

**EFFECT OF PLANT GROWTH REGULATORS AND
MICRO-NUTRIENTS ON YIELD, QUALITY SEED
PRODUCTION AND STORAGE OF POTATO IN
TISTA FLOODPLAIN SOILS OF BANGLADESH**



PH. D. THESIS

BY

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Session: 2006-2007

JUNE, 2013

**DEPARTMENT OF AGRONOMY
AND AGRICULTURAL EXTENSION
UNIVERSITY OF RAJSHAHI
RAJSHAHI, BANGLADESH**

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*A thesis submitted for the degree
of
Doctor of Philosophy
in the
Department of Agronomy and Agricultural Extension
University of Rajshahi, Bangladesh*

BY

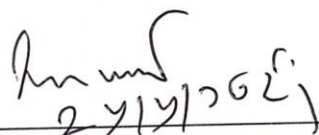
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JUNE, 2013 **DEPARTMENT OF AGRONOMY
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*DEDICATED
TO HONOURABLE ALL
FREEDOME FIGHTERS
WHO FOUGHT FOR
LIBERATION*

DECLARATION

I hereby declare that the whole work submitted as thesis entitled "EFFECT OF PLANT GROWTH REGULATORS AND MICRO-NUTRIENTS ON YIELD, QUALITY SEED PRODUCTION OF STORAGE OF POTATO IN TISTA FLOODPLAIN SOILS OF BANGLADESH" for the degree of Doctor of Philosophy is the result of my original investigation.



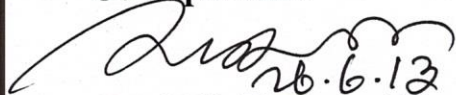
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CERTIFICATE

We hereby certify that the research work entitled “EFFECT OF PLANT GROWTH REGULATORS AND MICRO-NUTRIENTS ON YIELD, QUALITY SEED PRODUCTION AND STORAGE OF POTATO IN TISTA FLOODPLAIN SOILS OF BANGLADESH” as submitted for the degree of Doctor of Philosophy in the Department of Agronomy and Agricultural Extension, University of Rajshahi is a bonafide research work carried out by Md. Azmal Hossain Mondal under our supervision. The results of the investigation, which embodied here are original and have not been submitted before for any other degree of this or any other university.

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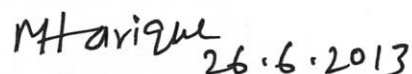
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The Author

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ACRONYMS

AEZ	=	Agro-ecological Zone
a.i	=	Active ingredient
AOM	=	Active Oxygen metabolism
BADC	=	Bangladesh Agricultural Development Corporation
BARI	=	Bangladesh Agricultural Research Institute
BSPC	=	Breeder Seed Production Center
BAU	=	Bangladesh Agriculture University
BBS	=	Bangladesh Bureau of Statistics
CGR	=	Crop Growth Rate
CRI	=	Crown Root Initiation
cm	=	centimeter
cv.	=	Cultivar
DAE	=	Department of Agricultural Extension
DAS	=	Days After Sowing
DAT	=	Days after transplanting
DMN	=	Dimethylnaphthalene
DMRT	=	Duncan's Multiple Range Test
<i>et al.</i>	=	and others
FAO	=	Food and Agriculture Organization
Fig.	=	Figure
FTY	=	Fresh Tuber yield
FWE	=	Field water capacity
FBAS	=	Flower Bud Appresume Stage
g	=	Gram
GDP	=	Gross Domestic Product
g m^{-2}	=	Gram Per Meter Square
$\text{g m}^{-2}\text{day}^{-1}$	=	Gram Per Meter Square Per Day
GA	=	Gebberillic Acid
ha	=	Per hectare

i.e	=	that is
L.	=	Linneaus (Carolus Linneaus)
LAI	=	Leaf Area Index
LAR	=	Leaf Area Ratio
LS	=	Level of Significance
LWR	=	Leaf Weight Ratio
MAP	=	Mono amonium phosphate
MH	=	Malic hydorzide
SSP	=	Single super phosphate
SLW	=	Specific Leaf weight
m	=	Meter
m ²	=	Square Meter
meq	=	Milliequivalent
MH	=	Meleic Hydrazide Acid
mm	=	Millimeter
NAA	=	Nappthal Acitic Acid
NAR	=	Net Assimilation Rate
NS	=	Not Significant
p ^H	=	Negative logarithm of hydrogen ion (H ⁺) concentration
ppm	=	Parts Per Million
RGR	=	Relative Growth Rate
RLGR	=	Relative Leaf Growth Rate
SCA	=	Seed Certification Agency
SLA	=	Specific Leaf Area
SRDI	=	Soil Resources Development Institute
t	=	Ton
TDM	=	Total Dry Matter
viz.	=	Namely
%	=	Percent
/	=	Per
°C	=	Degree Celsius

ABSTRACT

The experiment was conducted at Domar BADC farm, Sonaroy, Domar, Nilphamari from November to March of 2010-11 and at farmer's field at Debiganj, Panchaghar from November to March of 2011-12 to study the effect of plant growth regulators and micronutrients on yield, quality seed production and storage of potato in Tista Floodplain soils of Bangladesh. Three cultivars namely, Diamant (V_1), Asterix (V_2) and Granola (V_3) and six treatments on plant growth regulators and micronutrients including control. Results showed that physiological parameters like TDM and LAI increased with the advancement of plant age while SLA and LWR decreased with the increase of plant age. CGR was slow at early growth stage. With a few exception, the highest NAR values was found in control at all harvest. RGR, RLGR and LAR showed maximum values at early stages of growth and decrease gradually with the increase of plant age. All the yield contributing characters i.e, plant height, number of leaves per plant, number of haulms per plant and number of tubers per plant were varied significantly by the application of plant growth regulators and micronutrients. With a few exceptions, the highest yield contributing characters were recorded in Vitaplu+ Wuxalsuper treatment. The lowest values were found in control. Harvest index was influenced significantly and the highest harvest index was obtained from Brassinosteroid+ Wuxalsuper treatment. The highest BCR value was observed in Vitaplu+ Wuxalsuper treatment. Cold storage performance of both public and private were studied. Morphological appearance of the tuber of BADC cold storage, Domar was very positive in respect of weight loss, distorted, shriveled, early sprouted and colour in comparison to other two cold storages.

The highest weight loss of tubers (10.00-11.28%) were observed in Vitaplu and Brassinosteroid treatment. The lowest weight loss (6.25%) was observed in unsprayed control treatment. The average weight loss (10.70%) was observed

in private cold storages and the lowest weight loss (5.00%) was observed in BADC cold storage, Domar. As a seed potato, the highest BCR value was observed in Wuxalsuper treatment. On the other hand, the lowest BCR value was recorded in Brassionsteroid treatment. Some seed quality contributing characters i.e, number of total eyes per tuber, number of haulms per tuber, number of days to shoot emergence and seed vigour index were varied significantly due to the application of plant growth regulators and micronutrients. The maximus number of total eyes and number of haulms per tuber were obtained from Vitaplus+ Wuxalsuper treatment. The lowest number of eyes and haulms per tuber in unsprayed control treatment. At least 2-3 short days in comparison to average time of emergence needed to emerge shoot in treatments with plant growth regulators. The highest seed vigour was obtained from the tubers stored at BADC cold storage, Domar. The highest value of seed quality contributing characters was recorded in Domar BADC cold storage in comparison to other two private cold storages.

CHAPTER 1

INTRODUCTION

Potato is an important tuber crop in the world. In Bangladesh, it is one of the major vegetable crops. Potato ranks third position on the basis of production among the food crops. Recently it ranks second position. Around 88.38 Lac MT potatoes produced from 4.67 Lac hectare of land with average yield 18.94 MT per hectare in 2012-13 production years. (Source: Deputy Director, Monitoring, Department of Agricultural Extension, Khamarbari, Farmgate, Dhaka-1215). Potato is a starch dominated food after paddy and wheat- This is why; many of the country in the world (Holand, Poland, Germany, Belgium, Denmark, Norway, Sweden, Finland, Spain, Portugal and Austria) used potato as a staple food. But still people of Bangladesh is using potato as a vegetable crop, we have the opportunity to use potato as a staple food for following reason.

1. Per hectare yield of potato is higher than that of paddy and wheat.
2. As it grows in winter free from natural calamities.
3. It is a short duration crop; this crop can be harvested within 90-100 days.
4. Potato has a good taste and people are being accustomed to use it as it has multifarious uses.

Potato grows well only in the winter season in Bangladesh. Though it grows as a vegetable crop it plays a pivotal role as a major vegetable throughout the whole year. Potato is a nutritious food. This is why, intensive and extensive potato production may reduce the scarcity of food

and nutrition. It needs less water in comparison to same area of Boro crop. It provides more dry matter content and food energy. Fresh weight is 8 times high in potato than rice and wheat (Ahmed and Hossian, 1977).

Food grain	Irrigation water	Duration of crop (day)	Yield t/ha (Fresh wt)	Dry matter (%)	DM production /ha	Food energy /100gm	Total food /ha (lac kilo.cal)
Potato	20ac.inch	90	13.39	25.3	3.39	97	12.98
Wheat	20ac.inch	100	1.60	87.2	1.40	3.46	5.53
Paddy	60.ac.inch	125	1.58	86.3	1.38	3.45	5.45

At present potato is being used as a vegetable in our country. But it is playing predominant role as a staple food for people in many countries of the world. It is one of the main foods for European people. Potato has some inherent food quality and this is why, there is no problem to use potato as staple food. It is a starch dominated food like cereal crops. Food nutrients are found in balanced condition in potato. Assimilable plant protein value of potato in body is higher than that of rice and wheat. Though water content is high in potato but still it is nearer to cooked rice. So it can easily be taken as staple food. In addition to this, taste of potato is acceptable to all.

Potato is grown in different climatic zones, including temperate, sub-tropical and tropical regions, and in very different socio-economic environments, ranging from large-scale farming in the USA to small holdings in Peru. Currently the crop is grown in about 130 countries and covers about 18 million ha per annum. The Russian Federation and Poland together account for 26% of the world's cultivated potato area, followed by India and China, which collectively, account for 25% (Maldonado *et al.* 1998). There is a clear and continuous shift in

production of potato from the developed countries to the developing countries (Struik and Weirsema, 1999, CIP, 2000). Developing countries in Asia currently account for 24% of global potato production up from 7.6% forty years ago. Potato production and use expanded more in Asia than in any other region of the world during the last four decades (CIP, 2000). The key factors contributing now and in the future to raising yields in developing countries are, improved plant nutrition and disease free planting materials (Ghislain *et al.* 1999). Given these developments, scientists/researchers policy makers have increasingly focused attention on potato production for Asia as an area of anticipated growing importance. Bangladesh produces about 83.26 MT of tuber crop annually with an average production 18.94 tons/ha as against 2.91MT of rice, 2.60MT of wheat and 6.15MT of Maize (BBS,2010-11).

The potato is ranked fourth in the production of all agricultural commodities in the world and produces more dry matter and protein per hectare than the major cereal crops (Horton, 1980). Potato (*Solanum tuberosum* L.) tubers are a excellent sources of dietary protein, vitamin C, carbohydrates and iron for both humans and domesticated livestock. (Storey and Davies, 1992).

Bangladesh is the most densely populated country in the world. Per capita land is very small, 0.12 ha only. More than 80 percent of population depend on farming for their livelihood. Agriculture contributes (23 Percent) the lion share of the GDP in our country.

Potato is one of the major cash crops in North-West part of Bangladesh. Super gold, Planovit, Planofix, Vegemax, Vitaplus PGR, Egnol, Agro-grow, Biogreen, PGR, ferti etc are commonly used as plant growth

regulators. Potato farmers used them for enhancing vegetative growth of potato and ultimately to get higher yield. A good number of farmers store these potatoes in private cold storages for using them as a seed in the next growing session.

In statistics, it has been observed that government controlled seed potato farms namely Bangladesh Agricultural Development Corporation (BADC) and Breeder Seed Potato production Centre (BSPC) Bangladesh Agricultural Research Institute, (BARI) Debiganj, Panchagarh can provide only 2.3% seed potato to the farmers, But these farms do not use plant growth regulators to seed potato crop. Potato experts opined that Plant Growth Regulators (PGR) may have negative impact on quality seed production and rotting rate may be higher in the private cold storages.

Quality seed production depends on balanced use of fertilizer including micronutrients. A particular micro-nutrient needs very trace amount for quality seed production but its absence from soil limits quality seed production. Some micro-nutrients hinder vegetative growth, while other affects at growing point of the plant, shape, size and colour of seed potato. Combined effects of liquid micro-nutrients like Wuxulsuper and Bafolan on potato help to produce desired yield and quality seed.

A good number of farmers of North-West part of Bangladesh cultivate potato as cash crop. Some farmers want to get higher yield while other farmers desire to produce quality seed. A very few of both the categories of farmers know about the technique to use PGR and micro nutrients in potato crop. This is why, scarcity of quality seed prevails during growing season in every year. It has been observed that a good number of farmers can't afford money to purchase quality seed with much higher price

ahead of planting time. Finding no other way out, some insolvent farmers are compelled to use table potato as a source of seed. This leads to poor yield and ultimately gives poor economic return.

Potato farmers store their produces in the private cold storages. It is observed that these private cold storages have very little technical facilities to store seed potato. This is why; rotting rate of potato is higher in the private cold storages. It is thought that faulty preservation technique of seed potato coupled with indiscriminate use of PGR during production increase rotting percentage of tuber in the private cold storages. There are around 332 cold storages to store potato but there is not a single cold storage to preserve seed potato in the private level in Bangladesh. More than 20 new units, mostly in Rajshahi and Rangpur divisions, await power connections while the performance of the existing units deteriorated due to power supply problems, the leaders of the cold storage association opined.

It is important to state that the base temperature is extremely difficult to determine experimentally. Usually, the precise value has little physiological or practical significance. It is clear that the base temperature for potato tubers varies between cultivars but 4° C can be used for practical purposes in most cases (O' Brien *et al.* 1983).

Light generally inhibits sprout growth and thus contribute to dormancy enforcement. This effect is well characterized, and is used commercially in the management of seed tubers. The degree of growth inhibition is related to wavelength, with wavelengths below 500 nm (blue) and above 650 nm (red and far-red) having the greatest inhibitory effect (McGee, Jarvis & Duncan, 1987).

Humidity is of little importance in the consideration of tuber dormancy (Burton *et al.* 1992). There have been few reports on this subject, probably because changes in humidity within the ambient range are likely to have only small effects on tuber water status. Such small effects, however, may have important consequences for tuber quality, especially in the case of new potato (Mawson & Cunnington, 1995).

