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Evaluation of shade nets and Nuclear Polyhedrosis Virus (SeNPV) to control *Spodoptera exigua* (Lepidoptera: Noctuidae) on shallot in Indonesia

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Abstract. The beet armyworm, *Spodoptera exigua* (Lepidoptera: Noctuidae) is a serious pest of shallot in Indonesia. Chemical methods have failed to control this pest as this has developed resistance to almost all synthetic insecticides available. Shade nets are widely used to protect vegetables crops from pest and diseases. Field experiments were conducted during dry and rainy seasons (2012–2013) in Cirebon, West Java to assess the potential of shade nets and SeNPV for managing insect pests in shallot in order to reduce the use of pesticides. Completely randomized block design were used in this experiment with five treatments and five replications. The treatments viz. control treatments (without shade nets and SeNPV), shade nets (white and blue colors), applications of SeNPV and farmer's practices. The data observed were plant growth, population of *S. exigua*, percentage of plant damage and yield. The result showed that the number of *S. exigua* was significantly lower with shade nets (white and blue) compared to foliar insecticide sprays (farmer's practices). SeNPV moderately suppressed *S. exigua* with statistically significant efficacy over the control. Reduction in eggs and larvae of *S. exigua* numbers inside the shade nets ranged 98.40 to 100%. The shade nets also reduced number of pesticide applications by 100%. Furthermore, the lowest percent pest damage and the highest bulb yield were found at shade nets (white and blue) and foliar insecticide sprays. The use of shade nets in shallot production might offer several advantages. It would enable to protect shallot from *S. exigua* incidence, thus replacing applications of chemicals insecticides or hand picking practices. The technology is, therefore, friendly to the environment.

Key Words: beet armyworm, *Spodoptera exigua*, *Allium cepa*, shade nets, SeNPV.

Introduction. Shallot (*Allium cepa* L. group Aggregatum) is one of the important vegetable crops grown in Indonesia, because of a high consumer demand and giving good returns to the producers. In 2012, total cultivation areas was 99,519 ha producing of 964,221 tons with an average yield of 9,69 tons/ha (Statistics Indonesia 2013). One of the major problems faced by farmers in efforts to increase shallot production is the high crops damage caused by the beet armyworm, *Spodoptera exigua* (Lepidoptera: Noctuidae). According to Setiawati (1996), yield losses due to the pest ranged from 32% to 54% in 1994.

All farmers applied chemical pesticides to control pests and diseases. A large majority of farmers applied mixture of pesticides comprising as many as 2-5 different types and spray 2-3 times per week (Moekasan & Basuki 2007). The chemical pesticide that may enhance production costs and also increase environmental problems associated with agrochemical use. Frequent use of synthetic insecticides has resulted in widespread resistance in many *S. exigua* populations (Brewer & Trumble 1994; Kerns et al 1998; Moekasan & Basuki 2007; Saeed et al 2012; Che et al 2013). This is a major concern for growers and has been a topic for pest management researchers.

The use of shade nets and *Spodoptera exigua* Nuclear Polyhedrosis Virus (SeNPV) being safe and effective, would be more economical and practical alternatives to insecticide use. It has been reported by many researchers that SeNPV has a significant effective to control *S. exigua* (Adiyoga et al 2001; Moekasan 2004). The efficacy of baculovirus applications depends on multiple factors, principally the dose applied, the susceptibility to infection of the pest at each instar, the stage structure of the pest population and rate of inactivation of viral occlusion bodies (OBs) on foliage surfaces (Lasa et al 2007).

