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EFFECT OF BOTANICALS SEED PRIMING ON YIELD AND YIELD COMPONENTS OF MALT BARLEY (*Hordeum vulgare* L.)

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Seed priming

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ABSTRACT

Application of seed dressing synthetic compounds for enhancing yield and yield components of crops is becoming very expensive for resource poor farmers beside its negative effect on the natural environment. Thus, the current field and laboratory experiment was conducted during the 2018 main cropping season for testing the potential of locally available plant extracts; garlic (*Allium sativum)*, ginger (*Zingiber officinale)*, neem seed (*Azadracta indica)*, varnonia leaf (*Vernonia amygdalina)* and crouton leaf (*Crouton macrostachya)* as seed priming materials on malt barley. Three levels of each priming material (5%, 10% and 15 % concentration) were prepared and full sized malt barley seeds were soaked for 12hrs in these priming materials. Seed dressing chemical (Dynamic 400 FS), distilled water soaked seeds, and dry seeds were used as a control for the field experiment. Primed seeds with all concentrations of botanicals, including distilled water and dynamic dressing chemical had a significant enhancing effect on agronomic parameters of malt barley under both laboratory and field conditions except for the effect of ginger extract priming which negatively affected the agronomic parameters as compared to dry planted (untreated) seeds. However, there was clear variation among botanical extracts and this is depending on their concentration and types of used botanicals. Among the tested botanicals, all three levels of garlic extracts have a significant enhancing effect on all agronomic parameters and this was followed by the neem. From the result of this study, seed priming with naturally available plant materials were found to improve yield and yield components of malt barley where for this particular experiment, all levels of garlic performed best as compared to other priming materials.

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1 Introduction

Barley (*Holdeum vulgare* L.) is an ancient crop that has played an important role in the development of agriculture and civilization. It is an intensely studied crop in the science of agronomy, physiology, genetics, breeding, and brewing. It is commercially used for animal feed, malt production, and human consumption (Junhaeng et al., 2015). It is the world's fourth most important cereals next to wheat, maize, and rice in terms of both quantity and cultivated areas with an average world harvest of more than 140 million tons from nearly 50 million hectares (FAO, 2018).

In Ethiopia, barley ranks fifth after teff (local small seeded cereals), wheat, maize, and sorghum in case of area coverage (Abu & Rachel, 2020). Further, according to CSA, 2010 data, it was cultivated on a total area of 1, 129,112, hectares of land that accounted for a total production of about 1.7 million tons in Ethiopia. It is cultivated by smallholders in various parts of the country for its ability to grow at various levels of elevations (from 1800 to 3400m), and it performs best at the highest elevations (Gashaw, 2015; Muluken, 2016) where there is a limited alternative of crops (Yosef et al., 2011). Regardless of its wider range of cultivability, its low yielding capacity is the one that determines the profitability of the crop. Regardless of its wider range of cultivability, its low yielding capacity is the one that determines the profitability of the crop. The low yielding of the crop is attributed to a multitude of abiotic and biotic factors which includes poor crop management practices, susceptibility to disease and insect pests, and the inherently low yield potential of the prevalent local varieties (Tafa et al., 2004; Asamaa et al., 2011)

Seed quality (viability and vigor) can have a profound influence on the establishment and the yield of a crop. Healthy plants with well developed root systems can more effectively mobilize limiting nutrients from the soil, they can better withstand under adverse conditions (e.g., dry spells) and vigorous early seedling growth is associated with higher yields (Harris et al., 2000). The vigor of seeds can be improved by techniques generally known as seed priming, which enhance the speed and uniformity of germination (Hey-decker et al., 1975). Besides this, priming also had a significant influence on the emergence and seedling vigor and speed of germination for the successful establishment of the crop (Yalew et al., 2019). Thus, pre-planting seed priming has a significant effect on seed performance (Qadir et al., 2011). Priming induces a range of biochemical changes in the seed by modulating pre-germination metabolic activities (Asgedom & Becker, 2001). During seed priming, water penetrates the seed and reaches the embryo during which hormones and enzymes stimulate the physiological growing factors (Hoseini et al., 2013). Seed priming with plant extracts had also been stated as a non-expensive, eco-friendly and value added practice that greatly improves the yield (Imran et al., 2013). Scientific knowledge of seed physiology and seed bio-chemistry, combined with new technology, can enhance seed quality. However, these techniques depending on priming materials, priming time, and crop (Khan et al., 2010).

