Effects of Photoperiods, Hormone, and Phosphor on the Increase of Quality and Longevity of Soybean (*Glycine max* L. Merr.) Seeds

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ABSTRACT

The objectives of this experiment were to study the effects of photoperiods, hormone, and phosphor on the increases of quality and longevity of soybean (Glycine max L. Merr.) seeds. The experiment was conducted both during dry and wet seasons at Sebapo Experimental Station, Jambi and Center for Post Harvest Research and Development, Bogor from November 2009 until November 2010. The experiment used factorial split split plot designed which consisted of three factors, i.e. photoperiod (12 hrs and 14 hours 54 minutes) as the main plot, concentrations of IAA (0, 75 and 150 ppm) as sub plot, and dosages of phosphor (0, 60 and 120 kg P_2O_5 ha^{-1}) as sub sub plot. The parameters being observed included seed quality (carbohydrate, protein and lipid seed content) seed viability and vigor after storage for three months at room temperature and respiration rate during storage. The results showed that treatment of photoperiod 14 hours 54 minutes, IAA 75 ppm and P_2O_5 120 kg ha^{-1} increased seed quality and longevity indicated by the increased of soybean seed yield from 4.07 to 14.21 g $plant^{-1}$; increased protein, carbohydrate, and lipid content to 40.15, 32.23 and 14.21% respectively; increased seed longevity during storage at room temperature (seed viability before and after 90 days stored at room temperature were 97 and 90.77% respectively; rate of germination were 41.33 and 33.12%KN etmal-1 respectively; and decreased respiration rate during storage (only 0.683 ml CO_2 kg $seed^{-1}$ hr^{-1}). Seed quality and longevity which were produced during dry season were much better compared to wet season. Good agronomic practices resulted in increasing not only yield but also the quality and longevity of soybean seed during storage.

Key words: Photoperiods, Hormone, Phosphor, Quality, Longevity

INTRODUCTION

Seed quality is influence by abiotic and biotic factors during plant growth and development. Abiotic factors include light (Kantolic and Slafer, 2007; Kumudini et al., 2007), growth hormone (Golunggu et al., 2006), and soil mineral nutrion (Israel et al., 2007) while biotic factor includes plant symbiotic with *Rhizobium* (Salvagiotti et al., 2008; Stefan et al., 2009). Both abiotic and biotic factors are responsible in influencing seed quantity and quality as well as the ability of the seed lots to survive during storage.

Light is one of essencial elements which effect photosynthetic activities. Kumudini et al. (2007) stated that light duration (photoperiods) is one factors that might prolong photosynthetic periods. In addition, Kantolic and Slafer (2007) also stated that photoperiod of 15.3 hours during plant growth and development might increase soybean seed dry weight to 181 mg from 164.8 mg with light application of 12 hours. Sarkar et al. (2004) described that photosynthetic activities are responsible in the systhesis of hormone during plant metabolism.

Plant growth hormone is also responsible to increase *sink* capacity in photosyntate accumulation. Golunggu et al. (2006) stated that IAA with concentration of 150 ppm might increase 100 seeds-weight from 15.2 to 17.0 gram and increase plant resistance to stress condition. Anetor and Akinrinde (2006) also stated that *sink* capacity increases photosynthetic rate. so the need of soil mineral nutrions is a must in order to enhance better vegerative and generative gowth. In addition, Mulyaman (2005) reported that application of P_2O_5 72 kg ha^{-1} produced good soybean seed quality indicated by rate of germination 40.37% normal seedling $etmal^{-1}$.

Photosyntate influences development of food reserve substances including carbohidrate, protein and lipid (Khan et al., 2007). Elliott and Olfert (2003) as well as Gusta et al. (2003) stated that 90% of seed dry weight consists of food storage tissue which will be used by the embryo for growth and development. As a results, the composition of food storage tissue is related to vigor and seed capability to survive during storage.

This experiment was aimed to study the influence of photoperiods, hormone and phosphor in increasing soybean seeds quanity and quality as well as the capability of seeds to survive during storage at room temperature.

MATERIALS AND METHODS

This experiment was conducted from November 2009 until November 2010 at “Balai Benih Induk Sebapo Province of Jambi”. Seed quality testing was conducted at “Balai Besar Penelitian dan Pengembangan Pasca Panen, Kementrian Pertanian, Bogor”.