Shade nets are widely used to protect vegetables crops from pest and diseases (Ben-Yakir et al 2012; Elad et al 2007). In Africa, mobile net houses made of mosquito nets (25-mesh) were effective as physical barrier against the diamondback moth (*Plutella xylostella*), cutworms (*Agrotis ipsilon*), and loopers (*Trichoplusia ni*) providing 66 to 97% control of moths and caterpillars (Martin et al 2006). In China, Feng-cheng et al (2010) demonstrated the incidence of tomato yellow leaf curl virus reduced 90% under a 50-mesh net house. Perez et al (2006) reported shade nets can provide physical protection and affect environmental modification. Recent reports also suggest additional some beneficial aspects of colored nets for the production of fruits (Basile et al 2008; Retamales et al 2008; Shahak et al 2008; Takeda et al 2010) and vegetable crops (Ilic et al 2012; Kong et al 2012; Shahak 2008). Blue shade net ("shallot net") covered shallot are commonly used in the East Java area to protect the crops from *S. exigua* during the dry season. For increasing the profit margin, shade netting can be reused 6 times (Rauf et al 2012), depending upon conditions. However, efficacy of these shade nets for shallot production has not been scientifically evaluated. This technology will provide environment-friendly physical substitutes for the chemicals currently in plant protection.

The objectives of this experiments were to evaluate the used of shade nets and SeNVP to control *S. exigua* on shallot including the level of reduction of insect pests, insecticide sprays and bulb yields.

Material and Method. The experiments were conducted in the Ciledug sub-district of Cirebon district West Java, Indonesia during dry (June to August 2012) and rainy (May to July 2013) seasons. Experiment plots consisted of two rows of (5 m x 1.5 m) with a planting distance 20 x 15 cm. Distance between furrows 1.0 m. Vegetables shallot variety Bima Brebes was used as planting material. Composed was applied a basal treatment at the rate 5 t ha^{-1}. Inorganic fertilizer (15-15-15, N-P-K) was applied at transplanting, as well as 15 and 30 days later and an additional nitrogen-rich fertilizer was applied at 45 day after transplantting (dat).

The experiment was arranged in completely randomized block design with five treatments and five replications. The treatments was followed: without shading net and pesticide (control, T0); white shade nets (T1), blue shade nets (T2); application of SeNPV - was applied based on action threshold (10 adults $trap^{-1}$) (T3) and Farmer's practices (applications of insecticide with intervals 3 days + hand picking) (T4).

The shade nets were 500 cm (L), 500cm (W), and 150 cm (H) constructed entirely of 18-mesh white shade colors and 50–mesh blue shade color. In Indonesia white mosquito nets (AgroPro type R10-215TrM3-82 mesh-18) and blue nets (shallot nets mesh 50) has been used for controlling *S. exigua*.

Observations were made on 20 plants per plot as the sampler traversed a U-shaped path through each plot. The following observations were made: plant height, no. of sprout and no. of leaves; population of eggs mass and larvae of *S. exigua*; percentage of plant damage; number of pesticide applications; other important of pests and diseases and bulb yield (fresh weight, dry weight, diameter of bulb). Temperature was measured inside all shade nets and outside every day. The efficacy of treatments was calculated by comparing them with the untreated (control) plot.

***Statistical analysis**.* The collected data was analyzed with the software package SPSS 17.0 for Windows (SPSS Inc., Chicago, IL) using the analysis of variance to determine treatment significance. The analysis was continued with Least Significant Difference (LSD) at the 5% probability level to determine comparison between treatment means.

Results and Discussion

Climatic data. Daily maximum temperatures (^oC) were recorded inside and outside shade nets. Data are means ± SEM averaged over each 2 weeks from five replicate shade nets.

Table 1 shows that average daily maximum air temperatures were higher inside white nets compared with blue nets both in dry and rainy season. Highest air temperature were recorder under white nets (range 1.28 to 3.71^oC higher than blue nets).

Similar results were reported by Elad et al (2007) and Perez et al (2006) indicating that the influence of nets upon maximum temperatures under different net cover, they found black and blue net were decreased the air temperature under greenhouse in comparison with open field or white net cover.

Grantz (1990) reported that temperature impact plant growth and physiology, including disease development, in various ways. Based on the data the averaged temperature ranges from 34.14 to 38.91°C, and rainfall 0.00 to 132.86 mm.