Integration of plant growth regulators, vitamins, or nutrients during seed priming resulted in enhanced seed performance and early plant growth, particularly under adverse conditions (Ajouri et al., 2004; Bakht et al., 2011). However, resource poor farmers cannot use expensive plant hormones, antioxidants, or nutrients for seed priming (Basra et al., 2011; Imran et al., 2014). For this reason, there is a need to explore natural and environment friendly plant growth enhancers that should be reliable and economical under prevailing circumstances. Thus, this study was planned to investigate the potential of five locally collected botanical extracts [i.e. bulbs of Garlic (*Allium sativum)*, young leaves of Crouton (*Crouton macrosachya*) and Vernonia *(Vernonia amygdalina)*, seeds of Neem (*Azadracts indica)*, and tubers of ginger, *Zingiber officinale*] as seed priming materials with intention of evaluating the effect of different sources of botanical extracts as seed priming materials on yield & yield components of malt barley under field and laboratory conditions. Dynamic 400 FS seed dressing chemical, hydro priming, and dry seed planting was also used as a control for comparing the effect of botanical extracts priming.

2 Materials and Methods

2.1 Description of Experimental Site

The field experiment was carried out during the 2018 cropping season at Lole farm (Oromia Seed enterprise), located 215 km southeast of Addis Ababa, Ethiopia. The site is located at $7^{0}44$ N latitude and $38^{0}55$ E longitudes. It is found in the foothill of mount Chilalo with an altitude of 2474 m above sea level. The main rainy seasons begin in April and continue to till the end of September with an average annual rainfall of 558mm.

Laboratory experiment was carried in department plant science laboratory, Arsi University in 2018. Arsi University is located at 8°00' N latitude and 39°07' E longitude in Assela town, 166 km southeast of Addis Ababa at 2430 m above sea level. The agro-climatic condition of the area is wet and receives a mean annual rainfall of 809.15 mm from March to September.

2.2 Description of Experimental Materials

All selected botanical priming materials are locally available and do have a history of familiarity for being in use with farmers in pest management and medical importance. The unique chemical composition in these botanicals was assumed to contribute to enhancing the germination and vigorousity of malt barley seedling. Five different types of botanicals were selected for the preparation of extracts to be used as seed priming materials. Young leaves of Crouton (*Crouton macrosachya*) and Vernonia *(Vernonia* *amygdalina)* were collected from the University compound while the seed from the Neem tree (*Azadracta indica*) was obtained from the Ethiopian forest research center, and the bulb of garlic (*Allium sativum)* and ginger (*Zingiber officinale*) tuber were purchased from the local market. Moreover, distilled water, seed dressing chemical (Dynamic 400 FS), and dry seed were also used as a control treatment (Table 1). Dynamic 400 FS is a formulation of Thiram 20% and Carbofuran 20% which is used for seed dressing to prevent diseases and insect pests.

All collected fresh leaves were allowed to dry under laboratory conditions on filter paper for enhancing the drying process before grinding (Figure 1). An electronic blander was used for grinding all types of priming materials. After grinding, all priming materials were placed in separate 500ml labeled beakers and distilled water was added till the paste of priming materials were moistened and fully covered. The mixture was stirred thoroughly with a spatula to obtain a homogeneous suspension which was then covered with parafilm and left to stand for 24 hours at room temperature. After 24 hours of soaking, priming materials were transferred to pure muslin closes and squeezed with a manual lemon squeezer. Distilled water in a ratio of 100ml to 5gm, 10 gm, and 15 gm botanicals were gradually added and squeezed till clear water comes out of the priming materials to make a total 5%, 10%, and 15% concentration respectively (Figure 2). The initial amount of water added to make a paste of priming material was also considered in a total amount of distilled water added to make the required concentration. The experiment was conducted in a randomized complete block design (RCBD) for field experiment and completely randomized design (CRD) for laboratory experiment with three replications. For this study traveler malt barley variety was used for both field and laboratory experiments.

2.3 Laboratory experiment

One hundred fifty full sized malt barley seed lots were selected for each treatment (three levels of each priming materials) and all seed lots were rinsed in distilled water to remove dirt. The rinsed seed lots were rubbed with tissue paper for complete drying before treatment application. Then each seed lot was placed in a 500ml beaker containing different levels (5, 10 & 15%) of priming materials and remained soaked for 12 hours at room temperature. Distilled water-soaked seeds were taken as control. Each batch of soaked seed lots was then split equally (50 seeds) into three glass Petridis lined with moistening filter paper. All treatments were arranged in with completely randomized design (CRD) with three replications (Table1).