Materials being used included Anjasmoro variety from ”Balai Penelitian Kacang-kacangan dan Umbi-umbian Malang”; Urea, SP-36, KCl fertilizer; Indole Acetic Acid (IAA); Sevin™; ethanol; and aqueous. Laboratory equipment being used included analytical balance, dessicator, electrical oven, hand sprayer, lux meter, cool white fluorescent lamp 23 watt, Genset 10,000 watt, thermometer, and seed divider.

The experimental designed being used was split-split plot design with three replications. Main plot was photoperiods (F) consisted of F_0 = 12 hrs and F_1 = 14 hrs 54 minutes. Sub-plot was IAA concentrations (A) consisted of A_0 = 0, A_1 = 75 ppm, and A_2 = 150 ppm. Sub-sub plot was phosphor level (P) consisted of P_0 = 0, P_1 = 60 kg P_2O_5 ha^{-1}, and P_2 = 120 kg P_2O_5 ha^{-1}.

The experiment was conducted at filed experiment with ultisol soil condition. Each experiment plot was 4,5 m x 4,5 m. Basic fertilizer being used included 20 kg N ha^{-1} and 50 kg K_2O ha^{-1}. Plant holes were prepared with 4 cm diameter and 3 cm depth. Plant spacing was 40 x 15 cm. Each hole was planted with 3 seeds. Selective plant was carried out at 14 days after planting and 2 plants were choosen at each hole.

Photoperiod treatments used compact cool daylight fluorescent with intensity of 28,000 lux. Measurement of light intensity and number of light being used based on methods described by Van Harten and Setiawan (2000). Application of photoperiods followed the methods described by Runkle (2002). To avoid light dispersal, 2m-height black cotton fabric was surrounded the main plot area.

Phosphor with level of 60 and 120 kg P_2O_5 ha^{-1} were applied within plant lines at the beginning of plant growth. IAA with concentrations of 75 and 150 ppm were sprayed during vegetative growth at the age of 20 days after planting and during generative phase at the age of 40 days after planting with volume of 20 ml $plant^{-1}$.

Seeds were harvested at 105 days and were sun dried. After that seeds were packaged in the plastic high density polyethelene (HDPE) with 0.08 mm thick and stored for 90 days at room temperature (25-27 °C) for further analysis.

Seed viability (percent of germination) and seed vigor (rate of germination) were tested using sand. Carbohydrate composition was measured using direct acid hydrolysis methods, lipid using Soxhlet method and protein using Macro Kjeldahl analysis. While rate of respiration was measured by titration method described by Sudarmadji et al. (1984).

RESULTS AND DISCUSSION

Applications of photoperiods, IAA, and phosphor during plant growth and development might increase the quantity and quality of soybean seeds. They also influence chemical composition of soybean seeds as well as ability of seeds to be stored at room temperature for several months.

Seed production and 1000 seed weight were influenced by photoperiods, IAA and phosphor. Increased of photoperiod from 12 hrs to 14 hrs 54 minutes, increased of IAA to 150 ppm as well increased of P_2O_5 to 120 kg ha^{-1} has significantly increased seed productions from 5.07 to 11.57 g $plant^{-1}$ at wet season (MH) and from 4.07 to 11.55 g $plant^{-1}$ at dry season (MK). The increased of seed productivity followed by the increased of 1000 seed weight from 111.75 to 159.45 at wet season (MH) and from 85.08 to 158.73 at dry season (MK) (Table 1).

Table 1. The difference of seed productivity and 1000 seed weight of soybean seeds at both wet season and dry season after treatment with photoperiod, IAA, and phosphor based.

Code of treatments	Seed Production (g $plant^{-1}$)		Remarks	1000 seed weight (g)		Remarks
	MH	MK		MH	MK	
$F_0A_0P_0$	5.07	4.07	**	111.75	85.08	**
$F_0A_1P_1$	9.12	10.66	**	138.60	140.02	*
$F_0A_2P_2$	11.24	11.08	tn	146.63	147.50	tn
$F_1A_0P_0$	5.65	4.15	**	128.71	88.47	**
$F_1A_1P_1$	9.32	10.90	**	155.22	157.84	tn
$F_1A_2P_2$	11.57	11.55	tn	159.45	158.73	tn

tn = Not significant difference
* = Significant difference
** = Highly significant difference
F = Photoperiod
A = IAA
MH = Wet season
MK = Dry season

Table 1 illustrated that control (without treatment) and no phosphor added to the plant, resulted in the decrease of seed production and 1000 seed weight at dry season. This decrease was caused by using low seed quality from previous plant (seeds which were harvesting during wet season) and were planted during dry season at the same plot). Soybean which was cultivated at low phosphor soil condition produced seeds with low phosphor. Fatic acids is the main phosphor in seeds wich was source of energy for plant growth and development. This results supported by previous finding of Coelho et al. (2002) which stated that plant which cultivated by using low content of seed phosphor resulted in low vigor and viability that might decrease seed quality and quantity.