Table 1

Range of temperature under the shade nets and outside for shallot production, Cirebon 2012/2013

	Average temperature (^oC)			*Rainfall (mm)*
	White nets	*Blue nets*	*Outside*	
Dry season 2012				
The 1st week of July	32.0	31.2	30.8	0
The 2nd week of July	38.0	37.8	37.2	0
The 3rd week of July	38.0	32.0	32.0	0
The 4rd week of July	44.0	34.0	34.0	0
The 1st week of August	42.0	38.0	36.0	0
The 2nd week of August	42.0	38.0	35.0	0
The 3rd week of August	36.4	35.5	34.5	0
Average	38.91	35.2	34.21	0
Rainy season 2013				
The 1st week of May	37.0	36.0	33.0	56
The 2nd week of May	37.0	36.0	36.0	102
The 3rd week of May	33.0	32.0	31.0	298
The 4rd week of May	40.0	38.0	38.0	107
The 1st week of June	40.0	32.0	32.0	142
The 2nd week of June	31.0	34.0	35.0	104
The 3rd week of June	31.0	32.0	34.0	121
Average	35.57	34.29	34.14	132.86

Vegetative characteristics

Plant height (cm). The data regarding the height of the shallot plants showed significant results at different treatments, as shown in the Table 2.

In the dry season white nets were significantly larger than those other treatments followed by blue nets and farmer's practices treatment, whereas the least plant height was reported in SeNPV plot and not significantly with untreated plot (control).

In the rainy season various treatments were not significantly affected on plant height in shallot production.

Table 2

Plant height (cm) as affected by different treatments on shallot, Cirebon 2012/2013

Treatments	*Plant height (%) (Day After Planting = DAP)*					
	Dry season 2012					
	7	*14*	*21*	*28*	*35*	*41*
Control	11.53[a]	21.33[c]	25.66[c]	25.93[c]	25.11[c]	25.11[c]
White nets	11.18[a]	22.80[a]	29.41[a]	31.68[a]	32.85[a]	33.96[a]
Blue nets	11.42[a]	23.25[ab]	27.63[b]	28.79[b]	30.08[b]	30.08[b]
SeNPV	11.20[a]	21.08[c]	25.70[c]	26.12[c]	26.60[c]	26.60[c]
Farmer's	10.61[a]	21.75b[c]	27.23[b]	28.88[b]	30.04[b]	30.04[b]
LSD 5%	1.33	0.77	1.09	1.92	2.10	2.13
CV (%)	8.88	2.62	3.01	5.07	5.41	5.51
	Rainy season 2013					
	7	*14*	*21*	*28*	*35*	*41*
Control	5.25[a]	17.99[ab]	24.42[b]	27.30[a]	30.37[a]	32.96[a]
White nets	5.58[a]	19.07[a]	25.68[a]	27.86[a]	30.58[a]	32.40[a]
Blue nets	5.67[a]	18.13[ab]	24.96[ab]	28.32[a]	31.54[a]	33.71[a]
SeNPV	5.39[a]	18.01[ab]	24.00[b]	27.54[a]	30.23[a]	33.34[a]
Farmer's	5.33[a]	17.01[b]	24.22[b]	26.80[a]	29.97[a]	33.72[a]
LSD 5%	0.57	1.72	1.13	2.14	2.55	3.07
CV (%)	7.86	7.10	3.43	5.79	6.22	6.90

Note: Means followed by the same letter in each collumn are not significantly different at 5% level with Duncan test); LSD = Least Significan Difference with value 5%; CV = Coeficient of Variation.

Number of leaves per plant. Various treatments were not significantly affected the number of leaves per plant in shallot production. Maximum leaves were ranged from 20.40–23.01 in dry season and 22.25 and 28.27 in rainy season (Table 3).