2.4 Field experiment

The field experiment was conducted to evaluate the impact of seed priming on yield and yield components of malt barley (traveler) under field conditions. The size of each experimental plot was determined to be 2m x 2m (4m2). Treatments were planted in 10 rows for each plot and were arranged in a randomized complete block design (RCBD) and all plots received a uniform amount of NPS fertilizer (19N, 38P, and 7S ha-1) as basal application. Crop management practices focusing on weed management were performed manually to make all plots free from weed. All seed priming procedures followed during laboratory testing was followed for field experiments except 12 hours soaked seeds were used for field planting. In addition to distilled water soaked seeds, dry planted seeds and chemical dressed (Dynamic 400 FS) seeds were used as a control for the field experiment (Table 1). Seeds were manually drilled at the rate of 100 Kg ha^{-1} and spacing between rows was maintained at a 25 cm distance. The plantation was done in the first week of July 2018.

2.5 Data collected from the laboratory experiment

2.5.1 Germination percentage

Four round records for germination of primed seeds were conducted for determining the impact of primed and non-primed materials on the initiation of germination. The first round was done four days after seeding followed by seven, ten, and fourteen days after seeding respectively. All germinated seedlings were discarded from the Petri dish soon after counting. Finally, the germinated seeds were calculated and converted to germination percentage (GP=seeds germinated /total seeds x 100).

2.5.2 Coleoptile and plumule length (cm)

Coleoptile and plumule length was measured for ten randomly selected seeds from each treatment. Coleoptile length was measured from the base of the seed to the end of initiated root part while plumule length was determined by measuring the whole length starting from the seed base.

2.6 Data from the field experiment

2.6.1 Emergence percentage (%)

The total number of seeds planted in one meter length of two central rows was counted and the row length was tagged before covering with the soil. Data on the number of seedlings that emerged per meter row length was recorded at fourteenth days after planting and the emergence percentage of treatments under field condition was then determined (GP=seeds germinated /total seeds x 100).

2.6.2 Days to heading

Heading marks the emergence of the barley head from the flag leaf. Recording for days to heading was made from the time of sowing to the time when 50 % of the plants showed heading for each plot.

Table 1 Treatment components and descriptions

No.	Treatments	Application
1	Vernonia *(V.amygdalina 5%)*	Laboratory and Field experiment
2	Vernonia *(V.amygdalina 10%)*	Laboratory and Field experiment
3	Vernonia *(V.amygdalina 15%)*	Laboratory and Field experiment
4	Neem *(A. indica 5%)*	Laboratory and Field experiment
5	Neem *(A. indica 10%)*	Laboratory and Field experiment
6	Neem *(A. indica 15%)*	Laboratory and Field experiment
7	Garlic *(A. sativum 5%)*	Laboratory and Field experiment
8	Garlic *(A. sativum 10%)*	Laboratory and Field experiment
9	Garlic *(A. sativum 15%)*	Laboratory and Field experiment
10	Ginger*(Z. officinale 5%)*	Laboratory and Field experiment
11	Ginger*(Z. officinale 10%)*	Laboratory and Field experiment
12	Ginger*(Z. officinale 15%)*	Laboratory and Field experiment
13	Crouton *(C.macrostachya 5%)*	Laboratory and Field experiment
14	Crouton *(C.macrostachya 10%)*	Laboratory and Field experiment
15	Crouton *(C.macrostachya 15%)*	Laboratory and Field experiment
16	Distilled Water	Laboratory and Field experiment
17	Dry Seed	Field experiment
18	Dynamic 400 FS	Field experiment

Figure 1 Picture of all collected priming materials (a=Garlic and Ginger,b=Fresh leaf of Cruton (before drying) c= Fresh leaf of Vernonia (before drying), d= Dried leaf of Vernonia,e= Dried leaf of Crouton).

