Response of Soybean to Sowing Depth and Phosphorus Fertilizer Rate in Dilla, Humid Tropics of Ethiopia

Mieso Keweti Shengu* Yacob Alemayehu Ademe
Plant Science Department, College of Agriculture and Natural Resources), Dilla University, P.O. Box: 419, Dilla, Ethiopia

Abstract
An important aspect for improved crop variety is putting seeds at a desired depth with use of optimum fertilizer. These increase the likelihood of germination, emergence thereby improved productivity. The study was conducted with the objective of evaluating response of soybean varieties to planting depth and phosphorus application. A combination of 2 x 3 x 4 factorial experimental design was replicated three times in RCBD. Awassa 04 and Awassa 95 soybean varieties with 3 sowing depth (3.5, 5.5 and 7.5 cm) and 4 phosphorus fertilizers (0, 23. 46 and 46 kg per ha) were used at Dilla university. There were significant depth x phosphorus x variety for leaf number, number of pod plant-1 and thousand seed weights. The highest grain yield of 1273.67 and 1270.00 (t/ha) were obtained from 5.5 cm depth x 46 kg phosphorus ha-1 while the lowest grain yield of 1046 and 1040.33 were obtained from 3.5 cm depth x 69 kg of phosphorus ha-1 for Awassa 04 and Awassa 95, respectively. The maximum number of leaf plant-1 was recorded from 5.5 cm x 46 kg while plant height and branch number (43.11 cm and 5.56) were collected from 7.5 cm x 0 kg; and 7.5 cm x 0 kg ha-1 respectively. The highest means were recorded from 3.5 cm x 23 kg (9.63) and 5.5 x 23 kg (23.00), respectively. Maximum number of pod plant-1 (97.33) was recorded from 5.5 cm x 0 kg. Highest thousand seed weight (2803.33 gram) was obtained from 3.5 cm x 0 kg. The optimum standard germination was recorded from 5.5 cm x 46 kg ha^{-1}. Planting depth 5.5 cm x 46 kg ha^{-1} phosphorus is recommended to be used to increase soybean productivity. In general, further investigation is required to confirm the current investigation.
Keywords: soybean, depth, phosphorus, Dilla, Humid Tropics

1. INTRODUCTION

Although cereal crops are most important in Ethiopian agriculture in providing staple diet to the population, pulses are also important components of crop production (Ali *et al*., 2003). Because of their high protein and lysine content, they also represent good sources of supplementary protein when added to cereal seed and root crops, which are low in essential amino acids. Legumes are shown to be particularly useful in decreasing blood glucose responses compared with other high-fiber foods. These beneficial effects of legumes are thought to be derived from various components of the beans including their slow starch digestion and their fiber content (Jenkins *et al*., 1980).

Soybean crop is grown in many parts of the world and are primary source of vegetable oil and protein for use in food, feed and industrial application. It can substitute meat and to some extent also milk. Soybean is a nutritional powerhouse capable of solving protein energy malnutrition problems in Ghana, and has a great potential in the development of three key sectors of the economy: Health, Agriculture and Industry (Plahar, 2006).

Soybean has received increasing attention in recent years from health care providers, biomedical researchers and the lay public alike because of its potential role in the prevention of a number of chronic diseases like cancer, coronary heart disease and osteoporosis (Monje *et al*., 2006). Even though soybean has such merits its production is constrained by both biotic and abiotic factors such as lack of improved varieties, depth, drought, nutrient, weed and disease. Among these this paper deals with sowing depth, phosphorus fertilizer application and lack of improved variety are the most important limiting factor for the growth and productivity of soybean. Sowing depth can greatly influence soybeans' ability to emerge and establish a uniform stand (Herbek and Bitzer, 1988). It is important to plant accurately in order to achieve good germination, emergence and high plant population (Srivastava *et al*., 2006). The depth of sowing is important in maximizing the potential of seedling emergence and crop yield. Too shallow sowing results in thin germination due to inadequate soil moisture at the top soil layer. On the other hand, deep sowing (e.g. beyond 6 cm) can significantly affect crop emergence and yield (Aikins *et al*., 2006; Desbiolles. 2002). Soybean, like all other nitrogen fixing leguminous crops, requires phosphorus for its proper growth and N fixation, soybean's effective contribution on soil fertility improvement can be inhibited due to phosphorus deficiency (Giller and Cadish 1995). Legumes are especially sensible to low phosphorus availability because the biological nitrogen fixation requires high levels of phosphorus. The phosphorus deficiency can limit the nodules formation while the phosphorus fertilization can overcome the deficiency (Carsky *et al*., 2001).

