcd}
	KH ₂ PO ₄	3.53 ^{bcd}	6.54 ^a	6.22 ^a
	Water	3.40 ^{bcd}	6.47 ^a	6.27 ^a
	Control	2.87 ^{bcd}	2.87 ^{bcd}	2.87 ^{bcd}
<i>Gishema</i>	GA ₃	2.73 ^{cd}	2.47 ^d	3.00 ^{bcd}
	KH ₂ PO ₄	3.07 ^{bcd}	6.47 ^a	6.53 ^a
	Water	3.67 ^{bcd}	6.40 ^a	6.13 ^a
	Control	3.07 ^{bcd}	3.07 ^{bcd}	3.07 ^{bcd}
<i>Wello</i>	GA ₃	2.87 ^{bcd}	4.13 ^b	3.53 ^{bcd}
	KH ₂ PO ₄	3.93 ^{bc}	6.53 ^a	6.60 ^a
	Water	2.93 ^{bcd}	3.00 ^{bcd}	3.13 ^{bcd}
	Control	2.67 ^{cd}	2.67 ^{cd}	2.67 ^{cd}
LSD	1.38			
CV	9.92			

Where, PT= Priming types GA₃=Gibberellic acid, KH₂PO₄=Potassium dihydrophosphate. Means followed by the same letter(s) at each column and row are not significantly different from each other at 0.05 level of probability.

3.1.7. Stand count at harvest

There was a highly significant ($P \leq 0.01$) difference due to varieties, priming type and priming duration and significant ($P \leq 0.05$) interaction effect between variety and priming type for stand count at harvest. The highest stand count at harvest was recorded for Hydro primed (D) *Wello* (2) variety (119.67) followed by *Belessa 95*(1) variety primed with GA₃ (B) (119.44) and *Wello*(2) variety primed with GA₃(B)(119.33) that was at par with hydro primed (D) *Belessa 95*(1) variety (119.11), hydro primed (D) *Gishema* (3) variety (118.67), *Belessa 95* (1) and *Wello*(2) varieties primed with KH₂PO₄ (C) (118) and (117.78) respectively. The lowest Stand count at harvest was observed on three of unprimed (A) varieties *Wello*(2) (117.33) followed by *Belessa 95*(1) (116.67) and *Gishema* (3) (116) varieties (Table 1).

3.1.8. Harvest index

There was highly significant difference ($P \leq 0.01$) among varieties, priming type and between their interactions effects for Harvest index. The highest harvest index was observed on unprimed (A) *Belessa 95*(1) variety (31) and unprimed (A) *Gishema*(3) variety (30.67) followed by *Wello*(2) variety primed with KH₂PO₄(C) (30.33). Whereas the lowest harvest index was recorded on *Wello*(2) variety primed with GA₃(B) (21.67) followed by unprimed (A) *Wello*(2) variety (25.67) which were statistically similar results with that of *Belessa 95*(1) variety primed with GA₃(B) (25.78) and *Gishema*(3) variety primed with GA₃(B) (25.89) (Table 1). The findings are in agreement with Shahram (2015) who reported that soybean seed primed with water and KH₂PO₄ records the lowest harvest index (37.32) and (37.60) respectively compared to control which records (40.13) harvest index. It has also been observed that seed priming improved allometric traits, grain yield and harvest index (Ruan *et al.*, 2002)

3.1.9. Thousand Seed weight

The result of the study showed that there was a highly significant ($P \leq 0.01$) difference between varieties, priming type and their interaction effects on Thousand Seed weight. The highest hundred seed weight was recorded on *Gishema* (3) variety primed with water (D) (166.30) followed by *Gishema* (3) variety primed with KH₂PO₄(C) (163.90) and the lowest hundred seed weight were observed for *Wello* (2) variety primed with GA₃(B) (136.70) followed by unprimed (A) *Wello* (2) variety (140.00). Whereas the other shows intermediate values (Table 1). The results are in agreement with Shahram (2015) who reported that the soybean seed primed with water and KH₂PO₄ gave the highest thousand seed weight of (142.23) and (140.33) respectively compared to control (116.37).