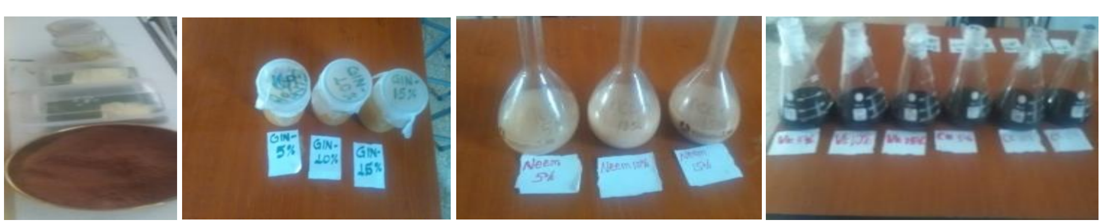

Figure 2 Extraction procedures (A=Botanicals Grinded=.Soaked, C1&C2= Extracted)

2.6.3 Days to physiological maturity

It was recorded as the number of days from sowing to the time when the crop was assumed to be ready for harvest as it attains physiological maturity. The crop was harvested to determine grain, straw yield, and harvest index. Moreover, data on yield and yield components were also collected following standard procedures.

2.7 Data Analysis

Data were subjected to analysis of variance (ANOVA) using SAS software 9.2. All significant pairs of treatment means were compared using the least significant difference test (LSD) at 5% and 1% level of significance.

3 Results and Discussion

3.1 Laboratory experiment

The results of the laboratory experiment indicated all treatments significantly ($P < 0.05$) affected the germination percentage, coleoptile length, and radicle length (Table 2).

3.1.1 Germination percentage

The germination percentage of malt barley seeds was significantly ($p<0.05$) affected by all priming materials (Table 2). However, the impact had been observed to be highly diversified. All tested ginger (*Z. officinale)*, concentrations had a negative impact on seed germination and reduced germination percentage compared to other priming materials which varied from (53.33-70.67%). On the other hand, Garlic (*A. sativum)* at 5% concentration was recorded as the best priming material in enhancing seed germination (98.33%), followed by its 10% concentration (97.33%) which was at par with distilled water priming (96.33%). The highest concentration of Garlic (15%) negatively affected seed germination and it was at par with the lowest concentration (5%) of Neem seed and vernonia leaf extracts (92.0%, 87.67%, and 88.0% respectively). All concentrations of Croton, *C. macrostachyus*, and 10 & 15% concentration of Neem, *A. indica* seed and Vernonia, *V. amygdalina* also retarded barley seed germination next to ginger which ranged from 75-85% and was found to be almost at par with each other. Similarly, many authors (Shafique et al., 2007; Hassan et al., 2012; Perelló et al., 2013) reported that plant extracts enhance the seed germination and seedling vigor of cereal grains. Perello et al (2013) also reported allicin in garlic juice had corrected poor germination of wheat seeds and enhanced germination. The ability of the extracts to increase grain germination and seedling emergence could be attributed to the suppression of the incidence of the seed borne fungi that could have killed the embryo of the grains. Faruk et al. (2015) and Nouman et al. (2012), concluded that seed priming with distilled water and moringa leaf extract (MLE) recorded a higher germination percentage when compared to an unprimed seed.

3.1.2 Coleoptile Length

Coleoptile length was significantly ($P < 0.05$) affected by seed priming (Table 2).The longest and significantly different coleoptile length was recorded in 5% concentration of garlic (12.58 cm). Though most of the botanicals priming had induced short coleoptile length which is significantly lower than the distilled water (11.81 cm), and the shortest and significantly different coleoptile length (5.48) was observed for the highest concentration (15%) of ginger. These results are in agreement with the findings of Perelló et al. (2013), those who reported that seeds treated with garlic juice had a relatively better germination percentage, coleoptile, and radicle length. Moreover, Mahboob et al. (2015) also reported hydro-primed sprouted grains had the longest radicles and coleoptiles and the highest hydrolytic enzyme activities.

3.1.3 Radicle Length

The radicle length was significantly influenced ($P<0.05$) by seed priming materials (Table 2). Though there was no consistency with effect on germination and coleoptile length, the highest radicle length (9.93) was recorded for 5 % vernonia and 15% garlic concentration (9.73) which was found to be significantly different from all priming materials. However, the control, distilled water priming was found to perform in middle (6.23) which was at par with 10% neem (6.37) concentration. The shortest radicle length (4.82cm) was recorded with a seed priming concentration of 10% crouton concentration and this value was statistically similar with ginger 15% (4.53cm) and Garlic 10% (4.41cm). The result of this experiment reviled that the response of botanical primed malt barley to coleoptile and radical length is not consistent. Botanical extracts induced extra inhibitory effects on radical emergence than on plumule growth (Panhwar et al., 2012).