Thereby, this paper is important to address a combined effect of sowing depth and phosphorus fertilizer application rate and recommend optimum planting depth and phosphorus fertilizer application to improve soybean productivity in Dilla area. Despite its preference, merits, production and productivity in the study area, there is no any research activity on the response of soybean variety to phosphorus fertilizer rates and sowing depth so far. Thus, this research was intended with the following objectives:

General objective

To evaluate the response of soybean varieties to planting depth and phosphorus fertilizer in Dilla

Specific objectives

To determine effect of planting depth on yield and yield components of soybean varieties

To determine effect of phosphorus fertilizer on yield and yield components of soybean varieties

To identify optimum planting depth and phosphorous fertilizer rate for soybean production

2. MATRAL AND METHODS

2.1. Description of study area

The experiment was done in Dilla university experimental site during 2015 main cropping season. Dilla is found in SNNPRS in Gedeo zone located at 6 and 14N and 38’3’E, latitude and longitude is 978 mm with maximum and minimum temperature of 21.7 and 18.3 C^o in that order And soil texture class is clay and loam soil type (Yacob *et al*., 2015).

2.2. Experimental design and treatments

A combination of 2 x 3 x 4 factorial experimental design was used with three replications arranged in RCBD. There were two soybean varieties (Awassa 04 and Awassa 95) with 3 sowing depth (3.5, 5.5 and 7.5 cm) and 4 phosphorus fertilizers (0, 23. 46 and 46 kg per ha). Two seeds per hole were sowed after emergence appropriate cultural practice followed (weeding, thinning, water management etc.). Each plot measured 1.2 m x 1.6 m with spacing between row and within row of 1 meter and 0.5 meter. The planting material was planted with 10 cm x 40 cm, on each row the number of plants are ten with the total production of 32 plants per plots.

2.3. Data collected

Germination percentage: ratio of number of germinated seedlings at 7th day to total seed sown

Number of leaves: counted from randomly selected ten plants from middle rows for each plot

Plant height: measured from ground to the top of the plant from ten plants by using centimeter

Number of branches: counted from ten sample plants from each treatment and averaged

Number of node: this was recorded from each ten sample plants and averaged

Number of pods: recorded simply by counting pods from each ten sample plants and averaged

Number of seeds plant-1: recorded by counting seeds from average of each ten plants pods

Thousand seed weight: recorded as weight of 1000 seeds from each plot and averaged

Grain yield: collected from whole plants per plot and converted to hectare basis (kg/ha)

2.4. Data Analysis

All collected data was subjected to analysis of variance using statistical procedures as described by Gomez and Gomez (1984) in RCBD. SAS (2002) was used to analysis. And level of significance of the parameters were tested by using least significance difference (LSD) test whenever treatments found significant at $P<0.05$, and $P>0.01$, in that order.

3. RESULTS AND DISCUSSION

3.1. Yield and yield components of soybean

All traits except plant height significantly ($p \leq 0.05$ and $p \leq 0.01$) increased by variety and P fertilizer rates (Table 1). There were significant difference at ($p \leq 0.05$) depth, phosphorus, depth x phosphorus, depth x variety, and depth x phosphorus x variety interactions for leaf number while depth, and phosphorus x variety interactions for number of node plant^{-1}. There were significant difference at ($p \leq 0.05$) depth x phosphorus and depth x phosphorus x variety interactions for number of pods plant^{-1} whereas depth x variety interaction for number of seed pod-1-^{1} and phosphorus for 1000 seed weight (Table 1).