3.1.10. Yield per hectare

Seed yield is the ultimate output of a crop around which all the other factors revolved. There was highly significance ($P \leq 0.01$) difference between varieties, priming type, durations of priming and their interaction effect for increments of yield per hectare. The results are in agreement with Harris *et al.*, (1999) who reported that primed crops produced higher yields than non-primed crops. The highest yield per hectare was recorded on *Wello* variety primed with water for 6hr (3418.85 Kg) followed by *Wello* variety primed with GA₃ for 6hr (3412.15 Kg) that was at par with *Wello* variety primed with GA₃ for 12hr (3406.60 Kg), for 0hr (3329.98 Kg) and *Wello* variety primed with KH₂PO₄ for 12hr (3395.24 Kg) and *Wello* variety primed with water for 12hr (3370.48 Kg), for 0hr (3297.59 Kg) (Table 6).

This result are consistent with the findings of Shahram (2015) who reported that soybean seed primed with water significantly increases yield per hectare (4.96ton/ha) compared to seed primed with KH₂PO₄ (4.61ton/ha) and control which records (4.13ton/ha). It was also reported that soybean seed priming made better seedling emergence and yield improvement (Arif *et al.*, 2008). Similarly, Taylor and Harman, (1990) reported that in the

low external input system of Bihar and West Bengal, in India, primed plots of chickpeas out-yielded non-primed plots in 41 trials with an average yield increase of around 13%. The lowest yield per hectare was observed on *Gishema* variety hydro primed for 0hr (2373.08) and with GA₃ for 0hr (2385.44) that was at par with unprimed *Belessa 95* variety(2390.55) and *Gishema* variety (2392.76). This results are in line with the report of Chavan *et al.*, (2014) who have reported that soybean seed variety primed with GA₃, KH₂PO₄ (100ppm) and water gave highest yield per hectare (2954.50), (2892.00) and (2715.00) respectively over the unprimed one (2403.20). (Mewael and Ravihunja (2008) have reported that soybean seeds primed with CaCl₂.2H₂O, GA₃ and KH₂PO₄ recorded (20.73, 17.93, 17.15 and 8.6%) increment in seed yield per hectare respectively over unprimed seeds. Priming of chickpea seeds has been reported to increase the seed yield (Kaur *et al.*, 2002). Shahram (2015) suggested that hydro-priming is a useful method for improving seedling vigor, establishment and yield of soybean in the field.

Table 6. Interaction effects of priming types, duration and varieties on yield per hectare

Variety	PT	Priming durations		
		0	6	12
<i>Belessa 95</i>	GA ₃	2429.25 ^{GHIJ}	2935.77 ^{CD}	3009.74 ^{BC}
	KH ₂ PO ₄	2627.84 ^{EFGHI}	2596.06 ^{FGHIJ}	2643.08 ^{EFGH}
	Water	2427.70 ^{HIJ}	2949.04 ^{CD}	2983.36 ^{BC}
	Control	2390.55 ^J	2390.55 ^J	2390.55 ^J
<i>Gishema</i>	GA ₃	2385.44 ^J	2985.88 ^{BC}	2950.10 ^{CD}
	KH ₂ PO ₄	2427.79 ^{HIJ}	2834.87 ^{CDE}	2664.39 ^{EFG}
	Water	2373.08 ^J	2736.10 ^{DEF}	3047.71 ^{BC}
	Control	2392.76 ^{IJ}	2392.76 ^{IJ}	2392.76 ^{IJ}
<i>Wello</i>	GA ₃	3329.98 ^A	3412.15 ^A	3406.60 ^A
	KH ₂ PO ₄	3301.46 ^A	3390.85 ^A	3395.24 ^A
	Water	3297.59 ^A	3418.85 ^A	3370.48 ^A
	Control	3194.09 ^{AB}	3194.09 ^{AB}	3194.09 ^{AB}
LSD				235.26
CV				3.89

Where, PT= Priming type, GA₃= Gibberellic acid, KH₂PO₄= Potassium dihydrophosphate. Means followed by the same letter(s) at each column and row are not significantly different from each other at 0.05 level of probability.