It can be considered a staple food through changing our food habit, and then we can play a pivotal role in food problem reduction.

In Bangladesh the amount of per capita land is very low and day by day it is decreasing. This is why; emphasis should be given for cultivation on such type of crops having more amounts of food materials per unit area of land.

In Bangladesh per hectare average yield of paddy, wheat and potato is 2907, 2600 and 18083kg respectively (BBS, 2010-11). There is a possibility to increase per hectare yield of potato in comparison to other crops. So potato is still a promising crop.

Table 1. Amount of food nutrient per unit area of land through cultivation of different crops

Name of Crop	Yield kg/ha	Production of crop (Day)	Calorie production 10kg. cal/ha/day	Protein production 10kg/ha/day
Rice	2052	150	34	0.8
Wheat	1441	120	41	1.5
Maize	1349	135	36	1.0
Potato	10737	125	55	1.4
S. potato	7248	135	52	0.7

Source: World potato facts 1982, International potato centre, Lima, Peru.

Potato is a profitable crop to farmers. It takes only 90 to 115 days for maturity and early varieties of potato can be harvested after 60-70 days. Though production cost of potato is high, farmers can easily draw profit

through cultivation of potato. It has proven successfully in cultivating as intercropping with sugarcane and maize in recent days.

It has been observed that the price of potato reduces to a great extent during harvesting in which the growers are deprived of fair price. Under the circumstances, if production of potato per unit land is increased remarkably then the growers will not have to face any loss. In our country, population is increasing gradually. If we want to keep per capita consumption at a constant level, it is essential to increase potato production. Both the producers and consumers will be benefited in it. As the cultivable land is decreasing day by day, it is the need of the hour to grow more potato from minimum land. So the use of quality seed is the key way to increase yield per unit area.

However, in the early 1980s Trewavas (1982) challenged the premise that endogenous concentrations of plant growth regulators dictate the magnitude of developmental response. Since that time, there has been increasing appreciation that changes in sensitivity to plant growth regulators may contribute to the control of plant development.

Tuberisation is influenced by many factors, including carbohydrate supply, nitrogen status, carbon to nitrogen ratio, day length, temperature, variety and endogenous and exogenous growth substances (Krauss, 1985; Burton, van Es & Hartmans, 1992; Arteca, 1996). There is evidence that endogenous gibberellins promote stolon elongation and inhibit tuberisation and that abscisic acid promotes tuberisation (Burton, 1989). It has also been suggested that tuberisation is related to the abscisic

acid/gibberellins ratio (Krauss & Marschner, 1982). The involvement of other growth substances, however, remains unclear (Arteca, 1996).

Roberts & Hooley (1988) concluded that concentrations of growth regulators at active sites and changes in sensitivity to growth regulators may both be important in the regulation of development.

But very little work has been done with plant growth regulators as foliar application on commercially cultivated potato cultivars though farmers across the country particularly in Tista Floodplain soils applying plant growth regulators and liquid micronutrients injudiciously with a view to getting maximum possible yield.

This study was, therefore, undertaken with the following objectives:

1. To determine the yield and seed quality of potato
2. To determine the effect of plant growth regulators and combined liquid micronutrients on yield and quality seed production of potato.
3. To know the storage ability of potato as well as seed quality after being treated with plant growth regulators and micronutrients both at public and private cold storages.
4. To investigate the economic aspect of plant growth regulators and micronutrients.

CHAPTER 2

REVIEW OF LITERATURE

Kumar *et al.* (2011) reported that the foliar spray of 100ppm GA₃ and 125ppm Cycocel produced maximum tuber yield 9.16kg/plot, GA₃ alone produced 8.04kg/plot (plot size=3m sq.) which were significantly higher than unsprayed control (6.89kg/plot).

Braun *et al.* (2011) conducted a field experiment to evaluate the effect of N on concentration and accumulation of macro and micro-nutrients in tubers of 4 cultivars Agata, Asterix, Atlantic and Monalisa in Brazil. They observed that there were no effect of N rate on P, K, Ca, Mg, S, Fe and Zn concentration of said 4 cultivars.

Otroshy *et al.* (2010) conducted a green house experiment to investigate the effect of different sizes of normal seed tubers (35-45, 45-55 and 55-65 mm) and various growth regulators (gibberellic acid: 2.5 and 5mg/L; chlomequat: 10 and 100mg/L) on the dormancy, sprout behaviour, growth vigour and quality of tubers of different potato cultivars. Highest number of sprouts with longest length and highest weight were produced by the size 55-65mm. Highest dose of GA resulted highest number of sprouts and uncut control produced the lowest number of sprouts. All parameters of vigour were highly significantly affected by cultivars and growth regulators while seed tuber size only affected number of stems. There were many significant two-way interactions between seed tuber size, cultivar or growth regulator application.

Yulin *et al.* (2008) conducted an experiment to study the different storage conditions with different temperature on the vigour and physiological characters and stored them under cold (4-6°C) cellar (8-12° C) and normal (18-22° C) storage conditions for 110 days. They observed that during storage water content was reduced, soluble protein was increased and starch was decreased.

Leon *et al.* (2008) observed that there was positive interaction between N and K which resulted in decrease of the loss of weight of tubers during the period of storage. With the combination of 12.65 and 7.03 nmol/litre of N and cause the K the lowest percentage of dehydration, they observed.

Rolbiecki *et al.* (2007) reported that the influence of irrigation (without and with sprinkler irrigation) and nitrogen fertilizer (75 and 125 kg/ha) on the technologies and storage value of potato cultivars Drop, Mors and Triada grown on a very light soil was studied during 2001-2003 in Poland. After harvest, the tubers were stored for six months in potato storage (air temperature 4° C, relative humidity 95%). The content of dry matter, starch, sugars and ascorbic acid was analyzed in tubers after harvest and after storage. Irrigation, N fertilizer application and storage influenced the storage value of potatoes.

Parmar *et al.* (2007) carried out some studies to enhance yield and profitability of potato through integrated production system in western Himalayas during summer season of 2003 and 2004. They observed that tuber yield and profit increased by 34.1 and 31.5% respectively, with the combined use of fertilizers N:P:K at 100:75:60 kg/ha and Fe: Mn: Zn:

Cu: B: Mo at 10:25:25:25:10:1 kg/ha) and organic manure as compared to farmer's practice.

Gauhar *et al.* (2007) conducted a field experiment in Uttar Pradesh, India to assess the efficacy of N and P nutrient with or without biofertilizers on nutrient uptake and yield of potato. The application of 120 kg N+80 kg P+120 kg K/ha+ soaking of seed tubers in 1% solution of urea and sodium bicarbonate + Azotobacter and Phosphobacteria increased N and P content and uptake by haulms and tubers of potato and tuber yield.

Samui *et al.* (2007) conducted a field experiment on the effect of triacontanol (miraculan and vipul) on potato during 2002-2003 and 2003-2004 on farmers' field at Surekalna, West Bengal, India. They observed that the application of miraculan at 0.250 g.a.i, 0.500 g.a.i and 1.00 g.a.i/ha and vipul at 0.500 g.a.i/ha significantly increased dry matter production, leaf area index, tuber bulking rate, size of tuber and yield of potato.

Thakare *et al.* (2007) reported that yield of tuber per plot and tuber yield per hectare were recorded maximum under the application 30kg of ZnSO_4 and 15kg FeSO_4 /ha.

Alexopoulos *et al.* (2007) reported that foliar application of gibberellic acid increased vegetative growth (fresh and dry weight) and the number of tubers per plant. Foliar application of GA induces tuber elongation as well as the formation of stolons and 'chain tubers', they added.

Boelcke (2007) reported that yield of potato tubers increases (up to 25%) were mainly due to K fertilizers especially when applied in spring.

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Gauhar *et al.* (2007) conducted a field experiment in Pantanagar, India to assess the efficiency of biofertilizers at 2 rates on growth and yield of potato cv. Kufri Jawahar. They observed that inoculation of seed tubers with *Bacillus cereus* showed better results compared to inoculation with *Bacillus subtilis* in terms of growth and yield.

Roosbahani *et al.* (2007) conducted a field study in Iran in 2003 to investigate the effect of foliar application (at complete emergence, tuber formation and tuber formation+ tuber filling period) of a complete fertilizer on the yield and yield component of potato cultivars Agria and Ajax. There was a significant difference between foliar application at tuber formation + tuber filling period and other treatments, with foliar application at tuber formation+ tuber filling period recording the highest yield.

Bzikov *et al.* (2007) tested different type of fertilizer (NPK, FYM and green manures) during 2000-2005 in North Ossetia in the northern Caucasus region (600m above sea level) of Russia in potato crops grown continuously or rotations. Yield of tuber 23.7 ton/ha were obtained when all fertilizers (NPK, FYM and green manures) sources were utilized. In continuous cropping trials, the control yield was 13.7 ton/ha rising to 17.4 ton/ha with the mixture of all 3 fertilizer treatment combination. Addition to the Zeolites (Irlit 1 and Irlit 7) increased tuber yield by 15-43% and improved tuber quality.

Lampe (2007) conducted a trial on sandy soils in Germany in reduced basic fertilizer use. A minimum application of 250 kg K/ha is needed to reach a maximum tuber yield. This only true for sulphate potash fertilizer, chloride potash reduced yield and drastically lowered starch contents.

Rzekanowski *et al.* (2007) reported that N fertilizer 125kg/ha along with irrigation in potato crop significantly increased yield and changed the yield structure.

Yarnia *et al.* (2007) reported that the cultivar Concord yielded 33.55ton/ha with 135+135kg N/ha which was 24.9% higher than control. Excess N application at sowing led to higher vegetative growth and shorter growth period was indicator of lesser yield in Concord.

Huayuan *et al.* (2007) suggested the best fertilizer application pattern on the tuber yield per unit area, tuber yield per hill and marketable tuber percentage was 100kg N, 70kg P and 210kg K with the NPK ratio of 1.4:1:3.

Mosquita *et al.* (2007) conducted an experiment in greenhouse using two soils Red Latosol and Cambisol to evaluate the effect of boron rates (0.0, 0.75, 1.50 and 3.0 dm^{-3}) on the yield and tuber quality of 2 potato cultivars Asterix and Monalisa. They observed that increasing boron rates improve the tuber quality reaching the maximum yield on the Red Latosol at 2.19 mg boron dm^{-3} . Asterix recorded 108% higher yield than Monalisa on Cambisol, although requiring 37% more boron.

Cardoso *et al.* (2007) reported that the split application of N and K fertilizer(50% during planting and 50% during tuberization) forward higher tubercle productivity in relation to the total fertilizer application.

Parmar *et al.* (2007) suggested that tuber yield and profit increased by 34.1% and 31.5% respectively with the combined use of fertilizer (N; P; K at 100:75:60 and Fe: Mn: Zn: Cu: B; Mo at 10:25:25:25:10:1kg/ha) and organic manure as compare to farmer's practice. Soil status was improved

after harvest and concentration of nutrients increased with use of a mix of synthetic fertilizer, organic manure and microorganisms at different stages, they observed.

Poljak *et al.* (2007) reported that the application of the different N rates had a positive effect on the yield and crude protein content. It had no significant effect on tuber dry matter and P, K and Mg concentrations but it increased the Ca content.

Samui *et al.* (2007) reported that the application of Miraculan at 0.250 g.a.i/ha, 0.500 g.a.i/ha, 1.000 g.a.i/ha and Vipal at 0.500 g.a.i/ha significantly increased dry matter production, LAI, tuber bulking rate, size of tubers and yield of potato.

Sidhu *et al.* (2007) suggested that for obtaining optimum potato and sunflower yield and maintenance of available P content of soil on sustainable basis, 13 and 26 kg P/ha to potato in the presence or absence of FYM respectively seems to be sufficient.

Mousavi *et al.* (2007) conducted a field experiment in order to study the effect of foliar application of Zn and Mn on yield and quality of potato crop in Lorestan, Iran. They reported that the application of Zn at 8ppt increased yield to 34170 kg/ha which was 25% higher compare with control. Meanwhile, application of Mn at 4ppt level increased yield to 33866 kg/ha which was only 15% higher than control. Maximum yield (38950 kg/ha) was obtained at 8ppt of Zn and 4ppt of Mn foliar application. Zn and Mn fertilizer together increased Zn and Mn percentage and decreased P percentage in tubers, that they were not significant.

Kumar *et al.* (2007) reported that the supplemental Ca application in Ca responsive cultivars result in increased tuber yield, size and Ca content in short duration early season potato crops in the sub-tropics.

Nyiraneza *et al.* (2007) observed that the integrated treatment (179 kg N/ha fertilizer+ manure) consistently increased tuber yield and N uptake efficiency by 20% compared with the unamended conventional management (224 kg N/ha fertilizer). High productivity and N efficiency were associated with integrating organic and inorganic N sources which represent an environmentally and agronomically sound management strategy.

Nowacki (2007) reported that the most common tuber disorder was damage caused by soil pests and for some cultivars damage from an increased number of small tubers (0-40mm). Storage losses were usually a bit lower for potatoes from organic farming than from integrated system, while sprouting were accelerated in organic farming compared to the integrated technology.

Czerko (2007) observed that natural losses in tubers kept in the store house with humidification were lower than those in tubers kept in the store house without a humidification system (4.0 and 4.9% respectively). In both store houses, the loss (0.5%) caused by the disease soft rot occurred in the upper part of the pile only.

Alexopoulos *et al.* (2007) reported that when GA₃ applied towards the end of vegetative cycle (either singly 60 DAT or repeatedly from the same date) it induced rapid breakage of tuber dormancy, a reduction in specific weight, a higher rate of respiration and increase weight loss during storage.

Wulf (2007) conducted an experiment on the impact of different storage temperature regimes on storage losses and disease infection of seed potato in Munster, Germany from 2003 to 2006. He used 3 different cooling and airing regimes: 1.fast mechanical cooling down to 4° C and keeping temperature constant at 4° C through mechanical cooling 2.slow cooling down to 4° C using external air and keeping temperature constant at 4° C through mechanical cooling 3.slow cooling down to 4° C using external air and two period of warming up temperature to 7° C during winter months through external cooling. Storage losses were highest in treatment regime 3 (7.5%loss) compared to regime 1(5.8%) and regime 2 (6.2%) and were mainly attributed to higher germination rate in treatment 3.

Paul *et al.* (2007) conducted a study on the effect of growth regulators on storage life of potato in West Bengal, India from mid-April to mid-August. They reported that minimum physiological loss in weight was observed with 2000 ppm NAA+ 1000ppm MH up to 45 days of storage. Sprout percentage, sprout length and rotting percentage were minimum with 2000 ppm NAA and maximum with the control treatment.

