The Intercropping Effect on Potato under Net House as Adaption Procedure of Climate Change Impacts

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Abstract: The intensive agricultural and intercropping systems take a great place in the consideration of decision makers as well as the farmers. Through climate change impacts on food security and the need to increase the agricultural production of the area unit led to change many traditional agricultural practices such as cultivation some export fruit (Orange, grape, mango and etc.) under net house instead of open field. The need to increase the soil use efficiency by using the free areas during the first three years of young trees among the rows and in between were so urgent to serve the food security options. In this study potato plants (*Solanum tuberosum* L., Valor cultivar) were cultivated as intercrop among young orange trees (first and second year), under different five net colors for covering greenhouses (yellow, white, red, blue and black) and open field to increase the soil use efficiency through the bare areas among the citrus rows especially at the winter season. Three in-row plant spacing were applied (12.5, 25 and 50 cm) under each net house color. Trial was carried out during two growing winter seasons of 2010/2011 and 2011/2012 at El-Bossily farm, CLAC, Agricultural Research Center, El-Behira Governorate, Egypt. This study investigated the effects of different net color on the growth and production of potato in terms of light intensity, air temperature, relative humidity and plant growth were evaluated over the two seasons. Regardless of net color, all treatments decreased maximum temperatures and increased relative humidity compared with open field conditions. The use of white and yellow nets resulted in a significant increase of the number of leaves, fresh and dry weight and tuber yield per plant compared to other treatments. Data revealed that under white and yellow nets the most appropriate microclimate for producing potato under Egyptian conditions. The net color and in-row plant space affected on the NPK content of potato plant. Increasing in-row plant distance from 12.5 to 50 cm led to increase the tuber yield per potato plant on contrary of tuber yield per unit area. The economic consideration suggest using 12.5 or 25 cm in row plant space in case of using the bare soil between the citrus plant.
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1. Introduction

Orange cultivation under net house is promising modern technique for increasing the export yield and for avoiding the climate change impacts (temperature and extreme weather events). While the disadvantage of net house summarized in the cost of net house establishments and the bare areas among the rows and in between plants concerning the first three years. Potato is one of the main crops of food security as well as one of the most threatened crops under the expected climate change impacts in Egypt. The crop is grown throughout the world but with particular importance in temperate climates. Present world production is 329 106 Mg fresh tubers from 19.1 million ha **(FAO, 2005)**. Low shading netting cover of numerous crops traditionally cultivated un-netted, revealed differential effects of colored nets on the performance of the plant production. The net-covering by itself was found to mitigate extreme climatic fluctuations, reduce heat and wind stresses, and improve canopy vitality. Most responses depend on the chromatic properties of the protecting net. These nets can be used outdoors as well as in greenhouses. They can provide physical protection, affect environmental (**Cerny *et al*., 2003; Ilias and Rajapakse, 2005; Kambalapally and Rajapakse, 1998; Mortensen and Stromme, 1987; Perez *et al*., 2006; Rajapakse and Kelly, 1995; Rajapakse *et al*., 1999; Wilson and Rajapakse, 2001).**

The colored net is an emerging approach, which introduces additional benefits, on top of the various protective functions of nettings. These nets are unique in that they both spectrally-modify, as well as scatter the transmitted light. The photoselective nets include "colored nets" (e.g. Red, Yellow, Green, Blue net products) as well as color nets (e.g. Pearl, White and Grey) absorbing spectral bands shorter, or longer than the visible range. The spectral manipulation is aimed at specifically promoting physiological responses, while light scattering improves light penetration into the inner canopy **(Rajapakse and Shahak, 2007).**

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 tuber yield from potato under these types of environments (Caliskan *et al*., 2004 and Foti 1999). Maher, 1996 reported that with increasing culture density, the average weight of tubers increased and low density, number of tubers harvested per unit area was low. Probably due to increased density of plants, stress and competition occurring within a plant or the number of large tubers that are produced in shoot high density, reduced the average size of lumps with increasing plant density on tuber yield per unit area is increased (Beraga and Caeser, 1990 and Jagroop *et al*., 1993).

The optimizing of plant density is one of the most important subjects of potato production management, because it affects to seed cost, plant development, yield and quality of the crop (Bussan *et al*., 2007). Adequate plant population has been reported by several scientists to be of advantage in crop production (Mauromicale *et al*., 2003). Creamer *et al*.(1999) reported that plant population density is a major factor that influenced growth and yield of sesame. verital responses vary in sweet potato. (Onunka and Nwokocha, 2008). Barry *et al* (1999) observed that the performance of crops can improve through plant population's densities and use of early maturing varieties. Improved management includes proper land preparation, optimum plant population, recommended fertilize application rate and timely harvesting. The optimizing of plant density is one of the most important subjects of potato production management, because it affects to seed cost, plant development, yield and quality of the crop (Bussan *et al*., 2007).

In practice, plant density in potato crop is manipulated through the number and size of the seed tubers planted (Allen and Wurr, 1992). Therefore, many studies have been conducted to establish the optimal combination of seed size and planting distance for a certain environment (Barry *et al*., 1990; Creamer *et al*., 1999; Kleinhenz and Bennett, 1992; Negi *et al*., 1995; Strange and Blackmore, 1990; Bussan *et al*., 2007). In general, total yields increased as increasing plant density while percentage of large tubers decreased. However, the optimal planting density differed depending on the environmental conditions and cultivars. As a general rule, the higher plant densities are recommended for early potato production systems in the Mediterranean type of environments since, out-season production of potato crop limits its growth and yield potential (Beukema and Zaag, 1990; Caliskan 1997; Mauromicale *et al*., 2003).