There were significant at ($p \leq 0.01$) phosphorus x variety interactions and phosphorus and variety for leaf number and number of branch plant^{-1} in the given order. There were significant difference at ($p \leq 0.01$) phosphorus, variety and depth x phosphorus interactions for number of node plant^{-1} while depth, phosphorus, depth x variety and phosphorus x variety interactions for number of pod plant^{-1}. There were significant at ($p \leq 0.01$) phosphorus, variety and phosphorus x variety interactions for number of seed pod^{-1} while depth, variety, depth x phosphorus, depth x variety and interaction of depth x phosphorus x variety for thousand seed weights while depth, phosphorus and depth x phosphorus interactions for grain yield ha^{-1} and depth, phosphorus, variety, depth x phosphorus interactions for germination percentage (Table 1). The interaction of sowing depth x P fertilizer rate significantly ($p \leq 0.05$ and $p \leq 0.01$) improved grain yield, number of pod plant^{-1}, thousand seed weight, number of pod plant^{-1}, leaf number plant^{-1} and germination (%). In the same fashion, interaction of depth x variety improved significantly ($p \leq 0.05$ and $p \leq 0.01$) leaf number, pod plant-1, seed pod-1,1000 seed weights, and standard germination. Similarly, phosphorus x variety interactions significantly ($p \leq 0.01$) affected leaf number, node plant-1, pods plant^{-1}, seed pod^{-1} and standard germination. Whereas, leaf number, thousand seed weight and pod plant^{-1} were significantly ($p \leq 0.05$ and $p \leq 0.01$) affected by the interaction of sowing depth, P fertilizer rate and soybean varieties (Depth × P × Var) (Table 1).

Table 1. Significance effects of sowing depth (Depth), variety (Var), phosphorus fertilizer rates (P) and their interaction on yield and yield related traits of soybean

Parameter	**Depth (2)**	**P (3)**	**Var (1)**	**Depth × P (6)**	**Depth × Var (2)**	**P × Var (3)**	**Depth × P × Var (6)**	**CV**	**MSE**
Leaf number plant^{-1}	*	*	ns	*	*	**	*	2.79	0.07
Plant height (cm)	ns	ns	ns	ns	ns	ns	Ns	4.05	0.20
No of branch plant^{-1}	ns	**	**	ns	ns	ns	Ns	9.24	0.06
Nodes plant^{-1}	*	**	**	**	ns	*	Ns	9.34	0.14
Pod plant^{-1}	**	**	ns	*	**	**	*	2.75	0.68
Seed pod-1^{-1}	ns	**	**	ns	*	**	Ns	6.44	0.06
1000 seed weight (g)	**	*	**	**	**	ns	**	1.92	10.32
Grain yield (kg ha^{-1})	**	**	ns	**	ns	ns	Ns	2.98	9.06
Germination (%)	**	**	**	**	ns	ns	Ns	2.32	0.75

Significant at * $p \leq 0.05$, **$p \leq 0.01$ probability levels; ns: not significant; MSE=Mean squares of error; CV: coefficient of variation; Values in parenthesis indicates the degrees of freedom.

3.2. Agronomic performance of soybean varieties

Mean agronomic performance of yield and yield related traits studied were presented and discussed in Table 2 below.

The highest grain yield of 1273.67 and 1270.00 (t/ha) were obtained from 5.5 cm depth x 46 kg phosphorus ha-1 followed by 3.5 cm x 46 kg ha-1 (1269.00 kg and 1264.33 kg) for Awassa 04 and Awassa 95 varieties, in that order. On the other hand, the lowest grain yield of 1046.00 kg and 1040.33 kg were obtained from 3.5 cm depth x 69 kg of phosphorus ha-1 for Awassa 04 and Awassa 95, in that order. In addition, 5.5 cm x 69 kg (1081.67), 7.5 cm x 23 kg (1082.23), 5.5 cm x 0 kg (1089.67) for Awassa 04 and 7.5 cm x 23 kg (1077.67), 5.5 cm x 69 (1078.67), and 7.5 cm x 0 kg (1100.33) performed poor in grain yield ha-1 (Table 2).