Roy *et al.* (2007) reported that the combination of 300 kg N/ha and 125 kg K/ha was the best combination for application mother tuber plants for the production of high quality True potato seed.

Srivastava *et al.* (2007) reported that soil application of Mo consists of 500-1000 g/ha and the foliar application consists of 0.05-0.10% with ammonium molybdate responded on potato yield and other Mo responsive crop besides citrus. They also opined that soil fertilization and foliar application are the 2 most effective methods alleviating Mo deficiency.

El-Haddad *et al.* (2007) reported that the best results were obtained when potato received 75% of NK of the recommended rate, inoculated by VA mycorrhizal fungi and sprayed with micro-nutrients at dose of Fe 150 Mn 75 and Zn 75ppm. This treatment resulted in the highest total tuber yield and its components and reduced chemical fertilizer inputs.

Merkys *et al.* (2007) reported that the possibility of regulating productivity of potato plants by applying the promising analogues of auxin-compounds (TA-12, TA-59, LN-14, LN-16 has been proved experimentally. The compounds at optimal concentration (TA-12 1.0. TA-59 0.5 LN-14 and LN-16 1.0 kg/ha) were found to activate the process of tuber formation, increasing the number of tubers and accumulation of assimilates in tubers.

Eltawil *et al.* (2006) observed that the quality of potato and its storage life is reduced by the loss of moisture, decay and physiological break down. These deteriorations are directly related to storage temperature, relative humidity, air circulation and gas composition. Potatoes being a living organism require an effective management for storage.

Sing *et al.* (2006) observed that the maximum net return of Rs. 63627/ha was also obtained from 100% NPK+30 ton FYM/ha resulted in significantly higher tuber yield of 465 q/ha. They also observed that benefit cost ratio (BCR) was almost same under 75% NPK with 30ton FYM/ha.

Powon *et al.* (2006) suggested a combination of P 100.4 kg/ha and FYM 20ton/ha resulted in an increase of 82% tuber dry weight and 62% of fresh tuber yield compared to the control. Tuber number and shoot dry weight were also affected by the application of P and FYM.

Divis *et al.* (2006) reported that higher tuber and starch yields were obtained when a 200 kg N/ha fertilizer was used. However, higher N fertilizer rates caused a decrease in starch content, they observed.

Shurmko *et al.* (2006) reported that 120kg N, 90kg P and 120kg K fertilizers produced 30ton potato per hectare.

Sahn *et al.* (2006) reported that increasing storage period increased water loss, specific gravity, dry matter, starch ratio and pH while decrease the vitamin C content, significant increase in water loss with increasing storage period were observed for potato tuber grown under well-irrigated conditions. After 4 months storage period, the water losses were between 6.87% and 9.29% for non-irrigated and well irrigated condition respectively.

Marwaha *et al.* (2005) reported that when potato stored in an evaporatively cooled store with total tuber weight losses between 8.5 to 12.5% during storage up to 90 days.

Hyunsoon *et al.* (2005) conducted a laboratory experiment to determine the effect of gibberellin GA₃ and its inhibitors on the shape of potato micro-tubers by using an in vitro tuberization system. GA₃ play a crucial role in determining potato tuber shape during tuberization.

Knowles *et al.* (2005) conducted a study to evaluate the effect of 14-DMN on the productivity of seed potatoes. They reported that depending on cultivar, yield of smaller tubers (<170 g) were 11% to 38% higher from 1.4 DMN treated seed. The shift of tuber size distribution for 'Ranger Russet' (RR) was accompanied by a 1.4 DMN-induced increase the tuber number per plant and per hectare. In most cases, the 1.4- DMN

effects on yield and tuber size distribution were independent of seed age. Thus, 1.4-DMN may be a suitable treatment to reduce average tuber size and increase yield.

Rainys *et al.* (2005) reported that among the fertilizers 90:90:180 kg NPK/ha+ micro nutrients recorded the highest yields 21.4-27.4 ton /ha when they studied on some potato (early, moderately early and moderately late) cultivars of potato in Lithuania during 2000-02.

Karam *et al.* (2005) determined the response of yield and tuber quality of 4 cultivars with different rate of potassium in Lebanon in 1999 and 2000. They observed that all the cultivars, potassium fertilization significantly increased ($p < 0.01$) the yield of medium (25-75 g) and large size tubers (> 75 g) at the cost of small size tubers (< 25 g). Finally result showed no significant differences between the two potassium levels (192 kg K/ha and 288 kg K/ha) for tuber yield and dry matter content.

Klikocka *et al.* (2005) reported that elemental S fertilization increased yield of potato tubers and improve tuber quality and resistance against *Streptomyces scabies*. With the increasing S dose a significant decrease of the infection rate with *Rhizoctonia solanai* was found for elemental S as well as for K.

Love *et al.* (2005) observed that each of the four cultivars showed a unique response to N application treatments. Bannock Russet achieved maximum yield and net returns with relatively small amounts of N fertilizer.

Danilchenko *et al.* (2005) reported that the application of manures and NPK fertilizer increased significantly the total yield, starch and dry matter yield.

Moinuddin *et al.* (2005) conducted an experiment on growth, yield and economics of potato in relation to progressive application of K fertilizer on 4 genotypes. Four levels of K (0, 75, 150 and 225 kg/ha) 200 kg N as urea and 100 kg P as di-ammonium phosphate were used. They reported that progressive application of K fertilizer up to 225 kg/ha significantly increased the yield of aggregate and large grade >75 g tubers. The optimum K dose for the yield of medium grade 30-75 g tuber was 150 kg K/ha as Murate of potash.

Cabalceta *et al.* (2005) found out the nutrient absorption curves of potato cv. MNF-80 were determined at the Irazu and Juau vinas (A and B farm respectively). Crop from farm B matured after 80 to 90 days while A needs over 135 days due to temperature total radiation and growth rate reduction. Higher amounts (100 kg) of absorbed K and N in both the farms were followed by smaller amounts of P, Ca, Mg and S (8 to 20 kg/ha). The yield from A and B farm were 36 and 28 ton/ha respectively.

Rainys *et al.* (2005) reported that among the fertilizers 90:90:180 kg NPK/ha and 90:90:180 kg NPK/ha +micronutrient recorded the highest yields (20.6-26.1 and 21.4-27.4 ton/ha) respectively. The growing period and cultivar had significant effects on starch and dry matter contents of tubers.

Yangi *et al.* (2005) conducted a field experiment during the 1999/2000 Kharif season in Dharwad, Karnataka, India on potato to determine the effect of row spacing (45 and 60 cm), planting date (18 and 25 June and

10 July) and N fertilizer rates (0,50,100 and 150 kg/ha. Plant height, leaf area index, total dry matter production, tuber per plant and tuber yield was highest with 45cm row spacing, 18 June planting and 150 kg N/ha supplementation. Tuber weight was highest with 60cm row spacing, 18 June planting and 150 kg N/ha supplementation.

Sorce *et al.* (2005) reported that the auxin-indole acetic acid (IAA) appears to induce sprouting as its concentration increases in tuber bud during dormancy release. The sprout inhibiting activity of the chemical rapidly weakens when treatments are discontinued, thus making it suitable for seed tuber preservation, they observed.

Long *et al.* (2004) conducted a field study in 2001 and 2002 in central Michigan to assess the tuber yield and post harvest quality characteristics for 5 cultivars in response to factorial combination of 3 N levels (200,300 and 400 kg/ha) and 2 seed piece spacing narrow and wide. They observed that the overall recommended N fertilizer level for moderately long duration potato cultivar in Michigan (200 kg N/ha) and a narrow seed piece spacing optimized yield and tuber quality performance while conserving N fertilizer.

Dalinenko *et al.* (2005) reported that the application of manure and granular NPK fertilizer at 72, 16 40 kg/ha with micronutrient increased significantly the total starch and dry matter yield.

Chourasia *et al.* (2004) conducted an experiment in a commercial potato cold storage to evaluate some of the operating and geometric parameters (loading density, percentage free space, potato temperature during cooling, cool down time, storage air temperature and humidity loading pattern etc.) related to the loss of stored produce. The loading density of

potato in stock and cold storage (534.63 kg/m³ and 366.01 kg/m³ respectively) were optimum. The percentage free space was adequate and found to be 31.54%. Therefore, centre most potatoes achieved safe temperature (12-13° C) in about 10 days and the maximum cool down temperature (12-13° C) was about 30 days. Hence, the potatoes were safe from rotting. Large variation in storage air temperature was observed during the cool down period which increased the weight loss from the potatoes. The average weight loss was 5.3% after 8 months of storage.

Niedziakowska (2004) carried out an experiment to determine storability of 25 new potato cultivars during the sessions 1997/98-2001/2002 at the department of potato storage and processing in Jadwisin. Potato tubers were always produced at the same location and were stored in a storehouse at 2, 4, 6 and 8° C (for table cultivars) and at 2, 4 and 6° C (for starch cultivars) at relative humidity of above 90%. The following characters of varietal storability were assessed. Physiological losses (natural and sprout losses) and infection of tuber with diseases. Cultivars significantly varied in natural losses and losses caused by the diseases. Losses caused by the diseases were dependent mainly on cultivar resistance, he opined.

The same investigator in another investigation during 1995-2002 determined the effect of potato cultivars and storage conditions on the length of tuber dormancy period and sprouting intensity. A total of 46 potato cultivars were used. The storage temperatures were 2,4,6,8 and 10° C (with 90% R.H) in the dark. It has been observed that the cultivars varied in the length of dormancy period and intensity of sprout development in tubers stored under the same conditions. Cultivars

earliness was not distinctly related with tuber dormancy or sprouting dynamics.

Sawicka (2004) analyzed the storage losses of potato tubers on samples from field experiments performed in 1998-2000 in Perczew, Poland. Two experimental factors were studied: Cultivation technology (with protection and without protection against potato late blight (*Phytophthora infestans*) and potato cultivars (Karlana, Jantar, Meduza, Panda and mixture of these cultivars). Tubers were taken from field experiment (6 from each combination) and stored in a clamp during 5 months and placed at two spots at $1/3$ and $1/2$ distance from the end of the clamp and 3 layers (bottom, middle and top of the pile). The following elements of storage durability were evaluated: germ weight, natural loss of tuber weight and loss due to the fungal and bacterial diseases. Technology of cultivation did not reduce tuber loss due to germination, evaporation, respiration and rots. Varietal properties determined the storage durability. Jantar and mixture of cultivars were very good for long term storage while Karlana, Panda and Meduza were also good.

Gasiorowska *et al.* (2004) investigated the influence of storage conditions and storage periods on the qualitative changes in potato tubers. The tubers were stored at 3-4 and 8-10° C and at relative humidity 90-95% for the period of 3 and 6 months. After storage periods, natural losses, tubers with infections, mass of sprouts and total loss were calculated which proved that the experimental factors had essential influence on the size of storage losses of potato.

Calskan *et al.* (2004) conducted a field experiment during the winter and spring months of 2000 and 2001 in Hatay, Turkey to study the effects of

FYM (0, 10, 20, 30, 40 and 50 ton/ha) and mineral fertilizers no or 200-90-90 kg NPK/ha respectively on growth and yield of early potato (*Solanum tuberosum* L.) crop. Mineral fertilizer application significantly increased value of morphological traits and tuber yield while it had negative effects on dry matter content of tubers. FYM also increased the efficiency of mineral fertilizer application. The application of FYM also had positive effects on growth and yield with or without mineral fertilizer application.

Yangi *et al.* (2004) reported that nitrogen significantly increased tuber number and weight per plant. Total and different grade tuber yields increased up to 150 kg N/ha (15.68 ton/ha). However, the net income (Rs.41906/ha) and B:C Ratio of 2.84 were higher with treatment combination of June 3rd week planting with 45 cm row spacing supplied with 150 kg N/ha, they observed.

Ramirez *et al.* (2004) reported that potato crop yield were the highest with the application of 100 and 150 kg N/ha. They also opined that the optimum rate of N for optimum potato production was 110kg N/ha.

Puzina (2004) grown potato plants in a green house using Zn and B deficient soil. He reported that boric acid treatment resulted in an increase in the IAA content and IAA/cytokinin ratio, an increase in tuber weight per plant was related to tuber growth. Zinc sulphate treatment abolished the apical dominance and increased the tuber weight due to their increased number, he observed.

Dhital *et al.* (2004) reported that 6-benzylaminopurine one kind of plant growth regulator when applied @ 10mg per litre produced significantly

higher percentage of tuberization and bigger minituber size (average 1.35 g/node) in 'Superior' cultivar.

Morar *et al.* (2004) reported that storage at temperature higher than 10° C accelerated the respiration and transpiration in the tubers, resulting in higher mass losses. Similarly, storage of tubers at 10-13° C resulted in the germination of the crop and consequently higher mass loss.

Chourasia *et al.* (2004) suggested that the percentage of free space should be 31.54% and it is optimum for a cold storage. The average weight loss was 5.3% after 8 months of storage.

Niedziakowska (2004) investigated the influence of temperature during storage of seed potato tubers on growth and development of progeny plants and observed that at least 54 potato cultivars were stored in a storehouse at 2, 6 and 10° C and relative humidity more than 90% storage conditions largely influenced the physiological state of mother tubers. With increasing temperature, the percentage of blank in the field increased. The proportion of missing plants in plantation was significantly correlated with optimum storage temperature, they observed.

Czerko (2004) reported that high natural losses (7.7%) were also observed at low ventilation.

Jabonski (2004) carried out an experiment to assess the influence of N fertilizer application on the tuber yield, its quality and storage stability. He reported that optimum dose was 150 kg N/ha and increase N fertilizer rate reduced both the development of late blight on potato foliage and incidence of common scab. Higher N rate resulted in the increase of

content of nitrates in tubers but had no significant effect on tuber loss during storage.

Maolin *et al.* (2004) reported that the temperature and relative humidity were the most important environmental factors affecting potato storage. The tuber weight loss each week was 0.90% and finally 3.28% when applied with sprouting inhibitor for 165 days.

Wszeelaczynska (2004) suggested that the highest yield of tubers and the most favourable effect in terms of chlorogenic acid content and citric acid was obtained with 70 kg Mgo/ha while ascorbic acid concentration was the highest at 50 kg Mgo/ha. Mg reduced tuber blackening.

Jiabao (2004) reported that combining 15kg N/mu with increasing rate of K increased tuber yield. The highest fresh tuber yield (2600 kg/mu) was obtained with 12.25 kg K/mu. The optimum applied amount of K was 8.7 kg/mu, resulting in a fresh tuber yield of 2580 kg/mu. (1mu=0.067ha)

Bosnjak *et al.* (2004) reported that the largest yield increase was measured with the preirrigation soil moisture of 70% field water capacity (FWC) and irrigation positively affected tuber size and it reduced the content of dry matter and ash in the tubers.