The objectives of this study are investigating the intercropping ability of potato to increase the efficiency of using the bare soil between the fruit tree rows and study the response of potato crop in terms of vegetative growth and yield to the net cover color and plant density.

2. Materials and Methods

The experiment was carried out in the two successive winter seasons of 2010/2011 and 2011/2012 under net house at El- Bossily Protected Cultivation Experimental Farm, Central Laboratory for Agricultural Climate (CLAC), Agricultural Research Center (ARC), at Behaira Governorate, Egypt. The treatments comprised five greenhouse net covers (yellow, white, red, blue and black) as well as open field and three in-row plant space treatments (12.5, 25 and 50 cm). The dimensions of each greenhouse were 9 m width x 60 m length x 3.5 m height. Potato (*Solanum tuberosum* L., Valor cultivar) tubers were cultivated in October, 18, 2010 and October, 22, 2011 for first and second seasons, respectively. The distance among potato rows and orange rows under greenhouses and opened field were presented in Fig. (1).

The experiment was designed in a split plot arrangement with three replicates. Greenhouse net color treatment was in the main plots, in-row plant space was allocated in the sub plot.

Potato plants were irrigated by using drippers of 4 l/hr capacity. The chemical fertilizers were injected within irrigation water system.

Samples of five plants of each experimental plot were taken to determine growth parameters at the end of season as follows (plant height, number of leaves per plant, fresh and dry weight, number of tubers and weight per plant. For mineral analysis, dried the youngest mature leaves were digested in the sulphuric acid and hydrogen peroxide digestion according to the method described by Allen (1974). Total nitrogen was determined by Kjeldahl method according to the procedure described by FAO (1980). Phosphorus content was determined using spectrophotometer according to Watanabe and Olsen (1965). Potassium content was determined photo-metrically using Flame photometer as described by Chapman and Pratt (1961). The permanent wilting point (PWP) and field capacity (FC) of the trial soil were determined according to Israelsen & Hansen (1962). The soil chemical and physical properties results were tabulated in Tables (1&2). Day light intensity, temperature and humidity were measured under different net color treatments every day. Average relative humidity (RH %) have been measured daily by Digital thermo hygrograph. Maximum and minimum thermometer was used to measure temperature (model, 5458 Fetcher, NC 28732), the mean temperature has been calculated by dividing the maximum temperature by the minimum one.

Statistical analysis was determined by computer, using SAS program for statistical analysis. The differences among means for all traits were tested for significance at 5 % level according to the procedure described by Snedicor and Cochran (1981).

Economical analysis, after considering the cost of potato tuber seed application per greenhouse 540 m^2 (9 x 60 m), the incomes from potato yield was used (CIMMYT, 1988) according to the formula: Net Income = value of obtained yield - cost of tuber seeds; Value cost ratio (VC) = value of yield obtained / cost of tuber seeds. Relative increase in income (RII) = (net income /income of control) x 100.

All other agriculture practices of potato cultivation were in accordance with standard recommendations for commercial growers by the Ministry of Agriculture, Egypt.

Table (1): The chemical properties of the soil experiment analyzed before cultivation.

Depth cm	pH	ECe (dS/m)	meq /l							
			Cations				Anions			
			Ca^{++}	Mg^{++}	Na^{+}	K^{+}	Cl^{-}	CO_3^{--}	HCO_3^{-}	SO_4^{--}
0-30 cm	7.75	1.25	2.80	2.15	6.69	0.9	4.50	-	1.90	6.14

Table (2): The physical properties of the soil experiment analyzed before cultivation.

Depth cm	Sand %	Clay%	Silt %	Texture	FC %	PWP %	Bulk density g/cm^3
0-30	95.31	4.30	0.36	Sandy	15.47	5.65	1.44

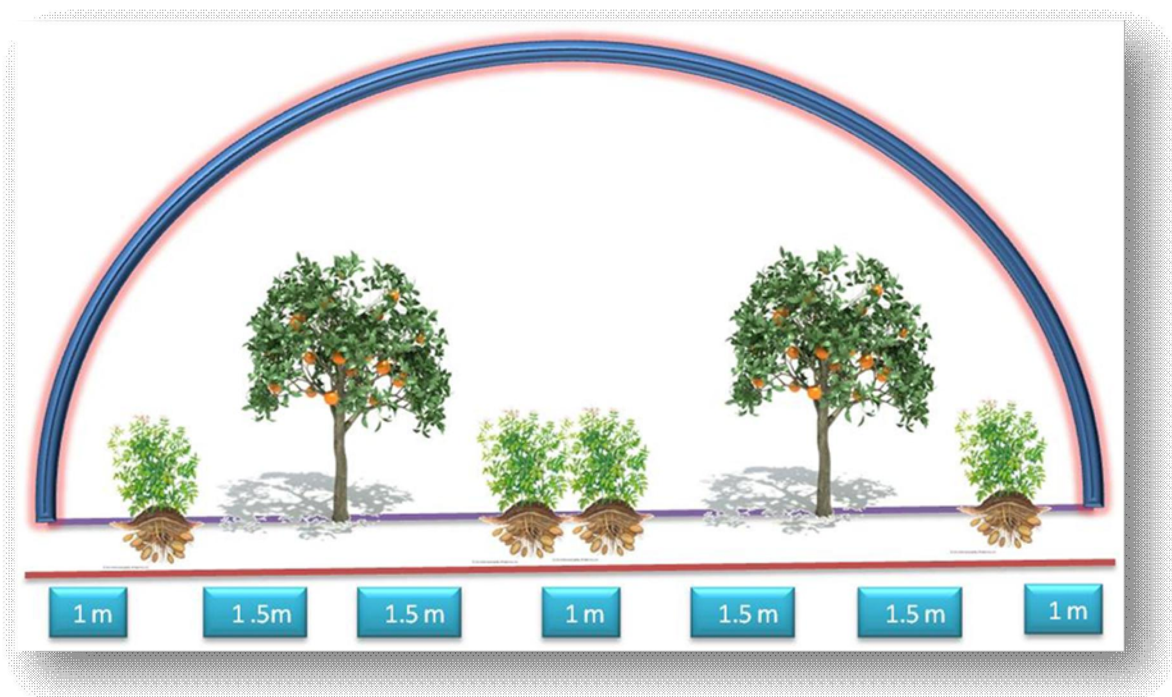

Fig. (1): The layout of the experiment (potato and orange tree intercropping)