In confirmation to the current study, Alemu Abera, (2013) reported that in western Ethiopia, soybean reached a peak yield of 2406.7 kg/ha with application of 46 kg P2O5/ha, but higher concentration of fertilizer produced lower yields as the evidence is observed compared with 57.5 kg P2O5/ha found in DAP. Similarly, in India Devi *et al.* (2012) reported significant differences in biomass yield when varied the levels of Phosphorus. In line with the current study, Idri *et al.* (1989) also reported phosphorus application significantly increased dry matter production as well as yield and yield contributing characters of soybean. In addition, Singh *et al.* (1973) also reported the positive role of phosphorus to increase the growth and yield of soybean. Similar with this finding, Berg *et al.* (2005) reported that plants per square meter and stems per square meter generally declined with increased P fertilization. They suggested that the addition of phosphorus fertilizer resulted in enhanced interplant competition for light, water, and nutrients, which eliminated smaller, less-vigorous plants and thus decreased plants per square meter and shoots per square meter.

In contrast to the current study, report by Agri-fax (1998) observed that the application of 60 kg P2O5 ha-1 increased seed yield, hastened flowering and reduced plant height compared to both an unfertilized check and a rate of 30 kg P2O5 ha-1.

In agreement with the current observations, Malhi *et al.* (2001) also reported that alfalfa forage productivity and profitability can be improved by banding the Phosphorus fertilizer with a coulter-type disc rather than using the conventional application method of broadcasting. In opposite to this study, positive yield responses to deep phosphorus fertilizer placement have been reported in alfalfa by several researchers (Teutsch *et al.* 2000; Singh *et al.* 2005). Aikins *et al.* (2006) for maize and Desbiolles (2002) for wheat also reported that 6 cm sowing depth gave best yield. However, Lawson *et al.* (2008) reported that soybean should be sown at a depth between 1 and 4 cm in Northern Ghana.

The maximum and minimum number of leaf plant-1 was recorded from 5.5 cm x 46 kg and 7.5 cm x 0 kg in that order. The higher the number of leaves, the higher the rates of photosynthesis with resultant increase in carbohydrate production and hence increase in food production. Leaves are the site of photosynthetic activities of crops through which biomass are produced, partitioned among various parts of crops and stored for crop productivity (Asare *et al.*, 2011). In addition, Ridge (1991) reported that the number of leaves produced by a plant is directly proportional to the photosynthate produced. Wareing and Philips (1970) indicated that when photosynthesis becomes active in a young seedling, the power of the plant to synthesize new materials is clearly dependent on the amount of leaves exposed to direct sunlight. The highest (43.11 cm) and lowest (40.71 cm) plant height and highest branch number (5.56 cm) and lowest (4.67 cm) were collected from 7.5 cm x 0 kg; 3.5 cm x 46 kg and 7.5 cm x 0 kg and 7.5 cm x 46 kg ha-1 in the given order. Similarly, in Iran Mahamood *et al*. (2013) reported linear and significative increase of plant height with increases of P levels up to 90 kg P2O5 ha-1. In contrast to the current results, Eden (2003) reported that the lowest plant height (82. 41cm2) was recorded at high application of P rate, this confirms with the lowest plant height (40.71 cm) was recorded at application rate of 46 kg ha-1. The highest rate of Phosphorus application at the study site had no effect on plant height. This might be due to high dose of phosphorus fertilizer tends to form nutrient interaction and may affects the availability of other nutrients which are essential for growth of the soybean varieties. Similarly, Saleh (1976) reported phosphorus application also significantly increased plant height over the control. Accordingly, maximum plant height might be due to stimulated biological activities in the presence of balanced nutrient supply. In agreement to the current study, (Zafar *et al*., 2003) reported that number of branches plant-1 was significantly affected by different rates of phosphorus application and this might probably be due to the cumulative effect of phosphorus on the process of cell division and balanced nutrition.