Maiti *et al.* (2004) reported that the application of both nitrogen and phosphorus influenced the growth attributes, tuber yield and net return were recorded maximum when the crop received 240 kg N coupled with 150 kg P per hectare.

Chettri (2004) observed that application of 10 ton FYM/ha along with 75% recommended dose of NPK appeared to be more remunerative to the application of inorganic fertilizer at high dose.

Long (2004) conducted an experiment in 2001 and 2002 to investigate the tuber yield, storability of Michigan cultivars in response to nitrogen management and recommended 200 kg N/ha for long duration potato cultivars in Michigan and narrow seed piece spacing optimized yield and tuber quality performance while conserving N fertilizer.

Alva (2004) conducted an experiment on potato nitrogen management and he suggested that management of nitrogen (N) fertilizer application, in terms of rate, timing and method of application, influence the yield and quality of potatoes. Optimum management of N and irrigation is important to improve N uptake efficiency and minimize yield losses while maintaining high yield and quality. Excessive N applications contribute to excess vine growth at the expense of the tuber production. Maintaining adequate supply of N availability in the soil is particularly important through the tuber bulking stage.

Klikocka (2004) studied the influence of soil tillage operation and sulphar fertilizer application on crop productivity and economic effectiveness of potato on East Poland and reported that using soli tillage with ridges in autumn with 50kg S/ha (elemental and sulphate) and 25kg S/ha applied in the form of sulphate gave the best financial surplus.

Zebarth (2004) reported that increasing rates of N fertilization increased tuber yield and tuber size. Timing of N application had little effect on tuber yield, size distribution under adequate soil moisture conditions. However, under dry soil conditions, split application reduced tuber yield and tuber size.

Koodziejczyk (2004) reported that the highest tuber yield, number of set tubers and their mean weight, percentage of commercial tubers and large

sized tuber fraction were obtained with mineral (NPK) fertilizer treatment.

Rolbiecki *et al.* (2004) conducted a field experiment to determine the influence of sprinkler irrigation and N dose on the yield, chemical composition and storage values of potatoes cv. 'Mors'. They reported that irrigation significantly increased potato yield while higher N dose did not significantly affect the amount the yield and its chemical composition. The storage of potatoes at storehouse 6 months significantly decreased the content of dry matter, starch and vitamin C in potato tubers.

Pravin-Kumar *et al.* (2004) suggested that the highest yield of process grade tubers (32.8 and 29.8 ton/ha in Kufri Chipsona 1 and Kufri Chipsona 2 respectively) were obtained with 124.5 kg K/ha. The K requirements of Kufri Chipsona 1 and Kufri Chipsona 2 (124.5 kg K/ha) were 50% higher than the K requirements of table purpose potato cultivars, such as Kufri Bahar, they opined.

Okonkwo *et al.* (2004) reported that the application of NPK fertilizer alone was at par with half dose of NPK+half dose of poultry manure which increased ungraded potato tuber yield by 48% than the control.

Khandakar *et al.* (2004) suggested that lime and potassium treatments significantly increased tuber yield. The highest increased yield was recorded~86.54% over the control. The optimum rate of lime and potassium in acid sandy-loam soils that could be recommended for potato cultivation is 2 ton/ha and 100 kg/ha respectively.

Mehta *et al.* (2003) reported that the rotting in tubers up to 120 day storage was also higher in immature tubers. Defoliation of the crop 10

days prior to harvest further reduces weight loss and rotting in tubers during storage.

Mehta *et al.* (2003) evaluated traditional on farm potato storage system (pit, heap and evaporative cool storage or ECS) using sprouting suppressant Isopropyl-3-Chlorophenyl Carbamate (CIPC) at 2.5 g/kg tuber as post harvest dust treatment. CIPC was again applied one month after the first treatment. The temperature under ECS and heap storage approximately higher by 2-3° C than the temperature under pit storage. The RH under all storage systems remained high (60-95.8%). Total weight loss in untreated potatoes remained low (7.4-9.4%) up to 12 weeks of storage. Pit storage and ECS were equally superior over to heap storage. Treatments with CIPC twice extended the storage life of potatoes for up to 16 weeks by reducing physiological weight loss (by 39.8%), sprouting (by 83%) and sprout growth (by 93.3%). Even a single application of CIPC showed significant suppression of tuber sprouting and weight loss up to 16 weeks.

Esfahani (2003) conducted a 2 years (1997-98) investigation in Isfahan, Iran to determine the various losses of potato tubers after harvesting and during the storage period and observed that approximately 23.02% losses were recorded. They were soft rot 3.43%, Fusarium dry rot 4.89%, brown rot 2.30% tuber greening 2.44% internal bruising 1.27% physiological disorder 4.38% deep injury due to unsuitable harvesting 1.72% and pest 1.65%).

Nunez (2003) evaluated 2 brassinosteroid analogues on callus formation and shoot induction in sweet potato (*Ipomoea batatas* (L.) Lam.) He reported that shoot induction was favoured when brassinosteroid

analogues were combined with IAA (0.05 mg/L) and Kinetin (0.2mg/liter).

Pruski *et al.* (2003) reported that a significantly higher number of stems and better yield of uniform tubers was also obtained from the ethylene treated seed tuber.

Khalia *et al.* (2003) studied the effect of chelated micro-nutrient compound Fertilon compi 7 (FC7; 2.5% Fe, 4.5% Mn, 6.5% Zn and 0.5% Cu on the yield and nutrient content of potato cv. Diamant in Gharbia governorate Egypt during 2001-2002 and 2002-2003. FC7 at 0.0, 0.1, 0.2 and 0.3% (equivalent to 0.0, 400,800 and 1200 g/feddan respectively) was sprayed vegetative growth (50 days after sowing) and tuber formation (60 days after sowing) stages. The tuber yield increased with the increase in Fe, Mn, Zn and Cu contents of tubers with 800 g/feddan resulting in the greatest increment (1 feddan=0.42ha).

Miller *et al.* (2003) reported the highest brassinosteroid levels (100 or 1000) micro liter significantly inhibited the growth of *Solanum tuberosum* and *Solanum chacoense* compared to the controls lacking brassinosteroid. Lower brassinosteroid levels (1 and 10 micro liter) significantly enhanced plantlet growth.

Birbal *et al.* (2003) investigated the effect of some plant growth regulators on the production of potato cv. Kufri Ashoka in Madhya Pradesh, India in autumn (October 2002-January 2003). The treatments were: gibberellic acid (GA) at 200 ppm, NAA at 50ppm, mepiquat chloride at 150 ppm, TIBA at 50ppm, ethrel at 250 ppm 2,4-D at 1ppm and the control. The crop was sprayed twice, at 25 and 50 days after planting. GA and NAA increased plant growth in terms of height and leaf

number. The highest number of tubers per hectare (5.82 lacks tubers) was obtained with NAA, followed by GA and ethrel. The highest tuber yield (374 q/ha) was obtained with NAA.

Civic (2003) investigated the effect of NPK fertilizer with or without Mg application on yield and quality of tubers on Jerla cultivar. He reported that the effect Mg were not statistically significant compared with NPK alone, with a tuber yield increase only from 53.87 to 56 ton/ha with 17.5 kg Mgo, compared with 37.70 ton in unfertilized controls. Application of higher Mg rates decreased yield, as the soil already had high Mg content.

Pashalidis *et al.* (2003) conducted a field experiment to the effect of N (at 330, 495 and 660 kg/ha) and K fertilizer (112, 225, 450 and 675 kg/ha) on potato cv. Spunta in 2001-2002 in Kalamata, Greece. They reported that the highest mean tuber yield was obtained under 495 kg N/ha and 112 kg P/ha mainly due to the total number of tubers. N and K had no effect on harvest index.

El-Beltagy *et al.* (2002) evaluated the response of different calcium levels on potato growth and productivity. Calcium, in the form of calcium chloride was added to the soil at 6.6, 15, 21.6, 28.2 and 34.8g Ca/plant in pots (30 cm diameter) filled with sandy soils. Calcium treatments were applied in 6 times throughout the growing season (35, 45, 55, 60, 70 and 80 days after planting). Results showed that calcium application up to the medium concentration promoted some morphological parameters such as stem length, number of leaves and stems, total leaf area, chlorophyll content and dry matter content of haulms and tubers. Tuber yield was improved as well. The highest two levels of Ca $2+$ (28.2 and 34.8 g Ca/plant) reduced all parameters under high temperatures conditions.

LiJun *et al.* (2002) conducted a field experiment with potatoes cv. Kexin No.11 during 1999-2000 in Keshan, China to investigate the effects of B-Mo nutrition on fresh tuber yield (FTY) and active oxygen metabolism (AOM) on the leaves of potato. Water solution with different concentrations of borax (2, 4, 6, 8 or 10 g/liter) and sodium molybdate 1 or 5g/liter was sprayed twice at 5 days interval at flower bud stage. A significant interaction was found between B and Mo nutrition. The water solution with Borax 6 g and sodium molybdate 5 g/liter increased the enzymes activities and fresh tuber yield. They concluded that the rational foliar application of B-Mo nutrition could benefit potato tuber production.

Maier *et al.* (2002) conducted 3 field experiments to investigate the effect of calcitic lime and phosphorus as fertilizer on soil pH, growth of haulms, tuber number, yield, dry matter content etc. Liming increased surface soil pH by up to 3.1 units while yield of leaves, stems and haulms were not significantly affected. Phosphorus fertilization increased total leaf, stem and haulm yields and plant height. Phosphorus fertilization also significantly increased tuber yield and tuber number in 3 experiments.

Ezekiel *et al.* (2002) investigated the weight loss in potatoes during storage at temperature regimes on the cultivars Kufri Bahar, Kufri Lalima and Desiree (control) were stored in the dark at 12 and 20° C and 80-85% relative humidity (RH). The weight loss due to evaporation and respiration of tubers and tuber sprout was recorded 30, 90, 120, 156 and 184 days after storage. The weight loss due to respiration and evaporation was greater when the tubers were stored at 20° C than at 12° C. The weight loss increased with increasing storage period at both temperatures.

Bohm *et al.* (2002) field tested 21 potato varieties at 3 organic farms in Northern Germany during 2000-2001. Average yield of potatoes used for crisp processing was 30.4 t/ha. Highest yields were obtained for the semi-early varieties Agria and Marlene (35.0 t/ha) and the late variety Sonate (34.0 t/ha). They have suggested improving organic crisp production with improved potato varieties aimed at good blight resistance, early tuber formation, and storage ability at 4° C and improved storage at 8° C without germination suppression.

Civic (2002) reported that the tuber yield was highest 27.23-29 ton/ha when applied with NPK + Mg fertilizer. He also reported that Mg application significantly increased vitamin c content in the tubers.

Kavvadias *et al.* (2002) reported that 300:150:250 Kg NPK fertilizer+200 kg Mg/ha gave highest tuber dry matter content (26.2%) and gave the highest tuber yield (39.7 ton/ha) and highest crop harvest indices (0.90)

Hua *et al.* (2002) conducted a field experiment on yield increasing effect of foliar application of triacontanol solution on potato cultivar Jinshu no 7 in 1999 and 2000 in Shanxi, China. Foliar application of triacontanol (0.1%EC) were carried out using different concentrations (0.2×10^{-6} , 0.5×10^{-6} , 0.8×10^{-6} and 1.0×10^{-6} g/litre) at flower (FS) or flower bud appearance stage (FBAS). Tuber yield, number of large tubers and starch content increased. Application at FS was more effective than at FBAS. When 0.8×10^{-6} g/litre was sprayed at FS, the highest tuber yield, number of large tubers and starch content were obtained.

Sawicka (2002) conducted a field experiment in 1993-1995 on a podzolic soil derived from the light loam in Perczew, Poland on the effect of plant growth regulators (0.05% Mival, 0.2% Moddus ME) applied before

planting and before flowering on the tuber yield of 6 potato cultivars. He observed that the application of plant growth regulators increased the number and weight of tubers plant and seed potato yield compared to the control.

Craighead *et al.* (2002) reported that the trials on seed crops showed no significant effect on N or K on yield. K applied as KCl increased tuber dry matter content compared to K applied as K₂N generally increased main crop and winter potato yield up to optimum rate but often reduced tuber dry matter. Foliar N had no effect on yield.

Sukumaran (2002) reported that several attempts have been made in India to use growth regulators to enhance productivity of the potato crop, improve seed tuber quality and improve the storage life of the tuber. Experiment showed that in general such attempts have not yielded consistent and significant beneficial results, with the possible exemption of the use of dormancy breaking and sprout suppressant chemicals.

Sharma *et al.* (2002) conducted a field experiment in Shimla, Himachal Pradesh, India during 1996-98 to determine the effect of N (60, 120 and 180 kg/ha) and K (0, 75 and 150kg/ha) on the yield and quality of potato cv. Kufri Jyoti as well as on the organic carbon status of the soil. They observed that average tuber yield of potato increased with increasing rates of single or combined application of N and K. Nitrogen content in potato tubers increased with increasing K and N rates up to 120 kg/ha. On the other hand, K content in the potato tubers increased with increasing rates of N up to 120 kg/ha, N and K uptake of the crop increased with increasing rates on N and K. Crop yield, tuber N and K and dry matter content were higher with the application of potash.

Imas *et al.* (2002) conducted a field experiment jointly with IPI, PRII and CPRI at Shimla (Himachal Pradesh) and Jalandhar (Panjab) showed that a balance N+K fertilizer application increased the tuber yield. Increasing K rates decreased the yield of small grade tubers and increased the proportion of large marketable tubers. Potassium application also dramatically decreased the incidence of Late Blight (*Phytophthora infestans*). In 1998, a maximum yield of 40 t/ha was obtained in Kufri (Shimla) when 180 kg N/ha, 100 kg P/ha and 150 kg K/ha were applied, compared to a tuber yield of only 14.6 t/ha in the control plots without NPK application. They opined that high yield and enhanced quality tubers can only be sustained through the application of optimum nutrient rates in a balanced proportion.

Kumar *et al.* (2002) conducted a field experiment on tuber yield and processing quality as influenced by N,P,K nutrients during 1995-98 in Modipuram, Uttar Pradesh, India. The effect of N (60,120,140 and 180kg/ha), P (40, 80, 120 and 160 kg/ha) and K (50, 100,150 and 200 kg/ha) on the yield and processing quality of potato cv. Kufri Jyoti were determined. The total yield of potato increased with increasing rates of N, P and K.