3. Results and Discussion

3.1 Climatic data

Average maximum daily temperatures for the different net color and opened field during 2010/2011 and 2011/2012 seasons showed that the use of nets exerted a different influence on greenhouse temperature (Fig. 2 and 3). The higher temperature was recorded by the open field treatment followed by white net, while the lowest maximum temperature was gained by black net. Maximum temperatures tended to be lower under the blue and black net by 3°C in comparison with open field, due to more interception of radiation which is greater than the gain of temperature caused by the use of color nets due to their role in the interception of air circulation or "greenhouse effect". Bigger differences were recorded on the growing seasons the air temperature were decreased during the growing season during November, December, January and February in comparison with October. Similar results were reported by **Elad *et al.,* 2007, Perez *et al.*, 2006 and Retamales *et al.,* 2008,** 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.

Average light intensity under each greenhouse net color and open field treatment during the two studied seasons is shown in Figures 4 and 5, respectively. The highest light intensity during the cultivation seasons was found in October under the open field treatment followed by white and yellow net (Fig. 4 and 5). At the same period, light intensity under blue and black net was lower than under the white and yellow. The obtained results are in agreement with those of **Stamps (2008)** who reported that nettings, regardless of color, reduce radiation reaching crops underneath. Obviously, the higher the shade factor, the more radiation will be blocked.

Average relative humidity increased by the use of all net color by 4-8% compared to open field during the two seasons (Fig. 6 and7). These results were in line with those reported by Elad *et al*., 2007, indicating a 2-6% increase in relative humidity associated with the use of nets. These authors also reported a decrease in evaporation associated with the use of nets and a significant reduction in wind speed. Campen and Bot (2003) explained the ventilation phenomenon. The pressure difference over the openings was one of the driving forces for ventilation, which could be either due to the wind outside the greenhouse or due to the temperature difference over the openings. At lower wind speed, which was true under present case, mainly the buoyancy effect contributes in ventilation.

3.2 Vegetative characteristics

The obtained results in Table 3 revealed that the net colors and in-row plant space significantly affected potato vegetative characteristics (plant height, number of leaves and fresh and dry weight per plant) in the two growing seasons. The white net treatments produced the highest vegetative characteristics in terms of number of leaves and fresh and dry weight. The yellow came in the second order followed by open field, while black net produced the lowest vegetative characteristics. The plant height recorded different trend, the black net gave the highest plant height followed by blue net; the open field had shorter plant height during the two studied seasons. Increasing vegetative characteristics under white greenhouse cover net could be attributed to the suitable climatic conditions for potato plants under the white net cover. The greenhouse cover 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 (**Gu *et al*., 2002; Guenter *et al*., 2008; Healey *et al*., 1998; Ortiz *et al*., 2006; Sinclair *et al*., 1992).** Any shade netting can scatter radiation, especially ultraviolet because netting is usually made using ultraviolet-resistant materials **(Wong, 1994). Nissim-Levi *et al*., 2008** added that shade netting that increases light scattering but does not affect the light spectrum has been shown to increase branching, plant compactness, and the number of leaves per plant. Colored shade nets can also increase light scattering by 50% or more and this alone may influence plant development and growth. On the other hand, black and blue net reduce radiation reaching crops underneath. Obviously, the higher the shade factor in dark net color, the more radiation will be blocked. Reductions in radiation resulting from netting will affect the climatic conditions under net and will reduce the plant growth especially in the winter season because of low natural radiation (Stamps, 2008).

Regarding to the in-row plant space, data indicated that 50 cm in-row plant space resulted the highest vegetative characteristics (number of leaves and fresh and dry weight) followed by 25 cm treatment. The lowest number of leaves and fresh and dry weight were obtained by 12.5 cm treatment. The plant height took different trend; 12.5 cm between plants gave the highest plant height followed by 25 cm.

The interaction between net color and in-row plant space treatments was significant for vegetative characteristics during the two growing seasons. The highest vegetative growth was preceded by white net combined with 50 cm followed by yellow net with 25 cm. the lowest vegetative growth was preceded by black net cover combined with 12.5 cm in row plant space. The obtained results are in agreement with those of Caliskan *et al*., (2004) who revealed that low plant densities contributed positively to higher plant growth and consequently improving yield per plant. Within-row spacing and the high plant density affect the number of leaves and fresh and dry weight per plant. On the other hand, high plant density largely affects crop access to resources including solar radiation and nutrients. Thus, crop population adjustment is considered as one of the most important and effective factors in potato yield improvement (Bussan *et al*., 2007). Black nets reduce the amount of light reaching the underneath plants, as they neither modify its spectral composition, nor its relative content of diffused light. Transparent nets scatter the light transmitted through them, but do not alter its spectral composition. The uniqueness of the translucent photo-selective nets is that they both spectrally-manipulate and scatter the transmitted light. Allen and Wurr (1973) concluded that effect of high plant density was significant on the plant height of main stem in potato crop and main stem became taller as density increased. The reason was further competition for more light absorption. Alvin *et al*., (2007) added that with increasing plant density, plant dry matter was decreased in each plant but increased per unit area. It can be said that all factors affecting tuber yield, affect total plant dry matter, as well (Hashemidezfooli *et al.,* 1998).