Table 3

No. of leaves per plant as affected by different treatments on shallot, Cirebon 2012/2013

Treatments	*No. of leaves per plant (Day After Planting = DAP)*					
	Dry season 2012					
	7	*14*	*21*	*28*	*35*	*41*
Control	9.43[a]	15.63[a]	19.97[ab]	21.09[a]	21.27[ab]	22.19[a]
White nets	9.21[ab]	14.61[b]	19.25[bc]	21.25[a]	21.11[ab]	20.40[a]
Blue nets	8.88[b]	15.41[a]	21.15[a]	22.78[a]	22.39[a]	23.01[a]
SeNPV	8.79[b]	14.28[b]	18.62[c]	21.24[a]	19.86[b]	20.78[a]
Farmer's	9.3[ab]	15.55[a]	20.98[a]	22.95[a]	22.02[a]	22.00[a]
LSD 5%	0.51	0.79	1.32	2.42	1.78	2.11
CV (%)	4.20	3.93	4.92	8.27	6.22	7.25
	Rainy season 2013					
	7	*14*	*21*	*28*	*35*	*41*
Control	12.86[a]	10.24[a]	12.79[b]	16.75[b]	20.31[b]	26.01[ab]
White nets	12.11[a]	10.93[a]	13.33[ab]	18.18[ab]	22.00[ab]	26.94[ab]
Blue nets	12.87[a]	10.67[a]	14.18[a]	19.66[a]	23.92[a]	28.27[a]
SeNPV	13.29[a]	10.37[a]	13.18[ab]	17.29[b]	20.99[b]	25.76[ab]
Farmer's	13.67[a]	10.15[a]	12.96[ab]	17.26[b]	21.46[b]	22.25[b]
LSD 5%	2.71	1.72	1.36	1.69	2.15	5.98
CV (%)	15.61	7.10	7.61	7.06	7.36	17.25

Note: Means followed by the same letter in each collumn are not significantly different at 5% level with Duncan test); LSD = Least Significan Difference with value 5%; CV = Coeficient of Variation.

Number of sprout per plant. Results regarding number of sprout per plant are presented in Table 4. Various treatments were not significantly affected the number of sprout per plant in shallot production. Maximum sprout was ranged from 5.00–5.64 in dry season and 22.25 and 28.27 in rainy season.

Table 4

No. of sprout per plant as affected by different treatments on shallot, Cirebon 2012/2013

Treatments	*No. of sprout per plant (Day after Planting = DA)*					
	Dry season 2012					
	7	*14*	*21*	*28*	*35*	*41*
Control	3.56[a]	4.6[b]	5.07[a]	5.14[a]	5.44[b]	5.64[a]
White nets	3.29[a]	4.11[a]	4.67[a]	5.52[a]	4.88[a]	5.00[b]
Blue nets	3.41[a]	4.48[b]	5.14[a]	5.46[a]	5.45[b]	5.56[a]
SeNPV	3.2[a]	4.28a[b]	4.72[a]	4.91[a]	4.95[a]	5.17[ab]
Farmer's	3.2[a]	4.6[b]	5.07[a]	5.68[a]	5.29[ab]	5.42[ab]
LSD 5%	0.34	0.24	0.32	1.05	0.44	0.49
CV (%)	7.43	4.07	4.91	14.73	6.31	6.78
	Rainy season 2013					
	7	*14*	*21*	*28*	*35*	*41*
Control	2.88[a]	3.88[b]	4.53[a]	5.13[a]	5.31[a]	5.29[a]
White nets	3.01[a]	4.11[ab]	4.65[a]	5.41[a]	5.61[a]	5.83[a]
Blue nets	3.14[a]	4.46[a]	5.10[a]	5.76[a]	5.86[a]	6.01[a]
SeNPV	3.14[a]	4.10[ab]	4.63[a]	5.47[a]	5.59[a]	5.76[a]
Farmer's	2.98[a]	4.13[ab]	4.69[a]	5.35[a]	5.45[a]	5.56[a]
LSD 5%	0.35	0.58	0.65	0.75	0.82	0.83
CV (%)	8.57	10.39	10.20	10.32	10.97	10.84

Note: Means followed by the same letter in each collumn are not significantly different at 5% level with Duncan test); LSD = Least Significan Difference with value 5%; CV = Coeficient of Variation.