3.2 Field experiment

3.2.1 Effects of seed priming on growth parameters of malt barley

3.2.1.1 Emergence percentage

The emergence percentage of malt barley seed under field condition was also significantly ($P<0.05$) affected by priming materials (Table 3). The highest and significantly different emergence percentage was recorded from seed primed with garlic 5% (96.67%) and Dynamic 400 FS (95.33%) dressed seed. Furthermore, 10% garlic concentration priming (96%) had initiated seedling emergence which was at par with distilled water priming (95.33) followed by garlic 15% (92.67%). The lowest emergence percentage which was even lower than dry planted seed (78%) was

Table 2 Effect of priming materials on germination percentage, coleoptile length and radicle length

Treatments	Germination (%)	Coleoptile length(cm)	Radicle length (cm)
Distilled Water	96.33[ab]	11.81[bcd]	6.23[ef]
Vernonia 5%	87.67[cd]	10.49[ghi]	9.93[a]
Vernonia 10%	79.67[fg]	8.21[l]	7.62[c]
Vernonia 15%	75[gh]	9.73[k]	8.49[b]
Crouton 5%	82.67[ef]	11.48[def]	7.45[c]
Crouton 10%	79.33[fg]	11.58[cde]	4.83[h]
Crouton 15%	77[g]	9.83[jk]	5.83[fg]
Ginger 5%	70.67[h]	11.30[def]	7.60[c]
Ginger 10%	65[i]	11.1[efg]	8.34[b]
Ginger 15%	53.33[j]	5.48[m]	4.53[h]
Neem 5%	88[cd]	10.42[hij]	6.64[de]
Neem 10%	85[de]	10.96[fgh]	6.37[ef]
Neem 15%	82[ef]	12.26[ab]	7.00[cd]
Garlic 5%	98.33[a]	12.58[a]	5.54[g]
Garlic 10%	97.33[a]	10.15[ijk]	4.41[h]
Garlic 15%	92[bc]	12.15[abc]	9.73[a]
SEM	8.32	0.14	0.14
LSD	4.8085	0.6189	0.6274
(P<0.05)	<.0.001	<.0.001	<.0.001
CV	3.523	3.502	5.445

Means sharing the same superscript letters under the same column do not differ significantly at P = 0.05 according to the LSD test. LSD = least significant difference; CV = coefficient of variation, SEM=standard error of mean.

recorded for all concentration ginger (55.67, 62.33, 68% for 15, 10, and 5% concentration respectively). Vernonia 5% (86.33%) and all concentrations of neem (87.67, 84.67, and 83.67% for 5, 10, and 15% concentration respectively) were at par with each other and performed better than that of dry seed but significantly lower than that of distilled water priming. However, all levels of croton and the highest concentrations of vernonia (10 and 15%) initiated seed emergence which is almost similar to dry seed plantation. Thus, among all botanicals, garlic concentrations were found to be better in initiating seedling emergence under field conditions and germination under laboratory testing. This finding may indicate that the active ingredients found in garlic has a clear role in enhancing seed emergence and germination as the result of which all garlic concentrations were found in comparable status with the effect of dynamic 400 FS seed dressing chemical. In support of this finding, Mustafa et al. (2017) reported germination and seedling-development of pathogen-infected wheat seeds were reduced by treatment with garlic juice. Numerous studies reported that the direct influence of garlic extracts and garlic derived allelochemicals on the growth and physiology of various vegetables which was supposedly due to the presence of organosulfur compounds such as allicin and Diallyl disulfide that allows the bioactivity of garlic extracts in the physiology of receiving plants (Muhammad et al., 2018).

3.2.1.2 Days to heading

Days to heading was significantly ($P<0.05$) affected by seed priming (Table 3). The earliest days to heading was recorded for seed primed with garlic 5% (62) & 10% (63), distilled water, and crouton 5%(62.67) which were at par with each other. The longest and significantly different day to heading was recorded from dray seed planted (76.33) plots (Figure 3). Besides its germination suppression effect, ginger and vernonia treated seeds had also caused delayed heading next to dry planted seeds respectively. However, seed dressing chemical (Dynamic 400 FS) did not show any significant effect in reducing days to heading as compared to distilled water priming while by far better than dry seed planted plots like other botanicals priming. This finding was in agreement