3.3 Yield parameters

Data in Table 4 showed that using white net increased the potato tuber yield per plant compared to the other net color during the two tested seasons. The yellow net came in the second order followed open field treatment. Black and blue cover gave the lowest tuber yield during the two studies seasons. The higher yield production under white net may be due to proper light distribution for potato, 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 and Shahak, 2007). White net increased air temperature during the vegetative growth during October, November, and the temperature during the December and January is acceptable for tuber bulking stage the same finding was reported by 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 tuber yield from potato under these types of environments.

Regarding the effect of in-row plant space, data revealed that 50 cm treatment recorded the highest values of yield per plant followed by 25 cm in the two studied seasons. In general, increasing in-row plant spacing increased total yield per plant but decreased production per unit area. The 12.5 cm in-row plant space gave the highest tuber yield per meter square, while the 50 cm between plants gave the lowest yield per meter square. This result is in line with findings of **Ojikpong et al (2009)** where maximum yields per land unit are obtained at a closer spacing. This attributed to better water utilization, less evaporation, better weed control through canopy shading, better radiant energy utilization and increased photosynthesis. **Bussan *et al*. (2007**) who reported the optimizing of plant density is one of the most important subjects of potato production management, because it affects to seed cost, plant development, yield and quality of the crop Adequate plant population has been reported by several scientists to be of advantage in crop production Namo *et al.,* (2006). Creamer *et al*.(1999) that plant population density is a major factor that influenced growth and yield of varietal responses vary in sweet potato (Onunka and Nwokocha, 2003). Bussan *et al*. (2007) observed that the performance of crops can improve through plant population densities and use of early maturing varieties. Improved management includes proper land preparation, optimum plant population, recommended fertilize application rate and timely harvesting. The optimizing of plant density is one of the most important subjects of potato production management, because it affects to seed cost, plant development and yield (Bussan *et al.,* 2007). Beukema and Van der zaag (1990) mentioned that increasing the density can increase the yield in three ways. First, the green leaves will cover the soil earlier and will absorb more sunlight and lead to more assimilation. Second, few lateral shoots will grow and the third is that the growth of tubers will start earlier. Moreover, Bohl *et al.,* (2001) reported that proper plant density very important in early potato production under the Mediterranean conditions since growing period is short and heat stress limits tuber growth during last period of plant life.

3.4 Leaf elementals content

The obtained results in Table 5 showed that the net color and in row plant space treatments significantly affected the uptake of NPK by potato leaf during the two growing seasons. The white net color increased the uptake of NPK followed by yellow net cover, while the lowest NPK content obtained by black net cover. results were in line with those obtained by Al-Helal, and Abdel-Ghany (2010), Batschauer (1999), Cerny *et al*., (2003), Folta and Maruhnich (2007) and Ilias and Rajapakse, (2005) who stated that the increasing uptake of NPK by white net may be due to increase in soil temperature due to application of greenhouse covers which resulted in enhancement of air and soil environment around roots of plants, which led to increasing plant growth, and hence increasing nutrient absorption and uptake. Moreover, Cooper, (1973) concluded that the optimal root zone temperature conditions allow for adequate root function including proper uptake of water and nutrients. Plant nutrient uptake, plant growth, and yield under mulch fit a quadratic relationship with root zone temperature.

Plant space treatments significantly affected the uptake of NPK percentages. The highest NPK resulted by 50 cm followed by 25 cm. The lowest NPK percentage was obtained by 12.5 cm treatment during the two seasons. Regarding the interaction effect between net color and plant space, the highest NPK content was obtained by white net combined with 50 cm plant space followed by yellow with 50 cm. The lowest NPK content was obtained by black net treatment with 0.125 m during both seasons. This results agreed with Beukema and Van der zaag (1990) and Bohl et al.(2001) who reported that increasing the high plant density increase nutrient use efficiency for the land unit, but the NPK percentage in high density become low due to the competition between high population plants for water and nutrients.

3.5 Economic consideration

The costs of economic consideration of using different in row plant spacing for potato are shown in Table 6 (A&B). The economic consideration didn't consider the cost of greenhouse cover because the potato consider as a second crop under this cover nets, then the economic consideration concerned about the cost and benefit of using different in row plant spacing. This study not considered the other costs of production such as labor, inputs, irrigation, etc.-, because these are the same for the different treatments. The tuber cost per greenhouse were calculated under different in row plant spacing treatments, the highest tuber seed costs was under 12.5 cm in row plant spacing treatments followed by 25 cm treatment. The highest net income was gained by 12.5 cm in row plant spacing followed by 25 cm treatment, the difference between 12.5 and 25 cm was marginal; while the (44 L. E. per greenhouse); while the difference between 12.5 cm and 50 cm was valuable (450 L. E. per greenhouse). This economic consideration suggest using 12.5 or 25 cm in row plant space in case of using the bare soil between the citrus plant.