Ezekiel (2002) investigated the effect of storage temperature of seed potato on growth and yield of potato in Modipuram, Uttar Pradesh, India. Seed potatoes of 4 cultivars were stored in darkness at 4 and 12° C during 1995-96 and at 4, 12 and 20° C during 1996-97. Cultivars Kufri Sindhuri and Kufri Bahar aged more rapidly, while Kufri Lalima and Desiree aged less rapidly. Physiological aging of seed tubers was more rapid at 12° C than at 20° C. Plant raised from seed tubers stored at 4° C were more vigorous, with higher number of stem and high ground cover and

produced higher number of tubers and higher yield. Storage at 12 and 20° C reduced tuber number and yield significantly.

Grag *et al.* (2002) determined the effect of diffused light in seed boxes, gunny bags or heaps and kept in the dark on the yield and sprouting performance of the tubers in the Shimla Hills. The number of sprout per tuber 180 days after storage and number of shoots per plant at flowering were highest in tubers stored under diffused light regardless of the cultivars used. Tuber stored under dark conditions resulted in the longest sprout per tuber. Tuber stored in the seed boxes and maintained under diffuse light produced highest yield and seed-sized tubers.

Sanderson *et al.* (2002) conducted a study in Prince Edward Island, Canada by comparing monoammonium (MAP) and diammonium (DAP) phosphate applied with and without lime, to determine a specific combination of lime, P source and rate would aid P utilization in potatoes. Applied P, even under high soil P conditions can boost yield productivity, without influencing processing quality. The greatest opportunity for improving P utilization lies in genetic improvement and cultivar choice.

Sing *et al.* (2002) carried out a field experiment during 1999 and 2000 at Shillong, Meghalaya, India revealed that inoculation of seed tubers prior to planting with phosphorus solubilizing bio-fertilizer significantly increased potato tuber yield, uptake of N and P as well as net returns over uninoculated seed tubers. Plants supplied with 100% of the recommended dose of N (120kg/ha) recorded the highest tuber yield, net returns and uptake of N and P.

Chettri *et al.* (2002) carried out a field experiment during rabi season of 1994-96 on sandy clay loam soils of a farmer field in Chandmari, West

Bengal, India to study the growth, productivity and late blight disease (*Phytophthora infestans*) of potato supplied with potassium and sulfur and farmyard manure (FYM). The highest dry matter production, bulking rate and tuber yield (297q/ha) potato were obtained with 120 kg N, 100 kg P and 100 kg K along with 10 t FYM/ha. Application of potassium significantly increased the dry matter production, tuber bulking rate and tuber yield compared to the control. Split application of potassium was better than basal application. Addition of sulfur through SSP (single super phosphate) also gave higher dry matter production, tuber bulking rate and tuber yield.

Rana *et al.* (2001) reported that N application induced significant increase in the tuber of shoots and tubers per hill only up to 75 kg N/ha, whereas plant height, leaf area index, yield of A and B grade tubers and tuber seed and tuber –equivalent yield per hectare recorded significant increase up to 150 kg N/ha. Application of N+S caused perceptible increase in the seed yield, B-grade tubers and tuber equivalent yield over N alone.

Slavov *et al.* (2001) set a field fertilizing trial of 4 magnesium containing fertilizers obtained from nitric acid aided magnesite decomposition on Kalina potato cultivar and concluded that Mg availability in fertilizer composition has a positive effects on yields and quality of potatoes produce of higher percentage of large tubers is obtained as well as increased dry matter content and reduced percentage of tuber contained reduced sugar.

Reverberi *et al.* (2001) investigated the influence of GA₃ on micro-tuber formation of potato. They reported that GA₃ decreased average micro-tuber yield.

Prakash *et al.* (2001) investigated the effect of plant growth regulators (PGRs) on growth parameters and tuber yield in potato cultivars Kufri Chandramukhi and HPS-11/67 in 1997 in Karnataka in India. He noticed that significantly higher tuber yield was recorded in growth retardant treated plants compared to the control, and the maximum tuber yield was recorded with Cycocel (1000 ppm) in both the genotypes. Kufri Chandramukhi showed higher leaf area, SLW and tuber yield than HPS-11/67.

Vornokov (2001) investigated the effect of new plant growth regulators vital-1 and vital-2 (Magnesium and triethanolamine salts of fumeric acid respectively) on the development crop yield and tuber quality of potato. Plants treated with 0.01% Vital -1 obtained a 41% higher crop yield and 45% lower haulm weight than the control. Plants treated with 0.01% Vital- 2 decreased the haulm growth rate. Pre-planting treatment of 0.01% Vital-2 caused an ~23% increase in tuber weight and additional treatment 14 days after prickling (DAP) caused a 34% increase in tuber weight.

Deka *et al.* (2001) conducted a field experiment in Jorhat, Assam, India during 1995-96 to identify the appropriate suppressant for preservation of potato tuber tubers without adversely affecting their growth and yield. Three cultivars and 3 treatments were used in the experiment. They observed that all the chemical treatments had no significant effect on growth and yield when applied at 76 days after planting.

Caldiz *et al.* (2001) investigated the effect of Maleic hydrazide (MH) on potato cultivars Atlantic, Kennebec, Ranger Russet, Russet Burbank and Shepody were investigated at different location in Argentina during 1995-

98. They observed that MH when applied during growth stage 1v at 9, 10, 12 and 14 litre/ha increased tuber yield of Kennebec, Russet Burbank and Shepody.

Elkina (2001) reported that the application of optimal amounts of macro and micronutrients significantly increased yield of potato.

Allison *et al.* (2001) carried out some field experiments in East Anglia, the Midlands the West and Southwest of England during 1995-99 to test the effects of Mg fertilizers on the yield of potato crops. Six experiments tested the effects of varying N, P, K and Ca supply on the tuber concentrations and uptake of Mg by potato crops. When these current experiments and previously published experiments are taken into account there is little justification for applying Mg fertilizer to soil with Mg indices >0 and soils with Mg index 0 an application of ~50 kg Mg/ha would be sufficient.

Swierczewska *et al* (2001) conducted a field experiment in Lublin, Poland on the effect of foliar application of Mg fertilizer on the yield of cereals, winter rape, potatoes, sugar beets and leguminous crops. Mg was applied in the form of 5% MgSO₄ at a rate of 300 dm³/ha increased crop yield due to the application of Mg fertilizer were 35 to 193 kg for cereals 36 kg for winter rape seed, 361 kg for potato tubers and 21 to 46 for legumes all per kg of MgO.

Juarez *et al.* (2001) conducted a field experiment to study the effect of nitrogen fertilizer on potato late blight caused by *Phytophthora infestans* i Huancayo and Oxapampa, Peru. Three rate of N (0, 160 and 320 kg/ha) and two cultivars Amarilis and Yungay were used. In the absence of LB more N led to more foliage development and higher yields. N had no

effect on the diseases when severity was very low or high. At intermediate level of severity, increased N led to increased disease. If farmers attempt to increase potato yields using n fertilizer, they may need to use more fungicides or varieties with higher resistance.

Giordano *et al.* (2001) compared some conditions in a trial at Battipaglia, Salerno, Italy in 1999 using potato cv. Arinda, Spunta and desairee in seed tuber production. Treatments included two planting dates, mulching and foliar application of GA. Use of gibberellin hastened dormancy breaking of seed tubers. Yield in the next crop was increased by using seed tubers produced in mulched plants.

Alekseev (2001) conducted some investigations during 1989-96 on use of plant growth regulator Mart 21 and ploughing with and without mouldboards. It is concluded that use of Mart 21 resulted in control of diseases (*Alternaria*, blight (*Phytophthora infestans*), common scab (*Streptomyces scabei*) and bacterial soft rot), increased yield and improved storage quality.

Luthra *et al.* (2000) conducted a field experiment in Modipuram, Uttar Pradesh, India during 1994-97 to investigate the flowering behaviour in 28 non-flowering potato genotypes during short days (SD) in the north-central plains was induced through artificially extended Photoperiod (LD) and hormonal treatment (LD+H, using gibberellic acid at 50 ppm, IAA at 10ppm and kinetin at 2ppm). Plant height, inflorescence stalk length and flower buds/inflorescence also increased by 27,151 and 138 percent respectively under LD+H. The results indicated that in addition to photoperiod, growth regulator do play important role for flower induction in non-flower potato genotypes under short days of north central plains.

Savitha *et al.* (2000) conducted a field experiment in Bangalore, Karnataka, India during rabi season of 1995 and 1996 to study the effects of K rate (60, 120 and 180 kg/ha) and application date (100% basal, 50% basal+50% at 30 days after transplanting and 50% basal+25% at 30 DAT+25% at 50 DAT) on the yield and quality of potato hybrid HPS 1/67. The application of 180 kg K/ha increased the tuber yield by 25.90% over 60 kg K/ha. The two-split application of K recorded 5.4 and 15.6% higher tuber yield than 100% basal and 3-split application respectively. K at 180 kg/ha applied in two-splits resulted in the production of high quality tubers. The application of recommended K rate (120 kg K/ha in 2-splits increased K uptake (73.40 kg/ha) and yield and improved tuber quality.

Sawicka *et al.* (2000) reported that the plant growth regulators Mival at 500 mg/liter

and Potejtin at 10 mg/liter responded differently on 3 Dutch and 34 Polish potato cultivars.

Barche *et al.* (2000) investigated the response of potato to fertility levels and plant growth regulators in black cotton soil in Pune, India. They reported that tuber fresh weight was significantly affected by fertilizers and growth regulators; the dry weight was also affected by growth regulators. The large size tubers were obtained from fertilizer and 500 ppm Cycocel treatment, while medium sized tubers were obtained from fertilizer and 250 ppm Cycocel treatments. Fertilizer and control treatments yielded small tubers. The highest tuber yields (339.68 and

323.01 q/ha) were recorded from the 500 and 250 ppm Cycocel treatments respectively.

Anjanappa *et al.* (2000) reported that tuber fresh and dry weights were generally high with the application of plant growth regulators Paclobutrazol (PBZ) at 5ppm and Cycocel at 3000 ppm which were applied at 45 and 60 days after planting (DAP)

Prakash *et al.* (2000) conducted a field experiment at Dharwad, Karnataka, India during kharif season of 1997 and 1998 to study the effect of some plant growth regulators TIBA (50 and 100 ppm),Cycocel (Chlormequat) 500 and 1000 ppm, Mepiquat Chloride (500 and 1000 ppm) and Lihocin (Chlormequat) 500 and 1000 ppm on the yield of potato cultivars Kufri Chandramukhi and HPS-11/67.The foliar application of growth regulators at 45 days after planting increased the chlorophyll a, chlorophyll b and total chlorophyll contents as well as the nitrate reductase activity with 1000 ppm Cycocel being the most effective. Cycocel (1000 ppm) increased the tuber yield from 23.11 to 30.22 t/ha (30.8%) in Kufri Chandramuthi and from 15.78 to 20.38 t/ha (28.9%) in HPS-11/67.

Naik *et al.* (2000) reported that more than 40% weight loss occurred both in normal and green micro tubers when stored in the light at 6° C for 6 months. Green micro tubers sprouted significantly earlier than normal micro tubers when stored in the dark at 6° C during post harvest storage.

Periskova *et al.* (1999) conducted a field study during 1997-1998 in Belarus showed that for early potato the combination of broadcasting of

organic fertilizer and local application of mineral fertilizer resulted in the highest yield increase. They observed that the application of plant growth regulators (Apin and Amistim) increased fertilizer efficiency and allowed a decrease in mineral fertilizer rates by 30%.

Prakash *et al.* (1999) conducted a field experiment on the effect of plant growth regulators on morphological traits their relationship with yield in TPS and tuber propagated potato. Cycocel 1000 ppm recorded the highest yield (30.22 t/ha) in Kufri Chandramukhi and 20.38 ton/ha in HPS-11/67 when applied at 45 days after planting (DAT).

Tabori *et al.* (1999) observed that there was no significant difference in duration of dormancy between different tuber size group and the loss increased significantly with a decrease in tuber size. They opined that the dormancy was long and was greatly elongated by low storage temperature.

Marghitas *et al.* (1997) reported that the total low losses of 1.26 and 1.31% were recorded at 150:90:150 and 200:120:200 kg NPK/ha respectively when the tubers were kept at 2-4° C and at 80-85% relative humidity for 7 months (October to May)

Ittersum *et al.* (1993b) observed that gibberellins, one of the plant growth regulator substantially shorten innate dormancy when applied to the foliage before haulm destruction and this treatment interact with storage temperature. A foliar spray of gibberellic acid decreased the dormant period of cvs. Diamant and Desiree by 30-50 and 80-100 days respectively, when treatment was followed by the most active storage regime.

Mikitzel (1992) observed that daminozide, one of the plant growth regulator treatments increased the number of tuber eyes of each 3 cultivars and did not alter the distribution of eyes between the stem and bud ends. After 5 g daminozide/litre treatment average eye number of the stem ends and bud ends of Nooksack increased up to 1.0 eye, by 27% for Shephody and by 31% for Ranger Russet. As a seed tuber production aid, daminozide can be used to increase eye number and in some cultivars, to reduce average tuber weight.

CHAPTER 3

MATERIALS AND METHODS

3.1 Description of the experimental site

3.1.1 Location

The experiment was carried set in the southern side of Foundation Seed Potato Production Farm, Bangladesh Agriculture Development Corporation (BADC) Sonaroy, Domar, Nilphamari in 2010. Geographically, the experimental field is situated at 26°05' North latitude and 88°7' East longitude at an elevation of 30m above the sea level belonging to the Agro-ecological Zone 25 and 3 (AEZ 25& 3) belongs to Tista floodplain soils of Bangladesh. In 2011, the experimental plot was set in the farmers field. It is situated on the bank of the river Korotoya 4 km away from Domar BADC farm and adjacent to Breeder Seed Production Centre (BSPC), Bangladesh Agricultural Research Institute (BARI), Debiganj, Panchagarh also belonging to the same geographical position and same Agro-ecological Zone.

3.1.2 Soil

The soil of the experimental field of BADC farm is well-drained sandy loam with moderately slow permeability, while the soil of farmer's plot at Debiganj, Panchagarh is well-drained and sandy loam bearing the low PH value and very trace amount of organic matters are available in the soil.