3.1.11. Correlation coefficient(r)

3.1.11.1. Correlation Coefficients between yield and agronomic traits of soybean varieties.

Correlation analysis between seed yield and the other field parameter showed that significant associations were observed between days to 50% flowering, Harvest index, thousand seed weight, number of pods per plant, number of seed per pods, physiological maturity and stand count at harvest. However, non-significant associations were observed among seed yield, number of primary branches and plant height at maturity (Table 7). There were highly positive correlations between seed yield with number of pods per plant (r=0.54), number of seed per pods (r= 0.42) and stand count at harvest (r=0.45) whereas highly negative correlations between seed yield with day to maturity (r= -0.71), days to 50% flowering (r= -0.67), Harvest index (r= -0.39) and hundred seed weight (r= -0.34) (table 7).

Table 4. Correlation Coefficients(r) between seed yield and agronomic traits of soybean varieties.

	DF	HI	TSW	NPB	NPPP	NSPP	PHM	PM	SCAH
HI	0.34**	1							
HSW	0.41**	0.20 ^{NS}	1						
NPB	0.16 ^{NS}	0.11 ^{NS}	0.17 ^{NS}	1					
NPPP	-0.18 ^{NS}	0.36**	0.36**	0.26*	1				
NSPP	-0.20 ^{NS}	-0.12 ^{NS}	-0.07 ^{NS}	0.14 ^{NS}	0.56**	1			
PHM	0.24*	0.02 ^{NS}	0.49**	0.62**	-0.02 ^{NS}	0.04*	1		
PM	0.53**	0.30**	0.49**	0.24 ^{NS}	-0.59 ^{NS}	-0.49**	0.40*	1	
SCAH	-0.17 ^{NS}	-0.41**	-0.12 ^{NS}	0.14 ^{NS}	0.62**	0.38**	0.17 ^{NS}	-0.44**	1
YIELD	-0.67**	-0.39**	-0.34**	0.05 ^{NS}	0.54**	0.42**	-0.12 ^{NS}	-0.71**	0.45**

Note, NS, **and * indicates non-significant, highly significant at 1% and significant at 5% level of probability respectively. DF=days to 50% flowering, TSW=Thousand Seed Weight HI= Harvest index NPB= number of primary branches NPPP= number of plant per pods NSPP=number of seed per pods PM= physiological maturity PHM= plant height at maturity, SCAH= stand count at harvest.

4. Conclusion and Recommendation

Priming treatment improves or enhanced most of the measured field parameters of the varieties. Under field conditions, there was highly significance (P≤0.01) difference among varieties, priming types, priming durations and their interactions for plant height, number of pods per plants, number of primary branches per plants and yields per hectares. The tallest plant height was recorded for *Belessa 95* variety (87.26cm) hydro primed for 12 hour, the

highest number of pods per plant was observed on *Belessa 95* variety primed with KH_2PO_4 for 12hr (46.00). Also, highest number of primary branches per plant was observed on *Wello* and *Belessa95* variety primed with KH_2PO_4 for 12hr (6.60) and for 6hr (6.54) respectively. Most of the Priming treatments increases the yields per hectares compared to the controls. The highest yield per hectare was recorded on *Wello* variety primed with water for 6hr (3418.85 Kg). Also highly significant ($P \leq 0.01$) differences were observed for variety by priming interaction effects for day to 50% flowering, harvest index, thousand seed weights and significance differences for number of seeds per pods and stand counts at harvest. The lesser days to 50% flowering (82 day) was taken by *Wello* variety primed with GA_3 . The highest number of seeds per pods were observed when *Wello* variety is primed with water (3) and KH_2PO_4 (3) and the highest stand count at harvest was recorded for Hydro primed *Wello* variety (119.67). Correlation analysis between seed yield and the other field parameter showed that significant ($P \leq 0.05$) associations were observed between days to 50% flowering, Harvest index, thousand seed weight, number of pods per plant, number of seed per pods, physiological maturity and stand count at harvest. Generally from field observations soybean varieties primed with water (hydro priming) and GA_3 priming Medias showed better results followed by KH_2PO_4 on most and each of the measured parameters. Hence, better to recommend for seed growers Hydro priming prior to seed sowing because, simple to use, cost effective and easily available for seed growers to overcome the problems of poor crop emergency and establishments under such adverse environmental conditions comparing to GA_3 priming media. However, this study was done only for one season at one location using three varieties, priming media and soaking duration. So that, to give conclusion and recommendations furthermore studies could be made on multiple varieties, priming medias and durations of soaking in research centers, on fields of soybean seed growers and on farmers' fields of different soybean growing areas of Ethiopia.

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