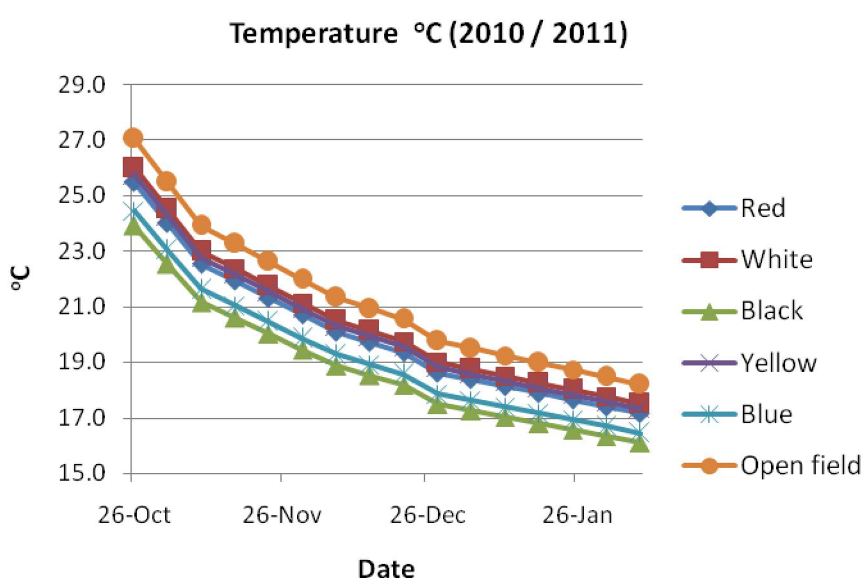

Fig. (2): The average air temperature (°C) at 15 cm depth under different color net and open field during 2010/2011 season.

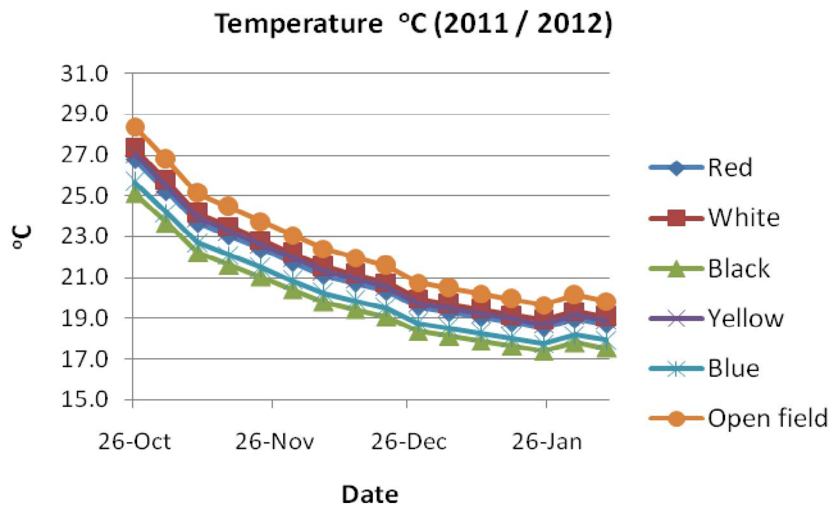

Fig. (3): The average air temperature (°C) at 15 cm depth under different color net and open field during 2011/2012 season.

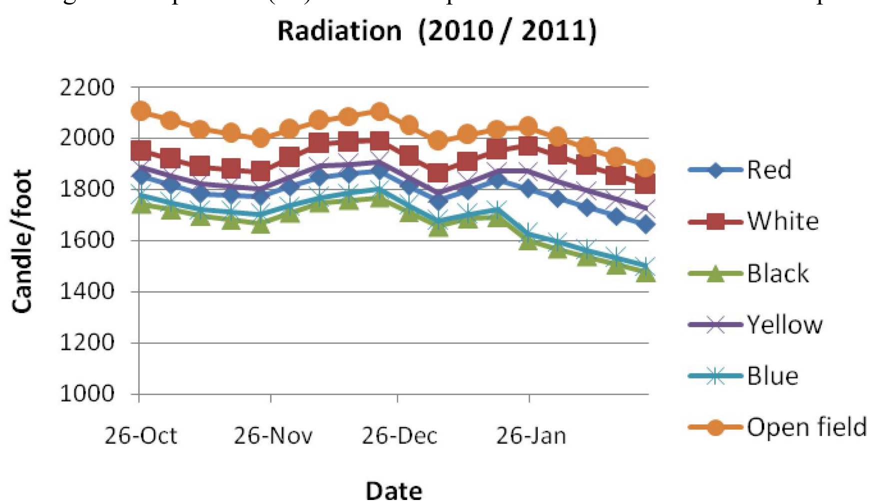

Fig. (4): The average light intensity (foot-candle) under different color net and open field during 2010/2011 season.

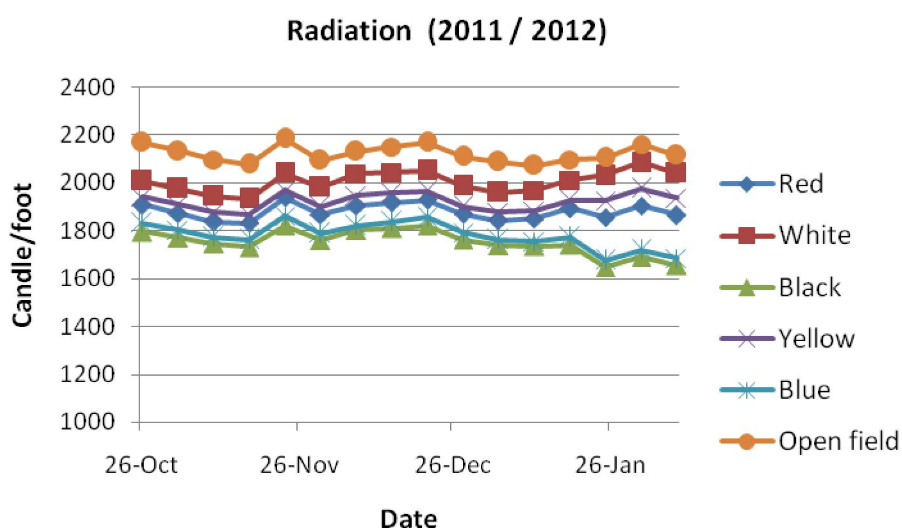

Fig. (5): The average light intensity (foot-candle) under different color net and open field during 2011/2012 season.