Table 3 Effects of Seed Priming on Growth Parameters of Malt Barley

Treatments	Emergence percentage	Days to heading	Days to physiological maturity	Plant Height (cm)	Spike Length (cm)
Dynamic 400 FS	96.67^{a}	65.67^{de}	100.33^{cd}	94.67^{a}	7.43^{ab}
Distilled water	95.33^{ab}	62.33^{jk}	100^{cd}	97.75^{a}	7.88^{a}
Dry seed	78^{hi}	76.33^{a}	114.33^{a}	56.33^{c}	5.67^{c}
Vernonia 5%	86.33^{de}	65^{efg}	105.67^{b}	93.42^{a}	7.53^{ab}
Vernonia 10%	79.33^{hg}	67^{c}	101^{cd}	95.67^{a}	7.47^{ab}
Vernonia 15%	75.33^{i}	66.67^{cd}	101.67^{bcd}	90.92^{a}	7.20^{ab}
Crouton 5%	81.67^{fg}	62.67^{jk}	101^{cd}	88.92^{a}	7.82^{ab}
Crouton 10%	79.67^{gh}	64.33^{fgh}	101.33^{bcd}	92.42^{a}	7.83^{ab}
Crouton 15%	79^{hg}	65.33^{ef}	101.33^{bcd}	92.33^{a}	7.75^{ab}
Ginger 5%	68^{i}	68.67^{b}	101.33^{bcd}	94.5^{a}	7.08^{ab}
Ginger 10%	62.33^{k}	69^{b}	$104b^{c}$	95.5^{a}	8.05^{a}
Ginger 15%	55.67^{l}	69^{b}	103.67^{bcd}	73^{b}	6.5^{cb}
Neem 5%	87.67^{d}	64.67^{efg}	102.33^{bcd}	91.5^{a}	8.13^{a}
Neem 10%	84.67^{def}	63.33^{hij}	102.33^{bcd}	92.18^{a}	7.78^{ab}
Neem 15%	83.67^{ef}	64^{ghi}	102.33^{bcd}	95.67^{a}	7.83^{ab}
Garlic 5%	96.67^{a}	62^{k}	99.33^{d}	92.33^{a}	7.83^{ab}
Garlic 10%	96^{ab}	63^{ijk}	100^{cd}	92.75^{a}	8.08^{a}
Garlic 15%	92.67^{c}	64^{ghi}	100.33^{cd}	96^{a}	7.38^{ab}
SEM	4.39	0.41	6.83	59.6	0.77
LSD	1.42	1.06	4.34	12.82	1.34
P<0.05	<.0.01	<0.01	<0.01	<0.01	<0.01
CV	2.56	0.97	2.55	8.57	11.71

Means sharing the same superscript letters under the same column do not differ significantly at P = 0.05 according to the LSD test, SEM=standard error of mean CV = Coefficient of variation

Figure 3 Pictures of early and late heading plots of experimental site

with Khalil et al. (2010) who have reported that minimum days to heading were taken for primed seeds while control (dry planted) seed took more days to heading. Moreover, Gunasekar et al. (2017) conclude that black gram seeds primed with *Prosopis* leaf extract 1% recorded reduced days to heading.

3.2.1.3 Days to physiological maturity

Days to physiological maturity was significantly (P<0.05) affected by seed priming and all primed seeds and chemically dressed seeds were significantly different from dry seed planting (114.33) where the longest days to mature was recorded this was followed by Vernonia 5% (105.67) and Ginger 10% (104) as mentioned in Table 3 and Figure 4.

On the other hand, the shortest and statistically significant days to maturity was recorded from seed primed with 5%garlic concentration where total days to maturity were observed to be 99.33 days. The two controls (distilled water priming and Dynamic 400 FS dressed seeds) did not induce significant difference to days of physiological maturity as compared to remaining priming materials but reduced days to maturity as compared with dry planted seeds. In agreement with this finding, Mahboob et al (2015) described hydro priming of maize seed exhibited minimum days to maturity. Chickpea seed priming with plant extract was reported to contribute to better and faster seedling establishment, earlier flowering, and earlier maturity that allowed the crop to escape from terminal drought and heat stress (Gunasekar et al., 2017).