Seed production and 1000 seed weight tended to increase after treatment with photoperiod both at wet and dry seasons. Liu et al. (2006) stated that photoperiod might give the chance of soybean palnt to prolong photosynthesis period, Experiment results done by Golombek et al. (1999) and Morandi (2007) indicated that soybean plant with photoperiod treatment of 15 hrs have high seed weight. The increased in seed weight was caused by the increased of ABA in seed caused by photoperiod. ABA stimulated distribution of sucrose from leaves to the seeds at cell proliferation phase of cotyledons. Rapid cell growth and development in the cotyledons could improve development of seed and resulted in increasing seed production and seed weight.

Yasari et al. (2009) stated that there were thre e important procees during seed filling. They were: 1) production of photosynthesis from plant organ that function as *source*, 2) translocation system from *source* to *sink,* and 3) allocation of photosynthesis in sink. It could be said that application of photoperiod and phosphor were essential in order to improve *source* capability while application of IAA was essential to improve sink capacity. The increase of seed production and seed weight followed by the increase of food storage composition (Table 2).

Tabel 2. Protein, carbohydrate, and lipid composition of soybean seed after storage of 90 days both at wet and dry seasons (MH and MK) with photoperiod, IAA and phosphor treatments.

Code of treatments	Protein (%)		Remarks	Carbohydrate (%)		Sig.	Lipid (%)		Remarks
	MH	MK		MH	MK		MH	MK	
$F_0A_0P_0$	33.81	32.36	*	29.21	28.83	*	14.35	15.44	tn
$F_0A_1P_1$	38.83	39.85	*	31.68	32.34	*	13.70	14.00	*
$F_0A_2P_2$	39.76	39.88	tn	30.26	30.46	tn	13.75	14.85	tn
$F_1A_0P_0$	35.46	33.72	*	30.43	30.09	*	14.45	15.82	tn
$F_1A_1P_1$	38.81	40.80	*	32.03	32.86	tn	13.92	14.22	tn
$F_1A_2P_2$	40.10	40.15	tn	32.43	32.23	tn	13.92	14.21	*

tn = Not significant difference
* = Significant difference
** = Highly significant difference
F = Photoperiod
A = IAA
MH = Wet season
MK = Dry season

The different of food storage composition of seed produced during wet and dry season was influence of plant metabolism as impacts of agronomi practices and micro climate during plant growth and development. Food storage compositions were influence by photoperiod both at wet and dry seasons. Experiment results were supported by research experiment done by Brown (2006) which demonstrated that treatment with 14 hrs photoperiod produced more glucose compared with photoperiod of less than 14 hrs. Liu et al. (2006) stated that glucose which was produce in leaves could produce protein, carbohidrate, and lipid during respiration (Krebs cycle) and stored as food reserved On the other hand, photoperiod gave no significant effect on seed lipid composition. Photoperiod only gave impact in increasing protein composition to 38.7%. The increase of seed production, seed weight and food storage correlated to seed size and rate of respiration during storage (Table 3).

Tabel 3. Seed moisture and rate of respiration of soybean seeds after 90 days storage both at wet and dry seasons after treatment with photoperiod, IAA and phosphor.

Code of treatments	Seed moisture content (%)		Remarks	Seed respiration rate (ml CO_2 kg seed^{-1}hr^{-1})		Remarks
	MH	MK		MH	MK	
$F_0A_0P_0$	10.86	10.87	tn	0.641	0.638	tn
$F_0A_1P_1$	10.88	10.86	tn	0.687	0.660	tn
$F_0A_2P_2$	10.97	10.95	tn	0.693	0.673	tn
$F_1A_0P_0$	10.88	10.86	tn	0.671	0.646	tn
$F_1A_1P_1$	10.93	10.90	tn	0.701	0.685	tn
$F_1A_2P_2$	10.96	10.94	tn	0.692	0.683	tn

tn = Not significant difference
* = Significant difference
** = Highly significant difference
F = Photoperiod
A = IAA
MH = Wet season
MK = Dry season

Meyer et al. (2007) stated that the increase of seed weight resulted in increasing space contact of seed to the air. As a consequences, seed moisture content and rate of respiration increase during storage. The increase of respiration rate caused not only by the increase in seed moisture content but also the incraese of respiration substrate. Seed moisture content and seed respiration rate after 90 days storage both at wet and dry seasons gave no significant impact but respiration rate tended to be more during dry season.