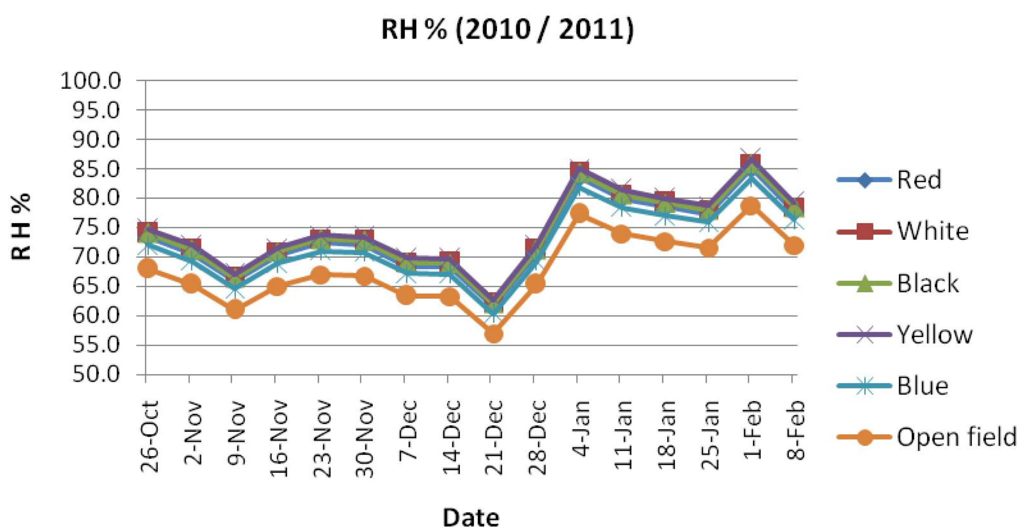

Fig. (6): The average air relative humidity (%) under different color net and open field during 2010/2011 seasons.

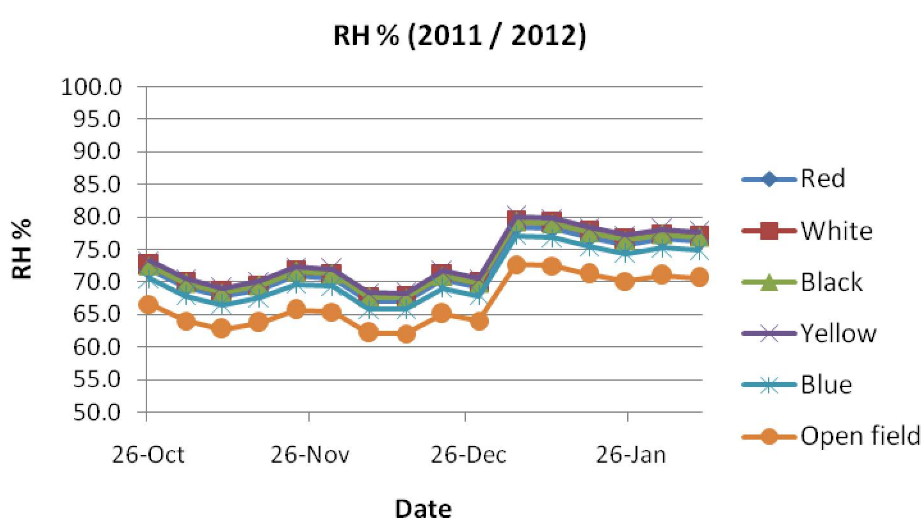

Fig. (7): The average air relative humidity (%) under different color net and open field during 2011/2012 season.

Table (3): Potato plant height, number of leaves, fresh and dry weight per plant as affected by different greenhouses net cover and plant density.