The lowest number of node plant-1 (6.21) and number of seed pod-1 (2.48) were obtained from 5.5 cm x 46 kg whereas the highest values were recorded from 3.5 cm x 23 kg (9.63) and 5.5 x 23 kg (23.00) in the given order. In confirmation with this investigation, Subramanian and Radhak (1981) reported that number of seeds pod-1 was also differed significantly by phosphorus treatments. This was due to more availability of nutrients by increasing the level of phosphorus ha-1 that increased the number of seeds pod-1. In contrast, Guareschi *et al*. (2011) reported non- significant differences in number of seeds pod-1 after varying P rates.

The result of the present study was in agreement with the findings of Shubhashree (2007), who reported that number of seeds pod-1 increased significantly to levels of phosphorus added. The increment of seeds pod-1 with increasing phosphorus fertilizer application up to optimum level might be phosphorus fertilizer for nodule formation, protein synthesis, fruiting and seed formation.

The highest number of pod plant-1 (97.33) was recorded from 5.5 cm x 0 kg while minimum value was obtained from 7.5 cm x 23 kg. The result was similar to Shubhashree (2007), who observed that applications of different rates of phosphorus fertilizer influence number of pod plant-1. In confirmation to the current investigation, Veeresh (2003) also observed significantly more number of pods plant-1 of common bean at application rate of 75 kg P2O5 ha. Singh and Singh (2000) also reported significant increase in number of pods plant-1, due to increased Phosphorus fertilization. In agreement to the current investigation, many investigators also revealed that the number of pods plant-1 was significantly affected by the effect of different rates of phosphorus application (Saleh, 1976; Jayapaul and Ganesaraja, 1990). Similarly, in Brazil Segatelli (2004), reported significant differences in number of pods plant-1 after the application of 36 kg ha-1 P2O5. In Kenya Mugendi *et al*. (2010), reported significative increase in number of pods with application of 50 kg ha-1 P2O5. In Iran Mohmoodi *et al*. (2013) found significant differences in number of pods with variation in P levels.

Highest thousand seed weight (2803.33 gram) was obtained from 3.5 cm x 0 kg whereas lowest (2618.33 gram) was from 7.5 cm x 69 kg (Table 2). In India Devi *et al*. (2012) also found significant differences in weight of 100 seeds when varying the levels of P fertilizer. Germination was peak at 5.5 cm x 46 kg ha^{-1}. Germination (%) ranged from 68.33 (7.5 cm x 0kg) to 91.67 (3.5 cm x 46 kg). The current result was in contrast with that of Amato *et al*. (1992 wherein seed germination and establishment rate of faba bean was not affected by the phosphorus application.

Table 2. Mean agronomic performance of two soybean varieties in response to planting depth and phosphorus fertilizer rate.