After storage of 90 days, seed vigor and viability still approximately 90 percents after treatment with photoperiod, IAA and phosphor. The capability of seed to maintain the viability followed by the capability of seed to germinate if (CPMG= critical point moisture for germination) for seed germination was occurred. It was measured by germination rate (Table 4).

Table 4. Soybean seed viability and germination rat after storage with both agronomic and no agronomic parctices.

Parameter observed	Agronomic practices	Days after storage				
		0	30	60	75	90
Viability (%)	Control	97.00 a	93.33 a	81.67 b	78.91 c	70.44 d
	F + A + P	97.67 a	95.56 a	95.00 a	92.24 b	90.77 b
Germination rate (% Normal seedling etmal^{-1})	Control	35.82 a	34.00 a	28.35 b	25.23 c	24.61 d
	F + A + P	41.33 a	40.15 a	38.45 a	35.74 b	33.12 b

Note: Numbers followed by the same letter and on the same row indicated no significant difference.

Table 4 showed that the difference of seed viability and germination rate in control were 26.56 and 11.21% normal seedling etmal^{-1} during 90 days. Agronomic treatment with photoperiod of 14 hrs 54 minutes combined with application of IAA 150 ppm and P_2O_5 120 kg ha^{-1}, the difference of seed viability and rate of germination were 6.90 and 8.21% normal seedling etmal^{-1} during 90 days. Decreased of seed quality indicated that seeds were still capable to survive during storage. This results has proved that using such technology during plant growth and development might improve seed quality and seed capability to be stored in room temperature. Technology package as mention in Table 4 might be used as strategy in plant cultivation in order to produce better soybean seed quality both at wet and dry seasons. Summary of agronomy strategy was described in Table 5.

Rate of germination gave information on seed vigor which was indicated by the ability of seeds to adapt with sub optimum environmental condition. Seed with rate of germination more than 30% KN etmal^{-1} catagorized as high vigor, while 25-30% KN etmal^{-1} catagorized as low vigor. During seed maturity nutrient was needed especially phosphore (Israel et al., 2007). This substances is required as source of energy for seed to germinate.

Seed viability and rate of germination of soybean seeds produced during dry season were much higher compared to wet season. Better soybean seeds quality were indicated by weight of 1000 seeds and seed protein content.

Table 5. Agronomic practices and quality values of soybean seed quality both at wet and dry seasons (year 2009-2010).

Seasons	Treatments			Parameter observed		
	F	A	P	X_1	X_2	X_3
Wet	12 hrs	0	0	5.07	33.81	24.61
	12 hrs	100	90.12	9.15	39.00	29.00
	14 hrs 54 minutes	100	90.15	11.00	40.00	30.11
Dry	12 hrs	0	0	4.07	32.36	20.79
	12 hrs	75	75.65	10.85	39.88	30.36
	14 hrs 54 minutes	75	75.65	11.25	40.50	31.18

X_1 = Seed productions (g plant^{-1})
X_2 = Protein content (%)
X_3 = Rate of germination (% of normal seedlings etmal-1) after storage of 90 days

Table 5 showed that during wet season tretament with photoperiod of 12 hrs, IAA 0 ppm, and P_2O_5 0 kg ha^{-1} combined with photoperiod of 14 hrs 54 minutes, IAA 100 ppm, and P_2O_5 90.15 kg ha^{-1}, increased seed productivity to 116.96%, 1000 seed weight to 42.68%, protein content to 18.31%, and rate of germination to 23.35%. Compared to dry season, the increase of seed production and seed quality was not significantly difference. But it it looked at as a whole, rate of germination of seeds produced during dry season ≥ 30% normal seedling etmal^{-1} which indicated that seed vigor was still high eventhough the input given was lower that during wet season. It was indicated that there was input efficiency still followed by increase seed quality during dry season.

CONCLUSION

Agronomic practices during plant growth and development were influencing the quantity and quality of soybean seeds. Seed vigor and viability were much higher if plant was cultivated during dry season. Agronomic practices such as the application of photoperiods for 12 hours combined with the used of 75 ppm IAA, 75 kg P_2O_5, and 50 kg ha^{-1} K_2O or the used of photoperiods of 14 hours and 54 minutes combined with 75 ppm IAA, 75 kg P_2O_5, and 50 kg ha^{-1}. CO_2 tended to increase the quantity and quality of soybean seeds and the capability of seeds to be stored at room temperature.

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