Plant height (cm)								
Net color	**12.5 cm**	**25 cm**	**50 cm**	**Mean**	**12.5 cm**	**25 cm**	**50 cm**	**Mean**
Yellow	46.1F	42.2H	41.1HI	**43.1 D**	41.0EF	37.6GH	36.6GH	**38.4D**
White	45.8F	41.8H	39.9 IJ	**42.5 D**	40.8EF	37.2H	35.6I	**37.8D**
Red	50.6E	47.1I	43.2GH	**46.9 C**	45.0D	41.9E	38.4G	**41.8C**
Blue	53.9C	51.4D	50.8E	**52.1 B**	47.9 C	45.7D	45.2D	**46.3B**
Black	58.3A	55.6B	50.8E	**54.9 A**	51.9A	49.5B	45.2D	**48.9A**
Open field	44.3G	40.1I	39.4J	**41.3 E**	39.9F	36.1I	35.5I	**37.1D**
Mean	**49.8 A**	**46.4 B**	**44.2 C**		**44.4A**	**41.3B**	**39.4C**	
No. of leaves/plant								
Net color	**12.5 cm**	**25 cm**	**50 cm**	**Mean**	**12.5 cm**	**25 cm**	**50 cm**	**Mean**
Yellow	38.1HI	53.2B	57.2A	**49.5A**	33.9G	47.3D	50.9A	**44.1A**
White	40.3G	52.9BC	57.8A	**50.3A**	35.9F	47.1B	51.4A	**44.8A**
Red	37.1I	43.8F	50.2D	**43.7C**	32.9G	38.9E	44.7C	**38.9C**
Blue	34.7J	39.7G	47.1E	**40.5D**	30.9H	35.4F	41.9D	**36.1D**
Black	34.7J	39.4GH	46.8E	**40.3D**	30.9H	35.0F	41.7D	**35.9D**
Open field	36.9I	46.3E	51.7C	**44.9 B**	33.2G	41.6D	46.5B	**40.5B**
Mean	**36.9C**	**45.9B**	**51.8A**		**32.9 C**	**40.9 B**	**46.2A**	
Canopy Fresh weight (g/plant)								
Net color	**12.5 cm**	**25 cm**	**50 cm**	**Mean**	**12.5 cm**	**25 cm**	**50 cm**	**Mean**
Yellow	286.9E	300.7D	358.3A	**315.3A**	255.3E	267.7	318.9A	**293.3B**
White	294.5DE	319.5C	366A	**326.7A**	262.1DE	284.4	325.7A	**305.1A**
Red	230.6J	253.6H	317C	**267.1C**	205.2J	225.7	282.2C	**253.9D**
Blue	224.8J	230.6J	265.2G	**240.2D**	200.1J	205.2	235.9G	**220.6E**
Black	213.3K	224.8J	242.1I	**226.7E**	189.8K	200.1	215.5I	**207.8F**
Open field	253.4H	275.2F	343.3B	**290.6B**	228.1C	247.6	309.0B	**278.3C**
Mean	**250.6C**	**267.4B**	**315.3A**		**223.4C**	**238.4B**	**281.2A**	
Canopy Dry weight (G/PLANT)								
Net color	**12.5 cm**	**25 cm**	**50 cm**	**Mean**	**12.5 cm**	**25 cm**	**50 cm**	**Mean**
Yellow	38.3DE	39.1D	44.8B	**40.7B**	34.1D	34.8CD	39.9B	**36.2B**
White	40D	42C	47A	**43.0A**	35.6C	37.4C	41.8A	**38.3A**
Red	29.9HI	32.9F	34.5F	**32.5D**	26.7HI	29.3F	30.7E	**28.9D**
Blue	28.8IJ	29.9HI	31.5GH	**30.1E**	25.6I	26.7HI	28.0G	**26.8E**
Black	27.7J	29.3HIJ	30.7GH	**29.3E**	24.7J	26.1I	27.3GH	**26.0E**
Open field	32.6FG	34.5F	37.8E	**34.9 C**	29.3F	31.0E	34.1D	**31.5C**
Mean	**32.9C**	**34.6B**	**37.7A**		**29.3C**	**30.9B**	**33.6A**	

Table (4): Potato tuber weight per plant and tuber weight per plant square meter as affected by different greenhouses net cover and plant density.

Potato yield Kg / plant								
Net color	12.5 cm	25 cm	50 cm	Mean	12.5 cm	25 cm	50 cm	Mean
Yellow	0.78F	1.22D	1.87A	**1.29A**	0.69H	1.09E	1.66A	**1.15A**
White	0.79F	1.18D	1.80A	**1.26A**	0.70H	1.05E	1.60B	**1.11A**
Red	0.49H	0.98E	1.44C	**0.97C**	0.43J	0.88G	1.29D	**0.87C**
Blue	0.40HI	0.83F	1.16D	**0.80D**	0.36K	0.74H	1.03E	**0.71D**
Black	0.33I	0.79F	1.07E	**0.73D**	0.29L	0.70H	0.95F	**0.65E**
Open field	0.60G	1.05E	1.58B	**1.08B**	0.54I	0.95F	1.42C	**0.97B**
Mean	**0.57C**	**1.01B**	**1.48A**		**0.50C**	**0.90B**	**1.3A**	
Potato yield kg/m^2								
Net color	12.5 cm	25 cm	50 cm	Mean	12.5 cm	25 cm	50 cm	Mean
Yellow	4.44A	3.49B	2.67F	**3.53A**	3.95A	3.11B	2.38E	**3.14A**
White	4.52A	3.38C	2.57G	**3.49A**	4.02A	3.01BC	2.29E	**3.11A**

Red	2.77E	2.82E	2.06J	**2.55C**	2.46D	2.51D	1.83H	**2.27C**
Blue	2.32HI	2.37H	1.66K	**2.12D**	2.06F	2.11F	1.47I	**1.88D**
Black	2.19I	2.26I	1.64K	**2.03D**	1.95G	2.01FG	1.46I	**1.81E**
Open field	3.43BC	3.01D	2.26I	**2.90B**	3.08BC	2.71C	2.03FG	**2.61B**
Mean	**3.28A**	**2.89B**	**2.10C**		**2.92 A**	**2.58 B**	**1.91C**	

Table (5): NPK contents in potato leaf as affected by different greenhouses net cover and plant density.