Treatments			Parameters								
Variety	Depth	phosphorus	LN	PH (cm)	Brno	NN	NP	NS	TSW (g)	GY (kg/ha)	Germination percentage
Awassa 04	3.5	0	10.33	41.29	4.74	9.03	91.67	3.00	2803.33	1204.43	79.00
	3.5	23	10.40	41.78	5.11	9.63	90.67	3.07	2770.00	1143.33	86.67
	3.5	46	11.18	40.71	4.73	6.70	86.33	2.60	2707.67	1269.00	91.67
	3.5	69	11.15	42.33	4.97	8.43	85.00	2.53	2692.33	1046.00	86.67
	5.5	0	10.07	42.48	4.84	9.15	97.33	3.10	2710.67	1089.67	76.00
	5.5	23	10.37	42.33	4.87	7.80	92.00	3.13	2713.33	1172.00	85.00
	5.5	46	11.30	41.11	4.83	6.21	92.00	2.48	2698.00	1273.67	90.33
	5.5	69	11.27	41.92	4.72	8.37	95.67	2.78	2709.00	1081.67	82.67
	7.5	0	10.03	43.11	5.56	9.22	90.33	2.97	2683.33	1143.33	72.33
	7.5	23	10.38	42.67	5.03	6.75	82.67	3.13	2639.00	1082.33	78.00
	7.5	46	11.18	42.67	4.67	8.81	83.00	2.60	2663.00	1201.00	82.00
	7.5	69	11.24	43.00	5.28	8.71	83.00	2.67	2618.33	1130.67	82.33
Awassa 95	3.5	0	11.15	42.09	5.23	9.53	90.67	3.19	2712.00	1199.33	71.33
	3.5	23	11.52	43.63	5.33	10.23	90.33	3.19	2617.00	1127.00	79.67
	3.5	46	10.97	42.00	4.01	9.00	92.33	4.29	2700.00	1264.33	84.33
	3.5	69	10.17	42.33	4.41	8.62	90.33	3.34	2500.00	1040.33	82.33
	5.5	0	10.48	42.53	5.00	9.63	94.00	3.20	2664.00	1123.67	72.33
	5.5	23	11.29	45.00	4.46	8.21	96.00	3.37	2650.33	1151.33	78.33
	5.5	46	9.80	41.67	3.81	8.87	97.00	4.06	2519.67	1270.00	85.33
	5.5	69	10.47	43.33	4.61	8.50	94.00	3.09	2496.00	1078.67	76.33
	7.5	0	11.11	43.48	4.98	9.71	85.67	3.06	2574.00	1100.33	68.33
	7.5	23	11.07	41.00	4.84	7.82	85.00	3.23	2622.67	1077.67	73.00
	7.5	46	10.31	41.00	4.33	9.24	81.33	3.84	2733.33	1196.33	77.67
	7.5	69	10.80	42.33	4.38	9.37	76.67	2.92	2689.33	1121.67	77.33
Significance level			*	ns	ns	Ns	*	Ns	***	ns	Ns
LSD (5 & 0.1%)			0.14	0.81	0.21	0.38	1.16	0.10	24.21	16.24	0.88
Coefficient of variation (%)			2.79	4.05	9.24	9.34	2.75	6.44	1.92	2.98	2.32

LN= leaf number, PH=plant height, Brno=branch number, NN=number of node, NP=number of pod, NS=number of seed, TSW=thousand seed weights, GY (kg/ha)= grain yield in kilogram ha-1, LSD=least significant difference.

4. SUMMERY AND CONCLUSION

Soybean (Glycine max L) is the most important grain legume crops in the world in terms of total production and international trade. It contains high quality protein, and relatively cheap than other protein sources like egg, fish, meat. Due to this reason soybean is called poor man's meat. Soya bean belongs to family leguminoaceae. It has the ability to fix nitrogen and is common soil building plants. Soya bean is produced for economic importance and domestic demand due to promising source of high quality of protein.

However, its yield is lower compared to other legume crops due to many factors affecting its production and lack of improved variety, sowing depth and phosphorus application rate are the most once. Thus, the study was conducted with the objective of evaluating response of soybean varieties to planting depth and phosphorus application rate in Dilla during 2015, main cropping season.

A combination of 2 x 3 x 4 factorial experimental design was used with three replications arranged in RCBD. There were two soybean varieties (Awassa 04 and Awassa 95) with 3 sowing depth (3.5, 5.5 and 7.5 cm) and 4 phosphorus fertilizers (0, 23. 46 and 46 kg per ha) at Dilla university field experiments. Data was collected from different growth parameters such as number of leaves plant-1, plant height, number of branch plant-1, number of node plant-1, number of pod plant-1, number of seed pod-1, thousand seed weights and grain yield ha-1.

Analysis of variance showed that all parameters exhibited significant except plant height. There was significant at ($P \geq 5\%$) planting depth, phosphorus, depth x phosphorus, depth x variety and depth x phosphorus x variety interactions for leaf number while significant at ($P \geq 1\%$) phosphorus x variety interactions. There was significant at ($P \geq 1\%$) phosphorus and variety for number of branch plant-1. There was significant at ($P \geq 5\%$) planting depth, and phosphorus x variety interactions for number of node plant-1 while significant at ($P \geq 1\%$) phosphorus, variety and depth x phosphorus interactions.