3.1.3 Collection of soil samples

Soil samples were collected before the ploughing of the experimental field. Physio-chemical properties of soil viz. soil pH, organic matter, total nitrogen, phosphorus, potassium, sulphur and zinc were analyzed from the regional office of Soil Resources Division Institute, Shyampur, Rajshahi. The physical and chemical properties of the soils of both the experimental plots are presented in (Appendix no. I and II)

3.1.4 Climate

The experimental site is characterized by moderately high temperature and moderate rain fall during kharif season and scanty rainfall with moderately low temperature during Rabi season. Favorable climatic condition persists from October to March for potato production. The monthly average temperature, rainfall and relative humidity during growing periods of crops are presented in Appendix-III and IV

3.2 Description of Experimental treatments

Two factors were included in the experiment namely plant growth regulators and combined liquid micro nutrients (Wuxulsuper) and three cultivars. Six treatments were considered in the experiments. They were as follows:

1. T₀: N P K S Mg were used but no plant growth regulators and micro-nutrients were used.
2. T₁: N P K S Mg and Vitaplus PGR, a kind of plant growth regulator. Vitaplus was used as a foliar spray specially at 30 DAP, 45 DAP & 60 DAP @ 500ml/ha
3. T₂: N P K S Mg and Brassinosteroid, a kind of plant growth regulator

Brassinosteroid was used through foliar spray at 30 DAP, 45 DAP & 60 DAP @ 800gm/ha. (1.6 gm/5 Decimal land)

4. T₃: N P K S Mg and Wuxulsuper, a kind of combined liquid micro-nutrient. Wuxulsuper was used by hand at 30 DAP, 45 DAP & 60 DAP @ 4000ml/ha.
5. T₄: In this treatment, N P K S Mg and Vitaplus and Wuxulsuper were used at 30 DAP, 45 DAP & 60 DAP Vitaplus was @200ml/ac while Wuxulsuper was used @1500ml/ha.
6. T₅: Like treatment T₄, N P K S Mg and Brassinosteroid and Wuxulsuper were used in this treatment at 30 DAP, 45 DAP & 60 DAP. The rate of application of Brassinosteroid was 320gm/ac while Wuxulsuper was used 1500ml/ha.

Studies and observations revealed that plant growth regulators and combined liquid micro nutrients like Wuxulsuper are conveniently used on the leaves of potato at 30 DAP but not exceeding 60 DAP show significant results after 60 DAP and before 30 DAP foliar application of plant growth regulators and micro nutrients show poor results. With a view to getting maximum possible benefit from plant growth regulators and wuxalsuper, spray schedule designed as mentioned above.

3.3 Description of plant growth regulators and micro-nutrients

S.L. No.	Materials	Trade name	Active Ingredients	Time and number of application
1.	Plant growth regulators	VitaplusPGR	Chlorophynoxy acetic acid	Foliar application 3 times at 30,45 and 60 DAP
2.	Plant growth regulators	Brassinosteroid	benzene, ethyl acetate 30:1 to 15:1 and 21.06g (75.7%) of 2 α , 3 α -dipropionyloxy-24S-ethyl-5 α -cholest-22-ene-6-one(V)	Foliar application 3 times at 30,45 and 60 DAP
3.	Combined micro-nutrients	Wuxul super	N-8.0%, P ₂ O ₅ -8.0%, K ₂ O-6.0%, B-0.01%, Cu-0.007%, Fe-0.015%, Mn-0.013%, Mo-0.001%, Zn-0.005%	Foliar application 3 times at 30,45 and 60 DAP

3.4 Description of the cultivar

Diamant: Diamant cultivar of potato possesses the following characteristics:

- The tuber is oval shaped but slightly tapering.
- The stem is stony and long.

- The skin is white
- The yield is around 20 t/ha
- The duration from sowing to harvest is around 85 to 90 days.
- The leaf is moderately flat

Asterix: Asterix cultivar of potato possesses the following characteristics:

- The tuber is cylindrical
- The skin is faint red
- The leaf is cylindrical in shape
- The duration of crop for sowing to harvest is around 85 to 90 days
- The stem is pigmented with brown colour, stony and long.
- The yield is around 18-20 ton/ha

Granola: Granola cultivar of potato possesses the following characteristics.

- The tuber is oval shaped
- The skin is white and rough
- The yield is around 17-18 ton/ha
- The stems are weak and small.
- The duration of crop from sowing to harvest is around 75 to 80 days.
- It is a early variety potato.

3.5 Experimental Design

The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. The treatments were randomly assigned in each replication. The plot size was 3m x 3m.

3.6 Land preparation

The land of experimental plot was opened with a tractor plough of BADC farm. Later on the land was ploughed and cross ploughed 2 times by tractor followed by laddering to obtain the desirable tilth. The visible larger clods were broken into small pieces by wooden hammer. Weeds and stubbles were removed from the field. The land was prepared smoothly with spade before planting of potato. The layout of the experiment was done in accordance with design adopted. Power tiller and country plough practice were done in the farmer's field in the following year. The soil was comparatively loose having no clods at all. Some weeds and crop residues were removed through hand picking. Thus the soil was prepared easily.

3.7 Fertilizer Dose

High yielding varieties of potato need sufficient amount of both organic and inorganic fertilizers. The following recommended fertilizer dose was given in accordance with the recent soil testing report of SRDI. No cow dung and micro-nutrients were used before or during the planting of potato.

Name of Fertilizers	BADC farm	Farmer's plot
Urea	321 kg ha ⁻¹	346 kg ha ⁻¹
T.S.P/DAP	272 kg ha ⁻¹	124 kg ha ⁻¹
MP	321 kg ha ⁻¹	272 kg ha ⁻¹
Gypsum	99 kg ha ⁻¹	86 kg ha ⁻¹
Magnesium sulphate	124 kg ha ⁻¹	124 kg ha ⁻¹

Source: Soil Analysis Report of SRDI, Shympur, Rajshahi

3.8 Application of fertilizer

The mode of application of fertilizer is very important. Major portion of fertilizers were used as basal dose during land preparation while the rest fertilizers were used as a top dressing and side dressing during planting of tubers and at vegetative stage.

3.8.1 Basal dose

Some fertilizers were used just before final land preparation while other fertilizers were applied during planting as a side dressing.

Total amount of Gypsum and Magnesium Sulphate fertilizers were applied during final land preparation. Total amount of Triple Super Phosphate (TSP) or Di-ammonium Phosphate (DAP), fifty percent urea and 50 percent potash fertilizers were applied during planting of potato as a side dressing.

3.8.2 Top dressing

When potato plants reached at the age of 30-35 days, 50 percent of rest of urea and 50 percent rest of potash was applied as a side dressing followed by earthing up.

3.9 Collection of Seed

Potato seed of cultivar Granola was collected from Breeder Seed Production Centre (BSPC), Bangladesh Agricultural Research Institute (BARI), Debigang, Panchagarh while seeds of cultivars Diamant and Asterix were collected from Foundation Seed Potato Production Farm, Bangladesh Agriculture Development Corporation (BADC) Sonaroy, Domar, Nilphamari.

3.10 Selection of seed stock

The following points were taken into account at the time of seed selection

- i. Seed tubers selected for planting were of uniform shape and size.
- ii. The tubers that showed surface disease like wart, scab and brown rot were separated out.
- iii. Shriveled tubers were separated and discarded.
- iv. Maximum 1 cm long sprouted tubers were selected at the time of sowing.

3.11 Planting of seed potato

Seed potatoes were planted on furrows at the depth of 8". Initially furrows were made by plough. In both sides of furrow, 2 furrows were made apart 4" for side dressing of fertilizer. After placing seed potato at the middle furrow and fertilizer on side furrows, the furrows were covered with smooth soil.

Tuber to tuber distance was 20 cm while line to line distance was 60 cm. Actual line to line distance was 50 cm., because irrigation channel reduced some area. Plot size was 3mx3m. Total number of tubers in the plot was 65. The seed rate was 2500 kg/ha. It may be mentioned here that whole tuber preferably 'A' grade size (21-27mm) was planted with a view to getting better performance with higher yield.

3.12 Preparation of Irrigation Channel

Soon after planning of potato irrigation channels were prepared for supplying irrigation water as per need of the crop. Channel and sub-channel divided the experimental plot into 54 plots. It was done to irrigate potato crop and to drain out surplus irrigation water from the

experimental plot simultaneously. Water logging condition was not desirable for experimental plot.

3.13 Weeding

Weeding was done manually with khurpi for 2 times. Plots were weed free till haulm pulling.

3.14 Irrigation

The crop was irrigated 3 times during its cultivation period at BADC farm plot. Irrigation was given at 35 DAP, 50 DAP and 65 DAP. Initially the soil was moistened. This was why, the irrigation started at 35DAP while 4 times irrigation was needed in the farmer's plot at 10-12 days interval as $\frac{2}{3}$ rd height of ridges were filled with irrigation water.

3.15 Disease management

In case of potato crop particularly for seed potato, it is wise to take preventive measures. As part of preventive measures fungicides were spread in the experimental plot at constant interval. This is why; there was no attack of 'Late Blight' disease till harvest. Acrobat MZ-72, Indofil and Dithane M-45 were sprayed one after another at the rate of 800gm/ac

3.16 Pest management

It is wise to take preventative measures against Aphids for quality seed production. Aphids are the main enemy of potato crops. It arrives in this belt in the beginning of January. This is why, insecticide spraying was started at the middle of December in the experimental plot at regular interval to keep the Aphids specially *Myzus persicae* species away from

attack till harvest. Asataf @ 500 gm/ha and Admire @ 250 gm/ha were sprayed alternatively to fight against Aphids.

3.17 Rouging

In case of seed potato production, rouging is essential practice to keep the crop free from all sorts of attack particularly dissimilar and off-type plants. The plants having abnormal growth or deviated from normal characteristics by the attack of diseases or pests were eliminated manually from time to time from the field to keep the crop free from all sort of attack. The main objective of rouging was to produce healthy and disease free seed.

3.18 Haulm pulling

When the crop reached full maturity, haulm pulling became necessary to collect the crop. Before haulm pulling the experimental plots should be irrigated with a view to keeping the soil cool till harvest. Otherwise, tubers might suffered with heat injury after haulm pulling in the field. It also helps to keep cutworm and other soil borne pests away from the attack of tubers. Haulm pulling is generally done manually keeping one hand at soil level while another hand helps in pulling the haulms out of soil.

3.19 Harvesting

Harvesting or tuber crop collection is done when the skin of tuber becomes hard. The hard skin of tuber protects it from physical injury. It needs around 12-15 days to reach at this stage. Plots were harvested manually separately as per requirement of the experiment and necessary data were recorded in the register accordingly.

3.20 Post harvest operations

Harvested tubers were kept in a shady place for shade curing for about 3-4 days in plot wise in an open place. Tubers of 3 replications were kept in such a way with a view to keeping separate identity of cultivars and treatments. Distorted, damaged, diseased and heat injured tubers were sorted out and graded as per Seed Certification Agency (SCA) manual and tagged for storing for experimentation in the next year.

3.21 Storing of potato

Plant growth regulator treated potato produced comparatively big size tubers which increased tuber yield. These tubers are not stored for seed purpose, because these tubers have no demand at farmer's level. This was why, big size (55mm and above) tubers were sorted out as per SCA manual before storing the tubers in the cold storages. Two private cold storages namely Saon cold storage, Domar and Sajeda cold storage, Saidpur and only one public cold storage BADC cold storage, Domar were selected to preserve potato tubers through mini gunny bags for about 8 months.

- a) **BADC cold storage, Domar:** It is situated at village Sonaroy, 25 km North from Nilphamari district head quarter and 6 km South-west from Domar upzila headquarter.
- b) **Saon cold storage, Domar:** It is situated 25 km North- east from Nilphamari district headquarter and one km East from Domar upazila headquarter on Domar-Dimla road.

c) Sajeda cold storage, Saidpur: It is situated 24 km South from Nilphamari district headquarter and 3 km East from Saidpur upazila headquarter on Dinajpur- Rangpur highway.

Before storing of tubers sorting, grading, initial weight, tagging and gunny bagging were done properly treatment wise and finally recorded in the register for three cold storage in both the years.

3.22 Cold storage performance study

The performance in cold storages both at public and private level can be achieved mainly through two ways viz.

1. study of physical properties of seed potato which may include morphological appearance, weight loss, initial weight and final weight of seed potato, status of relative humidity, temperature, fresh air intake (number and duration in a week), cleanliness etc inside the cold storages, and
2. seed potato quality test which may include total number of eyes per tuber, percentage of sprouted and non-sprouted eyes, germination percentage of tubers sprouted, number of days to shoot emergence, number of haulms per tuber, seed vigour index etc.

1. Physical properties

- a) Morphological appearance of seed potato after releasing from cold storages
- b) Data collection on initial weight, final weight and calculation of weight loss of potato
- c) Data collection on relative humidity and temperature from the cold storages during potato preservation

- d) Information about number and duration of fresh air intake per week at both private and public cold storages
- e) Cleanliness of cold storages after and before storing potatoes/ seed potatoes

a) Morphological appearance of potato after releasing from cold storages.

Potato farmers, seed growers and potato traders store potato in cold storages soon after harvest of potato. Potato remains in the field for about 3-3.5 months while it is stored at cold storages for about 7-8 months. The quality of potato depends on the performance of the cold storages across the country. At private level, there is not a single cold storage for seed potato preservation. In some cases, a chamber of normal cold storages are declared convenient as a seed chamber where relative humidity, temperature and free air movement are not maintained like seed potato storages. Under such circumstances, the quality of seed potato is deteriorated to some extent. A portion of this research activity is to find out the comparative study of performance of 3 cold storages at both private and public levels of Nilphamari district.

After collecting data of my experimental plots, the crop reached at maturity within 10 days. Haulm pulling operation was done before harvesting the crop in the field.

Potato tubers were collected from 3 replications following seed certification agency (SCA) manual for grading of potato. Oversize, undersize, damaged and diseased tubers were discarded during sorting and grading. The whole lot of tubers was divided into 3 equal portions in the curing shed before sending to 3 cold storages. Then potatoes were

kept in 3 cold storages around 7.5 months. The tubers were stored treatment wise by small gunny bags and finally through big gunny bags.

3.23 Seed quality test

As a part of research activity, seed potato had to store treatment wise at the latest of March in 3 public and private cold storages of Nilphamari district in 2010-11 and 2011-12. After being treated with plant growth regulators and micronutrients in the experimentation season, the stored potatoes were released from three cold storages in the beginning of November, just before setting up of experiment of seed potato quality test in the field in 2011-12 and 2012-13.

To find out the seed quality test of tubers stored in one public and two private cold storages, the following procedures were followed step by step through setting up of experiment in the pot in consecutive two years 2011-12 and 2012-2013.