N %								
Net color	**12.5 cm**	**25 cm**	**50 cm**	**Mean**	**12.5 cm**	**25 cm**	**50 cm**	**Mean**
Yellow	2.87D	3.04C	3.40B	**3.11A**	2.73D	2.89C	3.25B	**2.96A**
White	2.91D	3.09C	3.49A	**3.16A**	2.77D	2.93C	3.30A	**3.00A**
Red	2.59FG	2.74EF	3.08C	**2.80B**	2.46G	2.61E	2.93C	**2.66B**
Blue	2.40HI	2.53G	2.67F	**2.53C**	2.28I	2.41H	2.53F	**2.41C**
Black	2.21K	2.33I	2.46GH	**2.33D**	2.10K	2.22J	2.33I	**2.22D**
Open field	2.62F	2.77E	3.11C	**2.83B**	2.49F	2.63E	2.96C	**2.69B**
Mean	**2.60C**	**2.75B**	**3.03A**		**2.47C**	**2.61B**	**2.88A**	
P %								
Net color	**12.5 cm**	**25 cm**	**50 cm**	**Mean**	**12.5 cm**	**25 cm**	**50 cm**	**Mean**
Yellow	0.40E	0.43D	0.48B	**0.44B**	0.39E	0.41D	0.46B	**0.44A**
White	0.42D	0.45C	0.50A	**0.46A**	0.40DE	0.43C	0.48A	**0.45A**
Red	0.31I	0.33H	0.37F	**0.33D**	0.30H	0.31GH	0.35F	**0.33C**
Blue	0.31I	0.32H	0.34G	**0.32D**	0.28I	0.31GH	0.33G	**0.32D**
Black	0.25L	0.26K	0.28J	**0.26E**	0.24K	0.25JK	0.26J	**0.26E**
Open field	0.34G	0.36F	0.40E	**0.37C**	0.33G	0.35F	0.39E	**0.37B**
Mean	**0.34C**	**0.36B**	**0.39A**		**0.32C**	**0.34B**	**0.38A**	
K %								
Net color	**12.5 cm**	**25 cm**	**50 cm**	**Mean**	**12.5 cm**	**25 cm**	**50 cm**	**Mean**
Yellow	2.51C	2.66C	2.99A	2.72A	2.36F	2.50D	2.81B	**2.56B**
White	2.56C	2.71B	3.05A	2.77A	2.41H	2.55C	2.87A	**2.61A**
Red	1.99I	2.10GH	2.36D	2.15C	1.87K	1.98J	2.22G	**2.02D**
Blue	1.97I	2.08H	2.19F	2.08C	1.85K	1.96J	2.06I	**1.96E**
Black	1.81K	1.91J	2.01I	1.91D	1.70M	1.80L	1.89K	**1.80F**
Open field	2.15G	2.28E	2.56C	2.33B	2.02IJ	2.14H	2.40EF	**2.19C**
Mean	**2.17C**	**2.29B**	**2.53A**		**2.03C**	**2.15B**	**2.37A**	

Table (6a): Economic analysis of potato production under differences on gross profit under different treatments for single net house ($540m^2$) at the first season 2010/2011.

Treatments		No. of plants	Average tuber seed weight	Seed rate	Seed Cost	Total Seed Cost	Average production	Total production	Average Price	Gross Return	TOTAL Net income
Plant spacing	Cover net	GH	Kg/tuber	Kg/ GH	L.E. /kg	L.E. /GH	Kg/plant	Kg/ GH	L.E./kg	L.E. /GH	L.E. /GH
50 cm	Yellow						1.87	898		1346	1274
	White						1.80	864		1296	1224
	Red						1.44	691		1037	965
	Blue	480		24		72	1.16	557		835	763
	Black						1.07	514		770	698
	Open						1.58	758		1138	1066
	Mean		0.05		3		1.49	714	1.5	1070	998
25 cm	Yellow						1.22	1171		1757	1613
	White						1.18	1133		1699	1555
	Red	960		48		144	0.98	941		1411	1267
	Blue						0.83	797		1195	1051
	Black						0.79	758		1138	994

	Open						1.05	1008		1512	1368
	Mean						1.01	968		1452	1308
	Yellow						0.78	1498		2246	1958
	White						0.79	1517		2275	1987
12.5cm	Red						0.49	941		1411	1123
	Blue	1920		96		288	0.40	768		1152	864
	Black						0.33	634		950	662
	Open						0.60	1152		1728	1440
	Mean						0.57	1085		1627	1339

Table (6b): Economic analysis of potato production under differences on gross profit under different treatments for single net house (540m^2) at the second season 2011/2012.

Treatments		No. of plants	Average tuber seed weight	Seed rate	Seed Cost	Total Seed Cost	Average production	Total production	Average Price	Gross Return	TOTAL Net income
Plant spacing	Cover net	GH	Kg/tuber	Kg/ GH	L.E. /kg	L.E. /GH	Kg/plant	Kg/ GH	L.E./kg	L.E. /GH	L.E. /GH
	Yellow						1.66	797		1195	1123
	White						1.60	768		1152	1080
	Red						1.29	619		929	857
50 cm	Blue	480		24		72	1.03	494		742	670
	Black						0.95	456		684	612
	Open						1.42	682		1022	950
	Mean						1.33	636		954	882
	Yellow						1.09	1046		1570	1426
	White						1.05	1008		1512	1368
	Red						0.88	845		1267	1123
25 cm	Blue	960	0.05	48	3	144	0.74	710	1.5	1066	922
	Black						0.70	672		1008	864
	Open						0.95	912		1368	1224
	Mean						0.90	866		1298	1154
	Yellow						0.69	1325		1987	1699
	White						0.70	1344		2016	1728
12.5cm	Red						0.43	826		1238	950
	Blue	1920		96		288	0.36	691		1037	749
	Black						0.29	557		835	547
	Open						0.54	1037		1555	1267
	Mean						0.50	963		1445	1157

4. Conclusion

The present investigation revealed that, using net cover especially white net are useful for encouraging vegetative growth and high total yield. The use of 12.5 and 25 cm in row plant space placed in the experiment is useful for increasing the yield. Also, the study performed an evidence for using the bare area among the rows and in between trees to increase the agricultural productivity of area unit. Otherwise, the climate change impacts on food security are a driving force toward intensive and intercropping systems application.

The study indicated that, the need to investigate the intercropping effect on citrus growth especially with the fertigation program during the winter in the first three years.

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