The white nets treatments produced the highest vegetative characteristics in terms of plant height in dry season and number of in rainy season. The blue came in the second order followed by open field farmers practices, SeNPV and control. Increasing vegetative characteristics under white shade net colors could be attributed to the suitable climatic conditions for shallot plants especially for air temperature. The shade net (regardless of color) led to diffuse light and then increase radiation use efficiency, yields (both at the plant and ecosystem level), and even be a factor affecting plant growth (Guenter et al 2008; Gu et al 2002; Ortiz et al 2006).

It was observed that all treatments significantly reduced eggs and larval population of *S. exigua* compared to control (Table 5). Reduction in the number of insect pests is the overall goal of the shade nets technologies and an 18-mesh white nets followed by blue nets 50-mesh very well to block a number of *S. exigua* from reaching the shallot crops. In the dry season, there was one outbreak of thrips (*Thrips tabaci*) under the blue nets. It is suspected that thrips were introduced into the blue nets via the hole of shade nets might be due to mesh size of blue nets was larger than white net. Shahak et al (2008) reported the rates of pest infestations were affected by the color and reflectivity of the nets. Some of the photoselective shade nets contain pigments known to attract whiteflies and thrips (i.e. yellow and blue nets).

The total number of eggs mass and larvae of *S. exigua* were higher in the dry season than in the rainy season due to high frequency of rainfall during this season. Palasubramanian et al (2000) reported that the incidence of *S. exigua* was low during the period of Janury to Agust while Rauf (1999) stated that the *S. exigua* outbreak usually occurred on the third planting (Agust–October) of shallot in Brebes, Indonesia. Rauf (1999) demonstrated that beet armyworm larvae population density during dry season was about 78 times higher than those during rainy season. The shade netting (white and blue color) gave the best overall control followed by farmer's practices. The efficacy of these treatments was 98 to 100%, farmer's practices - 15.29 to 98.38% while SeNPV only 16.04 to 46.06% compare to the control.

Table 5

Reduction in eggs and larvae of *S. exigua* numbers inside the shade nets compared to normal outside (control plot) on shallot in Cirebon, 2012/2013

Treatments	*Total number of eggs mass*				*Total number of larvae*			
	Dry season		*Rainy season*		*Dry season*		*Rainy season*	
	Total eggs mass	*Reduction (%)*	*Total eggs mass*	*Reduction (%)*	*Total larvae*	*Reduction (%)*	*Total larvae*	*Reduction (%)*
Control	1.87	-	0.85	-	2.47	-	1.29	-
White net	0.03	98.40	0.00	100	0.00	100	0.00	100
Blue net	0.00	100	0.00	100	0.00	100	0.00	100
SeNPV	1.57	16.04	0.45	47.06	1.55	37.25	0.93	27.91
Farmer's	1.53	18.18	0.72	15.29	0.04	98.38	0.72	44.19

During the growing season, *S. exigua* in farmer's practices plot were managed with lambda-cyhalothrin + chlorfenapyr at the full recommended rate and total number of applications 26 times per seasons. It was obvious from the experiment that shade nets provided better control by reducing *S. exigua* in both seasons. The used of shade netting reduced pesticides by 100% while application of SeNPV based on pheromone trap (10 adult $trap^{-1}$) reduced 38.46% compare to farmer's practices

Majumdar (2010) reported the net house significantly excluded moths of tomato fruitworm (*Helicoverpa zea*) and beet armyworm (*S. exigua*) compared to the open field; exclusion efficiency was 82-100%. Direct scouting revealed armyworms (three species) and the tomato hornworm (*Manduca quinquemaculata*) caterpillar numbers reduced 98-100% under the net house.

Observation result on percentage of plant damage caused by *S. exigua* infestation was presented in Table 6. There were significant differences in plant damage at each sampling date. Percentage of plant damage increased in line with plant age, the highest plant damage was observed at 41 DAP. The highest and statistically similar reduction of plant damage was observed in shade nets and plots treated with lambda cyhalotrin + chlorfenafir (farmer's practice) both in the dry and rainy seasons.