- a) Total number of eyes per tuber
- b) Sprouted eyes (%)
- c) Non-sprouted eyes (%)
- d) Germination percentage
- e) Days need to shoot emergence
- f) Number of haulms per tuber
- g) Seed vigour index

Plate 1

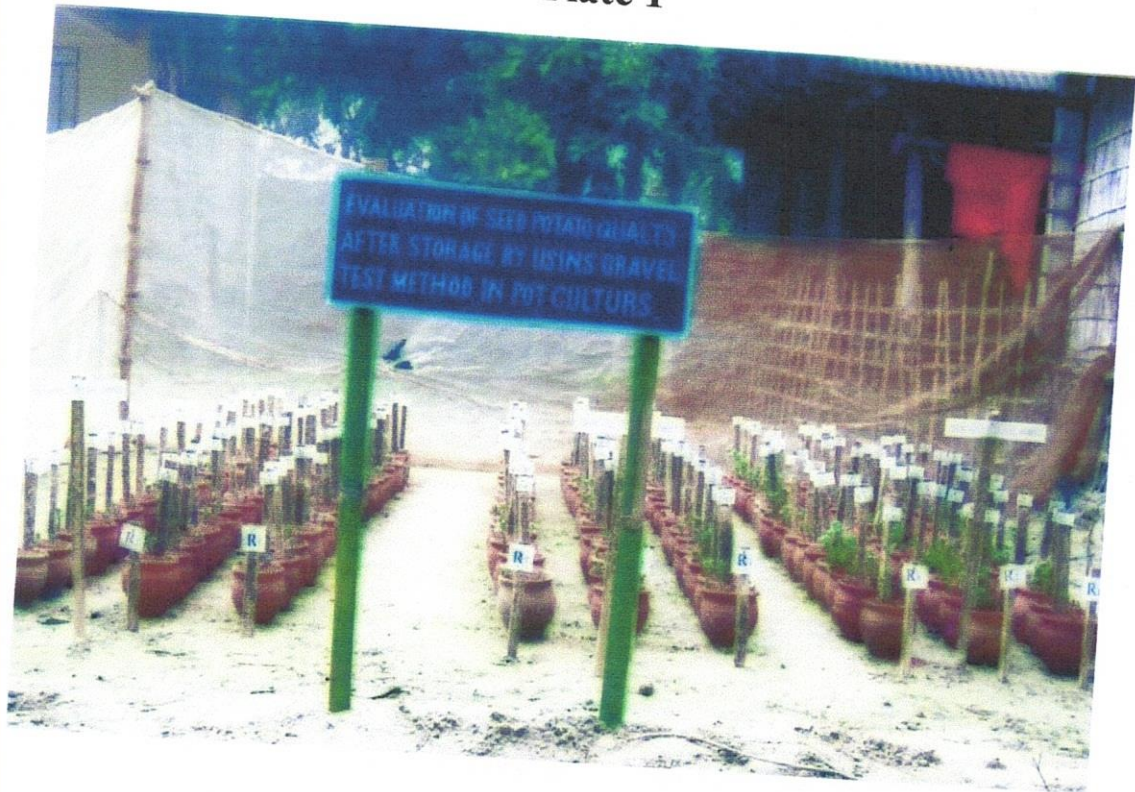


Plate 1. Evaluation of seed potato quality after storage by using Gravel test method in pot culture

- a) Number of total eyes per tuber:** Number of total eyes was counted for 10 tubers set to be planted for counting sprouting and non-sprouting eyes, germination test, vigour tests etc
- b) Number of sprouting and non-sprouting eyes:** Number of sprouted and non-sprouted eyes of each tuber were counted individually which was finally expressed in percentage.
- c) Germination test:** To find out the germination percentage the following steps were followed.
- i) Germination media:** Pots were used as media for germination test. Two thirds of each medium size pot (54 pots for 3 replication) were filled up with sandy loam soils. Three experiments for three cold storages were set in the pot side by side.
- ii) Seed setting:** Five hundred forty seed tubers were taken for germination test for one experiment. Ten seed tubers were set in each plot and finally covered with brick gravel (around 2-3 cm thick).
- iii) Data collection for germination test:** Data on germination of seed tubers were collected regularly after 10 days since first sprouting. After 5 days total number of germinated seedlings were counted. Percentage of germination was determined as follows:
- $$\% \text{ Germination} = \frac{\text{No. of germinated tubers}}{\text{No. of tubers set for germination}} \times 100$$
- d) Number of days to shoot emergence:** Days required to emerge shoot were counted for each treatment regularly till completely emergence of shoots. It differs from cultivar to cultivar.

e) Number of haulms per tuber: After complete emergence of shoot of tubers, the number of haulms was counted for each treatment. It also varies from cultivar to cultivar.

f) Vigour test: After setting seed tuber in the plot/field covered by gravel upto 2-3 cm data were collected regularly from the beginning to the end of experiment. Percent germination was calculated from the final count. Vigour index was found out by using the following formula (Maguire, 1962).

$$\text{Vigour index} = \frac{\text{No. of normal seedling (first count)}}{\text{Days to first count}} + \frac{\text{No. of normal seedling (final count)}}{\text{Days to final count}}$$

c) Yield and yield contributing characters

- Plant height (cm)
- Plant weight (g)
- Number of leaf per plant
- Number of tuber per plant
- Number of haulm per plant
- Yield (t/ha)
- Plant weight with tuber (t/ha)
- Plant weight without tuber (t/ha)
- Harvest index (%)

Harvest index was calculated according to the following formula:

$$\text{Harvest index (\%)} = \frac{\text{Grain yield}}{\text{Biological yield}} \times 100$$

(Biological yield = Grain yield + Straw yield)

3.24 Procedure of data collection at harvest

- a) **Plant height (cm):** The plant height was taken from five randomly selected plants of each plot. The height of the plant was measured from the base of the plant to the tip of the upper most leaf by meter scale.
- b) **Number of haulms per tuber:** Number of haulms per tuber was counted from those plants previously taken plant height.
- c) **Number of leaves:** Number of leaves was counted from randomly selected five plants from each plot.
- d) **Plant weight with tubers (gm):** The weight of randomly selected five plants was taken with potato tubers.
- e) **Plant weight without tuber (gm):** In the similar way, the weight of plants without tubers were taken from 5 randomly selected plants.

3.25 Benefit-cost ratio (BCR) as a table potato

Benefit-cost ratio indicated whether the cultivation is profitable or not. Benefit-cost ratio was calculated using the following formula:

$$\text{BCR} = \frac{\text{Gross return (Tk. ha}^{-1}\text{)}}{\text{Cost of production (Tk. ha}^{-1}\text{)}}$$

3.26 Calculation of benefit cost ratio (BCR) as a seed potato

Sorting and grading were done as per Seed Certification Agency (SCA) manual after releasing potato from cold storages. Initial weight of tubers was taken before storing. At this stage, final weight of tubers were taken

after sorting and grading to calculate the weight loss (weight loss due to low RH, using growth regulators on foliage and early sprouting during storage) of the individual treatments of three cold storages of both the years. The seed potatoes were ready for selling in the local markets. Just before the commencement of seed potato quality test in the pots, if the potatoes were sold out as a seed it could easily be calculated the benefit cost ratio (BCR) which was very much important to ventilate the causes of weight loss and rotting during preservation of potato treated with plant growth regulators.

3.27 Growth analysis technique

From the dry weight of different plant parts and leaf area data, the following growth attributes were calculated between two successive harvests by following the classical technique of growth analysis (Radford, 1967).

1. Crop growth rate (CGR) = $\frac{W_2 - W_1}{t_2 - t_1}$
2. Relative growth rate (RGR) = $\frac{\log_e W_2 - \log_e W_1}{t_2 - t_1}$
3. Net assimilation rate (NAR) = $\frac{(W_2 - W_1) (\log_e LA_2 - \log_e LA_1)}{(LA_2 - LA_1) (t_2 - t_1)}$
4. Leaf area ratio (LAR) = $\frac{(LA_2 - LA_1) (\log_e W_2 - \log_e W_1)}{(\log_e LA_2 - \log_e LA_1) (W_2 - W_1)}$
5. Relative leaf growth rate (RLGR) = $\frac{\log_e LA_2 - \log_e LA_1}{t_2 - t_1}$

$$6. \text{ Leaf area index (LAI)} = \frac{\text{Total leaf area}}{\text{Ground area}}$$

$$7. \text{ Specific leaf area (SLA)} = \frac{\text{Leaf area}}{\text{Leaf dry weight}}$$

$$8. \text{ Leaf weight ratio (LWR)} = \frac{\text{Leaf dry weight}}{\text{Total plant dry weight}}$$

Where W_2 and W_1 are the total dry weights. LA_2 and LA_1 are the leaf area per plant, t_2 and t_1 are the latter and former harvests, respectively.

3.28 Collection of experimental data

b) Plant characters at phenological stages

- Plant height (cm)
- Number of haulms per plant

3.29 Meteorological data

a) Meteorological data specially data of temperature, relative humidity and rainfall were collected from meteorological sub-station, Saidpur Air Port office, Nilphamari. The data like maximum and minimum temperature ($^{\circ}\text{C}$), relative humidity (%) and rainfall (mm) were collected during the study period- from October 2010 to March 2011 and from October 2011 to March 2012 (Appendix-4).

b) The data like temperature and relative humidity were collected from Sajeda cold storage, Saidpur, Saon cold storage, Domar and BADC cold storage, Domar of Nilphamari district from March 2011 to November 2011 and March 2012 to November 2012 (Appendix-5).

3.30 Statistical analysis of data

The experimental design was Randomized Complete Block Design (RCBD) with three replications. Analysis of variance was done by using MSTAT-C Programme. The mean differences were adjudged by Duncan's Multiple Range Test (Steel and Torie, 1960) at 5% level of significance.

Throughout the thesis, the following notations have been used to specify statistical significance

NS=Non-significant, *=Significant at $p=0.05$, **= Significant at $p=0.01$

CHAPTER 4

RESULTS

4.1 Growth characters

4.1.1 Total dry matter (TDM)

The analysis of variation indicated that cultivar differences for total dry matter (TDM) were significant at all the harvests in both the years. The treatment differences were also significant at all the harvests. On the other hand, interaction effect between cultivars and treatments was non-significant at all the harvests in both the years (Table 2a and 2b).

Cultivar Diamant showed the highest and cultivar Granola showed the lowest TDM values in both the years. TDM values of cultivar Diamant (V_1) and Asterix (V_2) were found statistically identical at 65 DAP in 2010-11 and in 2011-12. On the other hand, TDM values of cultivar Asterix and Granola were found statistically identical at 35 DAP in both the years (Table 3a and 3b)

The highest TDM values were obtained from the treatment of T_4 (Vitaplus+Wuxalsuper) at all the harvests in both the years. TDM values of treatment T_2 (Brassinosteroid) and T_3 (Wuxalsuper) were found statistically identical at 35 DAP in 2010-11. TDM values of treatment T_1 (Vitaplus) and T_2 (Brassinosteroid) were found statistically identical at 65 DAP in both the years. The lowest TDM values were found in T_0 (control) treatment at all the harvests in both the years (Table 4a and 4b).

TDM was not significantly affected by the interaction effect between cultivars and treatments.

Effect of treatments on total dry matter (TDM) of three cultivars at different stages of growth of both the years is shown in the Figure 1a and 1b for 1st year and 2nd year, respectively. Total dry matter increased slowly up to 55 DAP but after that it increased rapidly with the progress towards the growth period up to 75DAP and thereafter it decreased slowly in all the treatments of three cultivars in both the years.

Table 2a. Mean squares from analysis of variance for total dry matter (g m^{-2}) of potato [1st year (2010-2011)]

Sources of variation	df	Days after planting					
		35	45	55	65	75	85
Replication	2	1408.31	6733.78	3586.10	1722.31	14783.21	10933.70
Cultivar (A)	2	424.27 ^{**}	6680.07 ^{**}	6192.28 ^{**}	4662.50 ^{**}	12793.05 ^{**}	9461.51 ^{**}
Treatment (B)	5	1010.97 ^{**}	16055.06 ^{**}	46688.82 ^{**}	107729.23 ^{**}	127900.08 ^{**}	94593.95 ^{**}
A×B	10	17.48 ^{NS}	538.05 ^{NS}	127.23 ^{NS}	192.75 ^{NS}	460.54 ^{NS}	340.57
Error	34	16.28	484.96	195.38	424.04	284.13	210.13
CV(%)		5.03	7.77	2.67	2.50	1.49	1.49

Table 2b. Mean squares from analysis of variance for total dry matter (g m^{-2}) of potato [2nd year (2011-2012)]

Sources of variation	df	Days after planting					
		35	45	55	65	75	85
Replication	2	1033.63	9165.83	3517.67	2057.96	15400.26	11390.31
Cultivar (A)	2	324.33 ^{**}	9268.68 ^{**}	5939.73 ^{**}	4725.91 ^{**}	13250.05 ^{**}	9800.19 ^{**}
Treatment (B)	5	1111.91 ^{**}	19713.43 ^{**}	46550.90 ^{**}	107666.22 ^{**}	129445.26 ^{**}	95736.73 ^{**}
A×B	10	14.59 ^{NS}	102.89 ^{NS}	130.86 ^{NS}	190.63 ^{NS}	498.24 ^{NS}	368.43 ^{NS}
Error	34	8.55	156.95	212.72	395.16	278.42	205.94
CV(%)		3.66	4.40	2.76	2.40	1.47	1.47

Table 3a. Effect of cultivars on total dry matter (g m^{-2}) at different days after planting [1st year (2010-11)]

Cultivars	Days after planting					
	35	45	55	65	75	85
Diamant (V_1)	85.74a	302.54a	540.02a	837.44a	1158.94a	996.69a
Asterix (V_2)	78.39b	283.74ab	525.73b	827.44a	1131.42b	973.02b
Granola (V_3)	76.57b	264.01b	503.23c	805.95b	1105.63c	950.84c
Level of significance	**	**	**	**	**	**

Table 3b. Effect of cultivars on total dry matter (g m^{-2}) at different days after planting [2nd year (2011-12)]

Cultivars	Days after planting					
	35	45	55	65	75	85
Diamant (V_1)	84.71a	305.71a	544.64a	842.54a	1166.05a	1002.80a
Asterix (V_2)	78.85b	287.47b	530.23b	833.28a	1137.03b	977.85b
Granola (V_3)	76.47b	260.60c	508.55c	811.01b	1111.83c	956.17c
Level of significance	**	**	**	**	**	**

Table 4a. Effect of treatments on total dry matter (g m^{-2}) at different days after planting [1st year (2010-11)]

Treatments	Days after planting					
	35	45	55	65	75	85
T ₀	59.79d	211.04e	383.94e	624.77e	915.26e	787.12f
T ₁	79.77c	264.01d	520.93d	810.45d	1106.80e	951.84e
T ₂	82.21bc	283.60cd	533.05cd	816.02d	1132.02d	973.54d
T ₃	83.65bc	298.63bc	546.91c	848.40c	1163.75c	1000.82c
T ₄	89.98a	330.31a	586.19a	936.73a	1250.38a	1075.32a
T ₅	85.99ab	312.97ab	566.94b	905.29b	1223.77b	1052.44b
Level of significance	**	**	**	**	**	**