3.2.1.4 Plant Height

Plant height was significantly (P<0.05) affected by priming materials and seed dressing chemical used (Table3). Dry seed planted plots exhibited the shortest and significantly different plant height (56.33cm) followed by the high concentration of 15% ginger, (73.00) which was still significantly different from dry planted seeds. Regardless of variability in other growth parameters, all priming materials and seed dressing chemicals had induced a similar effect on plant height which ranged from 97.75 distilled water to 88.92 for Croton 5% seed priming. Lashin et al. (2013) reported Artemisia extract at 20% concentration increased the plant height. Plant height on soybean was also reported to be significantly higher at 10% and higher concentrations of the seaweed extract (Rathore et al., 2009).

3.2.1.5 Spike Length

Like plant height, spike length was also affected P<0.05) by applied priming materials. The shortest and significantly different spike length was recorded from dry seed planted malt barley seed (5.57) and 15% ginger (6.5cm) concentration while remaining all priming materials including two checks (distilled water and seed dressing chemical) did not show any statistically significant difference about spike length (Table 3). Thus, the result of this experiment is in agreement with the previous results of Jafar et al. (2012) who concluded that maximum spike length was observed from osmo-priming and hydro-priming treatments in the case of wheat. Moreover, Yasmeen et al. (2013) also reported seed priming with different priming agents increased the number of grains per spike and spike length.

3.2.2 Effect of seed priming on yield and yield components of malt barley

3.2.2.1 Number of seeds per spike and 1000 grain weight

Regardless of the effect of priming on growth parameters; it had been observed that seed priming did not affect the number of seeds per spike and 1000 grain weight for this particular experiment. Faruk et al. (2015) also reported that the numbers of seeds per spike were not affected by different osmo-priming applications (Table 4).

3.2.2.2 Grain yield

From the result of this experiment, it had been made clear that all priming material used had induced the highest grain yield as compared to plots that had been planted with the dry seed (Table 4). The highest yield was recorded from chemical dressed (4906.25kg), Garlic 5% (4906.25kg), and distilled water (4593.75kg). The lowest and significantly different grain yield was recorded from dry seed planted plots (2875kg ha^{-1}) followed by 5% cruton (3843.75kg). The overall yield variations that had been observed among priming materials and dressing chemicals were not significantly different. In other words, the finding of this experiment indicated that dry seed plantation has got significant yield disadvantage as compared to all levels of priming materials and seed dressing chemicals used. This advantage might be induced as a result of seed priming that had resulted in biochemical change that had been taking place in the structure of the seeds, such as activation of enzymes related to germination and stand establishment. Jafar et al. (2012) reported that osmo-priming of seeds had enhanced protease and α-amylase activities, which directly involved improving carbohydrate metabolism, leading to better assimilate translocation. Iqbal & Ashraf (2007) also reported seed priming had improved tillering capacity of crop plants through increasing fertile tiller to enhance plant growth potential and grain yield. Moreover, Faruk et al. (2015) also reported seed priming treatment with different priming materials (Distilled water, IAA, KCl, KHPO, PEG-6000, and GA) showed significant effects on the number of stems per square meter, number of spikes per square meter, plant height (cm), heading date (day), spike length (cm), number of grains per spike, grain yield per spike (g), and grain yield per hectare.

Table 4 Effect of seed priming on yield and yield components of malt barley

Treatments	Seed number/ spike	1000 Grain weight (gm)	Yield ($Kg.ha^{-1}$)
Dynamic 400 FS	30.67	45.93	4906.25[a]
Distilled water	27.00	45.63	4593.75[a]
Dry seed	29.33	41.75	2875[c]
Vernonia 5%	30.00	45.43	4687.5[ab]
Vernonia 10%	28.67	45.31	4687.5[ab]
Vernonia 15%	29.00	45.05	4156.26[ab]
Crouton 5%	26.33	44.95	3843.75[b]
Crouton 10%	26.33	44.30	4375[ab]
Crouton 15%	26.00	45.05	4468.75[ab]
Ginger 5%	28.67	46.88	4281.25[ab]
Ginger 10%	27.00	42.25	4468.75[ab]
Ginger 15%	28.33	43.73	4375[ab]
Neem 5%	27.50	44.97	4375[ab]
Neem 10%	29.00	44.53	4156.25[ab]
Neem 15%	27.33	45.47	4468.75[ab]
Garlic 5%	27.00	46.10	4906.25[a]
Garlic 10%	29.00	44.77	4687.5[ab]
Garlic 15%	36.00	45.55	4468.75[ab]
SEM	10.65	3.81	3.10
LSD	NS	NS	0.293
(P<0.05)	-	-	0.040
CV	-	-	12.64

Means sharing the same superscript letters under the same column do not differ significantly at P = 0.05 according to the LSD test. LSD = least significant difference, CV = Coefficient of variation, SEM=standard error of mean,NS= none significant

Figure 4 Picture of early and late maturing plots of experimental site.