Table 6

Plant damage (%) due to beet armyworm, Cirebon 2012/2013

Treatments	*Plant damage (%)(Day after Planting = DA)*					
	Dry season 2012					
	7	*14*	*21*	*28*	*35*	*41*
Control	0.35^{a}	4.56^{a}	25.32^{a}	49.73^{a}	48.44^{a}	73.01^{a}
White nets	0.00^{a}	0.74^{b}	0.00^{c}	0.00^{c}	0.00^{c}	0.00^{c}
Blue nets	0.00^{a}	1.23^{b}	0.00^{c}	0.22^{c}	0.00^{c}	0.00^{c}
SeNPV	0.22^{a}	4.80^{a}	14.86^{b}	25.79^{b}	26.01^{b}	39.54^{b}
Farmer's	0.00^{a}	0.00^{b}	0.06^{c}	0.16^{c}	0.00^{c}	0.00^{c}
LSD 5%	0.38	2.47	3.37	9.74	6.04	5.37
CV (%)	47.26	18.08	31.22	47.85	23.13	17.80
	Rainy season 2013					
	7	*14*	*21*	*28*	*35*	*41*
Control	2.20^{a}	5.32^{a}	9.56^{a}	10.11^{a}	11.92^{a}	11.92^{a}
White nets	0.00^{a}	0.00^{c}	0.00^{c}	0.00^{c}	0.00^{c}	0.00^{c}
Blue nets	0.00^{a}	0.00^{c}	0.00^{c}	0.00^{c}	0.00^{c}	0.00^{c}
SeNPV	1.20^{b}	2.38^{bc}	5.79^{b}	4.34^{b}	2.56^{b}	2.56^{b}
Farmer's	1.23^{b}	3.12^{ab}	3.44^{b}	1.66^{bc}	1.57^{bc}	1.57^{bc}
LSD 5%	0.59	2.68	2.95	2.91	2.06	1.74
CV (%)	47.31	29.42	25.56	26.40	47.92	23.61

Note: Means followed by the same letter in each collumn are not significantly different at 5% level with Duncan test); LSD = Least Significan Difference with value 5%; CV = Coeficient of Variation.

Efficacy of SeNPV was not as high as expected. Results of our experiments showed that application of SeNPV controlled low to moderate levels of *S. exigua* might be due to short persistence on shallot foliage (dry season). SeNPV activity also might be reduced by wash-off by rainfall or degradation by sunlight (rainy season). Rauf et al (2012) reported that combining of SeNPV with hand picking increased of shallot yield compared to SeNPV alone. Moekasan (2004) reported that mixture of SeNPV and chemical insecticides increased efficacy of SeNPV.

Yield parameters. Yields generally followed trends in pest incidence, although with more differentiation among treatments. In the dry season, maximum bulb yield of 9.15 t ha^{-1} was recorded in farmer's practices plot which could reduce 51.04% yield loss over control followed by white nets (8.87 t ha^{-1}), blue nets (7.79 t ha^{-1}) and SeNPV (5.83 t ha^{-1}) which could reduce 49.49, 42.49 and 23.16% yield loss respectively, over control (Table 7). In the rainy season, maximum bulb yield of 8.02 t ha^{-1} was also recorded in farmer's practices plot which could reduce 22.69% yield loss over control followed by white nets (7.73 t ha^{-1}), SeNPV (7.60 t ha^{-1}) and blue nets (7.28 t ha^{-1}) which could reduce 19.79, 18.42 and 14.85% yield loss respectively, over control. Rauf et al (2012) reported that shade nets can be reused for 6 growing season. Cost of shade nets/ha/season Rp. 4.162.917 - while insecticide Rp. 7.561.500.