There was significant at ($P \geq 5\%$) depth x phosphorus interactions and depth x phosphorus x variety interactions for number of pod plant-1 while significant at ($P \geq 1\%$) planting depth, phosphorus, depth x variety and phosphorus x variety interactions. There was significant at ($P \geq 5\%$) planting depth x variety interaction while significant at ($P \geq 1\%$) phosphorus, variety and phosphorus x variety interactions for number of seed pod-1. There was significant at ($P \geq 5\%$) phosphorus while significant at ($P \geq 1\%$) planting depth, variety, depth x phosphorus interactions, depth x variety interactions and interaction of depth x phosphorus x variety for thousand seed weight.

There was significant at (P≥1%) planting depth, phosphorus and depth x phosphorus interactions for grain yield ha-1. The highest grain yield of 1273.67 and 1270.00 (t/ha) were obtained from the interaction of 5.5 cm sowing depth x 46 kg phosphorus ha-1 followed by 3.5 cm x 46 kg ha-1 (1269.00 and 1264.33) for Awassa 04 and Awassa 95 varieties, in that order. On the other hand, the lowest grain yield of 1046 and 1040.33 were obtained from interaction of 3.5 cm sowing depth x 69 kg of phosphorus ha-1 for Awassa 04 and Awassa 95, in that order. In addition, interaction effects of 5.5 cm x 69 kg, 7.5 cm x 23 kg, 5.5 cm x 0 kg (1081.67, 1082.33, and 1089.67) for Awassa 04 and 7.5 cm x 23 kg, 5.5 cm x 69, and 7.5 cm x 0 kg (1077.67, 1078.67, and 1100.33) performed less.

From the two varieties Awassa 04 performed best in most studied yield and yield related traits and thus, should to be used in the future in the study area. The maximum and minimum number of leaf plant-1 was recorded from 5.5 cm x 46 kg and 7.5 cm x 0 kg in that order. The highest (43.11 cm) and lowest (40.71 cm) plant height and highest (5.56 and lowest (4.67) branch number were collected from 7.5 cm x 0 kg; 3.5 cm x 46 kg and 7.5 cm x o kg and 7.5 cm x 46 kg ha-1 in the given order. The lowest number of node plant-1 (6.21) and number of seed pod-1 (2.48) were obtained from 5.5 cm x 46 kg whereas the highest values were recorded from 3.5 cm x 23 kg (9.63) and 5.5 x 23 kg (23.00) in the given order. The highest number of pod plant-1 (97.33) was recorded from 5.5 cm x 0 kg while minimum value was obtained from 7.5 cm x 23 kg. Highest thousand seed weight (2803.33 gram) was obtained from 3.5 cm x 0 kg whereas lowest (2618.33 gram) was from 7.5 cm x 69 kg. Germination percentage was maximum 91.67 (3.5 cm x 46kg) and 90.33 (5.5 cm x 46 kg) whereas minimum 68.33 (7.5 cm x 0 kg). The optimum standard germination was recorded from 5.5 cm x 46 kg ha^{-1}.

In conclusion, the result indicated that using appropriate combination of sowing depth and phosphorus fertilizer rate should be aim of soybean producers in an effort to increase productivity. Depths of sowing and phosphorus fertilizer rates were revealed significant difference on leaf length, number of pod plant-1 and thousand seed weights. Planting depth of 5.5 cm x 46 kilogram of phosphorus performs best in both varieties in yield and yield components in most traits. Whereas deviation from this declined performance of these traits. Thus, based on the result obtained, it was possible to conclude that planting depth of 5.5 cm x 46 kilogram of phosphorus ha-1 was promising to enhance yield of common bean in Dilla. In general, further investigation is required to highlight the economic and environmental benefits of different varieties to depth and phosphorus application.

ACKNOWLEDGEMENT

The authors would like to thank Dilla University Research filed and laboratory assistants especially Mrs. Abeba was highly appreciated for her support during data collection and people who contributed for the research were also acknowledged.

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