Table 5 Effect on insect and disease incidence

Treatments	Insect Incidence %	Disease Incidence (%)
Dynamic 400 FS	9.00^{cd}	5.60^{c}
Distilled water	11.00^{cd}	9.00^{b}
Dry seed	24.00^{a}	10.37^{a}
Vernonia 5%	14.00^{cd}	6.70^{bc}
Vernonia 10%	13.00^{cd}	6.90^{bc}
Vernonia 15%	11.00^{cd}	7.00^{bc}
Crouton 5%	21.00^{ab}	7.30^{bc}
Crouton 10%	23.00^{ab}	7.40^{bc}
Crouton 15%	15.00^{c}	6.80^{bc}
Ginger 5%	15.00^{c}	7.70^{bc}
Ginger 10%	15.00^{c}	5.70^{c}
Ginger 15%	15.00^{c}	7.50^{bc}
Neem 5%	8.00^{d}	7.50^{bc}
Neem 10%	9.00^{cd}	7.30^{bc}
Neem 15%	12.00^{cd}	6.10^{c}
Garlic 5%	7.00^{d}	6.10^{c}
Garlic 10%	11.00^{cd}	6.10^{c}
Garlic 15%	12.00^{cd}	6.70^{bc}
SEM	0.02	0.05
LSD	7.74	3.253
(P<0.05)	0.017	0.056
CV	34.588	29.402

Means sharing the same superscript letters under the same column do not differ significantly at P = 0.05 according to the LSD test. LSD = least significant difference, CV= coefficient of variation,SEM=standard error of mean.

Figure 5 Pictures of insect (shoot fly) damaged plots of dry seed plantation

3.2.3 Effect of seed priming on disease and insect pest incidence

3.2.3.1 Insect Incidence (%)

The incidences of barley shoot flies (*Dalia spp.*) which is normally expected at the seedling stage of barley was significantly affected by application priming materials and seed dressing chemical, Table 4 and Figure 5. The highest shoot fly incidence which was significantly different from all priming materials and seed dressing chemical used (P<0.05) was recorded from the plots planted with the dry seed (24). Among plant extracts used as priming materials, the highest shoot fly incidence was recorded on plots planted with all concentrations of croton and Ginger primed seeds (21, 23, 15, and 15 for 5%, 10%, 15% crouton, and 5-15% ginger respectively). All concentrations of vernonia leaf, Neem seed, and garlic extracts, and distilled water priming had significantly reduced the incidence of barley shoot fly which is comparable with the impact of seed dressing chemical (Dynamic 400 FS). The result of this experiment indicated that besides distilled water priming, even the lowest concentration of garlic, neem seed, and vernonia leaf extracts used as priming materials, can effectively reduce the problem of barley shoot fly. This could have resulted in seed priming had assisted speedy and uniform germination so as enabling seedling to escape the time of occurrence of barley shoot fly. As it had been reported by Ashok et al. (2019), hydroseed priming induced reduced shoot fly incidence while higher shoot fly incidence was recorded in the control treatment.

3.2.3.2 Disease incidence (%)

Though the occurrence of disease during the cropping season was observed to be low, the analysis of data was conducted based on the recorded result for the sake of comparison of the effect of priming materials. The disease incidence measurement focused on prevalent disease of area (barley net blotch) was significantly affected by seed priming materials and dressing chemical where the highest disease incidence was recorded on plots planted with dry barley seeds (10.37) (non-primed seeds) (Table 5). Moreover, though low disease incidence as compared to the dry seed planted was recorded in distilled water primed seed (9.00), all plant extract primed seeds were found to have less disease incidence which was comparable with seed dressing chemical by the time of data collection. In most crops, the disease is a serious problem and usually controlled by synthetic fungicides which are unaffordable for resource poor farmers and is also an environmentally hazardous method as compared to the seed priming strategies with plant extracts. Perelló et al. (2013) justified that the garlic extract used as priming material for wheat seed had suppressed the effect of seed born disease which had contributed to better performance of the crop at physiological maturity. Moreover, Abuamsha et al. (2011) also reported bio- priming had the advantage to protect the plant against adverse biotic and abiotic factors within the seed.

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