Table 7

Yield of shallot in dry season, Cirebon 2012

	Sample (20 plants)				*Plot*			
Treatments	*No. of bulb*	*Bulb diameter(cm)*	*Fresh weight(g)*	*Dry weight(g)*	*Fresh weight(kg)*	*Dry weight(kg)*	*t ha^{-1}*	*Yield loss(%)*
Control	117.60[a]	1.63[b]	397.40[b]	345.00[b]	12.80[d]	9.60[d]	4.48	-
White nets	110.60 [a]	2.37[a]	686.80[a]	576.40[a]	22.70[ab]	19.00[ab]	8.87	49.49
Blue nets	116.00[a]	2.23[a]	637.20[a]	544.20[a]	18.90[bc]	16.70[b]	7.79	42.49
SeNPV	110.20[a]	1.79[b]	373.20[a]	324.40[b]	15.00[cd]	12.50[c]	5.83	23.16
Farmer's practices	113.00[a]	2.24[a]	718.00[a]	551.00[a]	25.10[a]	19.60[a]	9.15	51.04
LSD 5%	12.52	1.96	44.39	82.08	3.99	2.65		
CV (%)	8.36	7.29	13.41	13.32	14.52	13.00		

Note: Means followed by the same letter in each collumn are not significantly different at 5% level with Duncan test); LSD = Least Significan Difference with value 5%; CV = Coeficient of Variation.

Elad et al (2007) and Shahak (2008) reported that production of pepper three cultivars of bell pepper were increased by 16 to 32% when grown under shade nets (Table 8). Slightly lower results on the use of the net caused by the characteristics of shallot plants included in plant with needs more light intensity. The use of net reduces the intensity of light received by the plant that affect the yield, but the use of net to reduce the use of chemicals which this issue is a major problem in which farmers use pesticides is very high.

Table 8

Yield of shallot in rainy season, Cirebon 2013

	Sample (20 plants)				*Plot*			
Treatments	*No. of bulb*	*Bulb diameter(cm)*	*Fresh weight(g)*	*Dry weight(g)*	*Fresh weight(kg)*	*Dry weight(kg)*	*t ha^{-1}*	*Yield loss(%)*
Control	90.60[a]	2.34[b]	612.00[a]	408.00[c]	17.70[ab]	13.28[d]	6.20	-
White nets	127.60[a]	2.84[a]	992.00[a]	836.00[a]	19.80[b]	16.57[ab]	7.73	19.79
Blue nets	120.40[a]	2.89[a]	1,028.00[a]	800.00[a]	18.20[ab]	15.60[c]	7.28	14.85
SeNPV	120.00[a]	2.67[a]	920.00[a]	622.00[b]	19.70[ab]	16.29[b]	7.60	18.42
Farmer's practices	124.40[a]	2.86[a]	1,023.00[a]	808.00[a]	22.00[a]	17.18[a]	8.02	22.69
LSD 5%	23.80	2.58	237.63	176.68	4.36	2.65		
CV (%)	15.22	7.07	19.37	18.97	17.42	13.00		

Note: Means followed by the same letter in each collumn are not significantly different at 5% level with Duncan test); LSD = Least Significan Difference with value 5%; CV = Coeficient of Variation.

The number of bulb, fresh/dry bulb and diameter of bulb were least from untreated plot and greatest on farmer's practices plot, the latter closely followed by white shade nets and not different from blue shade nets both in dry and rainy seasons.

Data in Table 7 and 8 showed that using white net increased the bulb yields per plot compared to the blue net during the two tested seasons. The higher yield production under white net may be due to proper light distribution for shallot, which creates favorable conditions for plant growth, photosynthesis and metabolites translocation. Other possibility was increasing available water and nutrients uptake which ultimately accelerated the rate of vegetative growth and yield (Rajapakse & Shahak 2007). White nets increased air temperature compare to blue nets. Caliskan et al (2004) mentioned that low temperatures after planting and early growth stages and high temperatures during the tuber bulking stage significantly constrain growth and yield of potato. Therefore, application of proper management practices to enhance vigorous early growth is very important to achieve higher bulb yield from shallot under these types of environments.

Conclusions. The used of shade nets both white and blue color could reduce pest damage and number of sprays up to 100% and produced the highest yields. Applications of Se-NPV were also beneficial in reducing pest damage by 38.46% compare to farmer's practices. The use of shade nets in shallot production might offer several advantages. It would enable to protect shallot from *S. exigua* incidence, thus replacing applications of chemicals insecticides or hand picking practices. The technology is, therefore, friendly to the environment.

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