Table 4b. Effect of treatments on total dry matter (g m^{-2}) at different days after planting [2nd year (2011-12)]

Treatments	Days after planting					
	35	45	55	65	75	85
T ₀	58.92e	201.62e	388.91e	630.77e	919.93f	791.14f
T ₁	78.69d	266.70d	526.77d	814.50d	1112.52e	956.76e
T ₂	81.37cd	286.89c	537.62cd	820.97d	1138.94d	979.49d
T ₃	84.32bc	302.01bc	550.624c	853.92c	1171.75c	1007.70c
T ₄	90.660a	333.71a	591.364a	942.80a	1257.13a	1081.13a
T ₅	86.11b	316.62b	571.53b	910.68b	1229.54b	1057.41b
Level of significance	**	**	**	**	**	**

T₀= Control, T₁ = Vitaplus, T₂= Brassinosteroid, T₃=Wuxalsuper

T₄= Vitaplus + Wuxalsuper, T₅= Brassinosteroid+ Wuxalsuper,

In a column, the figures bearing same letter(s) or without letters are identical and those having dissimilar letters differed significantly as per DMRT

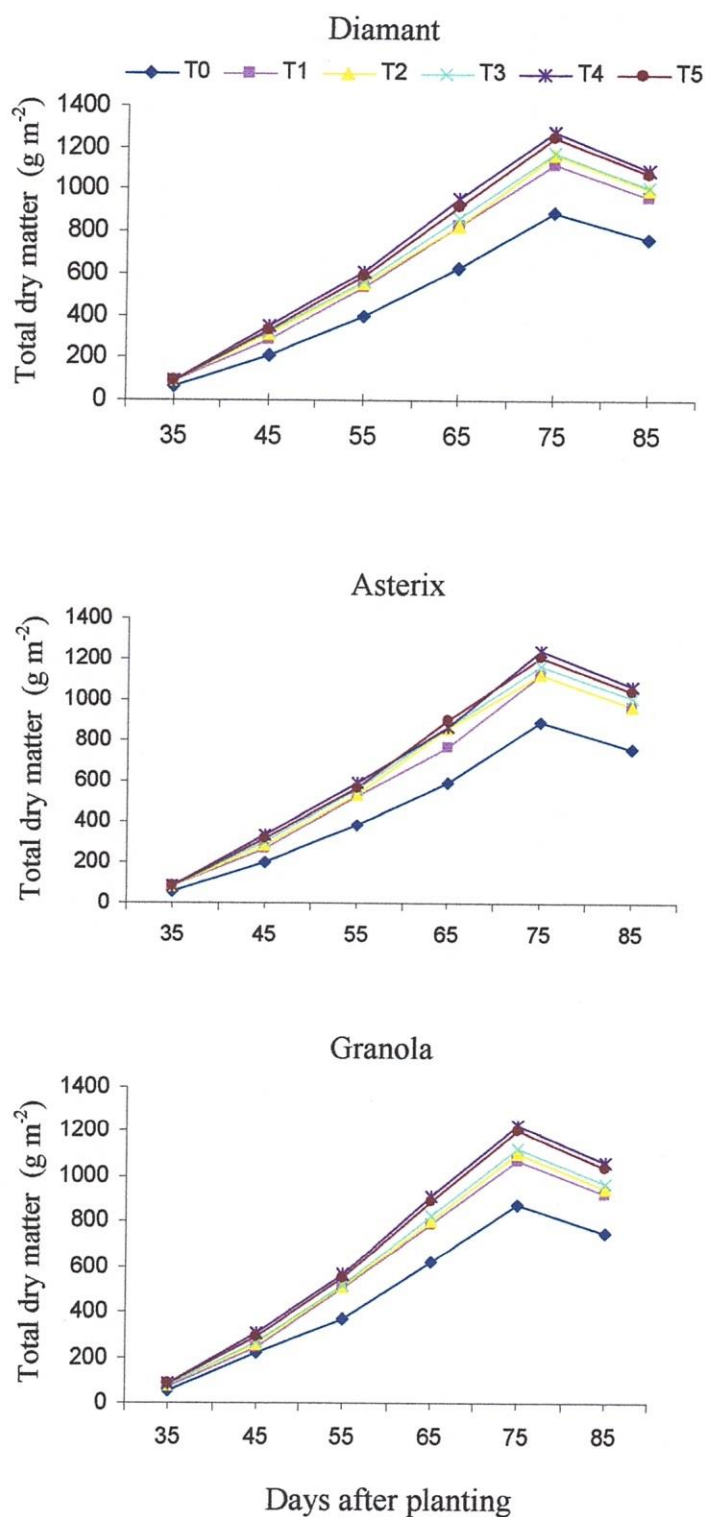


Figure 1a. Effect of plant growth regulators and micro nutrient treatments on total dry matter (TDM) of three potato cultivars at different stages of growth [1st year (2010-2011)]

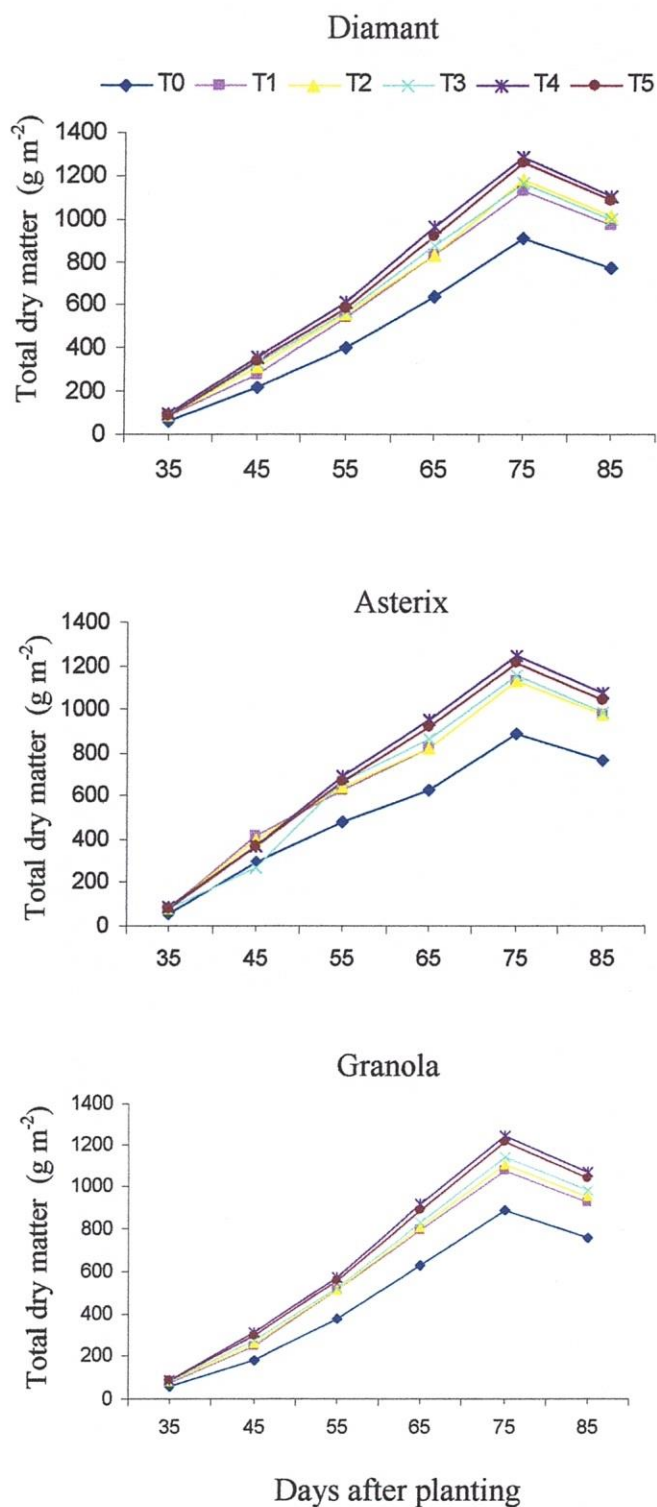


Figure 1b. Effect of plant growth regulators and micro nutrient treatments on total dry matter (TDM) of three potato cultivars at different stages of growth [2nd year (20110-2012)]

4.1.2 Leaf area index (LAI)

Analysis of variation indicated that cultivar differences for leaf area index (LAI) were significant at all the harvests in both the years except at 45DAP in 2011-12. Treatments were significant at all the harvests in both the years. Interaction effect between cultivars and treatments were non-significant at all the harvests in both the years (Tables 5a and 5b).

Cultivar V₁ (Diamant) showed the highest values at all the harvests in 2010-11 and 2011-12. LAI value of the cultivar Diamant and Asterix was found statistically identical at 55 DAP in 2010-11 and LAI value of the cultivar Asterix and Granola was found statistically identical at 45 and 65 DAP in 2010-11 and at 55 and 65 DAP in 2011-12 (Tables 6a and 6b).

Treatment T₄ (Vitapulus + Wuxalsuper) produced the highest LAI at all the harvests in both the years. The second highest LAI value was observed in the treatment T₅ (Brsssinosteroid + Wuxalsuper). LAI values of the treatment T₄ and T₅ were found statistically identical at 35 and 85 DAP in 2010-11. The LAI value of treatments T₁ (Vitapulus), T₂ (Brsssinosteroid) and T₃ (Wuxalsuper) were found statistically identical at 35 DAP in 2010-11 and at 75 and 85 DAP in 2011-12. Similarly, the LAI value of treatments T₁ (Vitapulus) and T₂ (Brsssinosteroid) were found statistically identical at 55 and 75 DAP in 2010-11 and at 35 DAP in 2011-12 (Tables 7a and 7b).

Effect of treatments (plant growth regulators and micronutrients) on LAI of three cultivars at different stages of growth is shown in the Figures 2a & 2b. LAI of three cultivars and all the treatments increased progressively with the age of plants and attained peak at 75 DAP and decreased slowly at the later stages of plant growth.

Table 5a. Mean squares from analysis of variance for leaf area index of potato [1st year (2010-2011)]

Sources of variation	df	Days after planting					
		35	45	55	65	75	85
Replication	2	0.004	0.001	0.000	0.001	0.001	0.001
Cultivar (A)	2	0.001 ^{**}	0.001 ^{**}	0.001 [*]	0.001 ^{**}	0.003 ^{**}	0.003 ^{**}
Treatment (B)	5	0.003 ^{**}	0.026 ^{**}	0.040 ^{**}	0.068 ^{**}	0.085 ^{**}	0.063 ^{**}
A×B	10	0.000 ^{NS}	0.000 ^{NS}	0.000 ^{NS}	0.000 ^{NS}	0.000 ^{NS}	0.000 ^{NS}
Error	34	0.000	0.000	0.000	0.000	0.000	0.000
CV(%)		5.62	2.02	2.44	1.35	0.94	0.93

Table 5b. Mean squares from analysis of variance for leaf area index of potato [2nd year (2011-2012)]

Sources of variation	df	Days after planting					
		35	45	55	65	75	85
Replication	2	0.003	0.002	0.000	0.001	0.002	0.001
Cultivar (A)	2	0.000 [*]	0.000 ^{NS}	0.002 ^{**}	0.001 ^{**}	0.003 ^{**}	0.003 ^{**}
Treatment (B)	5	0.004 ^{**}	0.030 ^{**}	0.053 ^{**}	0.072 ^{**}	0.085 ^{**}	0.063 ^{**}
A×B	10	0.000 ^{NS}	0.000 ^{NS}	0.000 ^{NS}	0.000 ^{NS}	0.000 ^{NS}	0.000 ^{NS}
Error	34	0.000	0.000	0.000	0.000	0.000	0.000
CV(%)		4.76	2.44	1.54	1.32	0.97	0.99

Table 6a. Effect of cultivars on leaf area index at different days after planting [1st year (2010-11)]

Cultivars	Days after planting					
	35	45	55	65	75	85
Diamant (V ₁)	0.175a	0.398a	0.556a	0.700a	0.839a	0.721a
Asterix (V ₂)	0.166ab	0.387b	0.554a	0.688b	0.826b	0.710b
Granola (V ₃)	0.162b	0.385b	0.543b	0.684b	0.811c	0.697c
Level of significance	**	**	*	**	**	**

Table 6b. Effect of cultivars on leaf area index at different days after planting [2nd year (2011-12)]

Cultivars	Days after planting					
	35	45	55	65	75	85
Diamant (V ₁)	0.176a	0.416	0.585a	0.714a	0.854a	0.722a
Asterix (V ₂)	0.169ab	0.411	0.575b	0.702b	0.842b	0.711b
Granola (V ₃)	0.168b	0.408	0.567b	0.698b	0.827c	0.698c
Level of significance	*	NS	**	**	**	**

Table 7a. Effect of treatments on leaf area index at different days after planting [1st year (2010-11)]

Treatments	Days after planting					
	35	45	55	65	75	85
T ₀	0.14c	0.28	0.42e	0.52e	0.63e	0.54d
T ₁	0.16b	0.40	0.55d	0.70d	0.84d	0.73c
T ₂	0.17b	0.41	0.56d	0.71cd	0.85d	0.73bc
T ₃	0.17b	0.41	0.58c	0.72c	0.86c	0.74b
T ₄	0.19a	0.43	0.60a	0.75a	0.89a	0.77a
T ₅	0.18a	0.42	0.59b	0.74b	0.88b	0.76a
Level of significance	**	**	**	**	**	**

Table 7b. Effect of treatments on leaf area index at different days after planting [2nd year (2011-12)]

Treatment	Days after planting					
	35	45	55	65	75	85
T ₀	0.14d	0.30e	0.42e	0.53e	0.65d	0.54d
T ₁	0.17c	0.42d	0.59d	0.71d	0.86c	0.73c
T ₂	0.17c	0.43cd	0.59cd	0.73c	0.86c	0.73c
T ₃	0.18bc	0.43bc	0.60c	0.74c	0.87c	0.74c
T ₄	0.19a	0.46a	0.63a	0.77a	0.91a	0.77a
T ₅	0.19a	0.44b	0.62b	0.75b	0.89b	0.75b
Level of significance	**	**	**	**	**	**

T₀=Control, T₁ = Vitapulus, T₂= Brassinosteroid, T₃=Wuxalsuper

T₄= Vitapulus + Wuxalsuper, T₅= Brassinosteroid+ Wuxalsuper,

In a column, the figures bearing same letter(s) or without letters are identical and those having dissimilar letters differed significantly as per DMRT

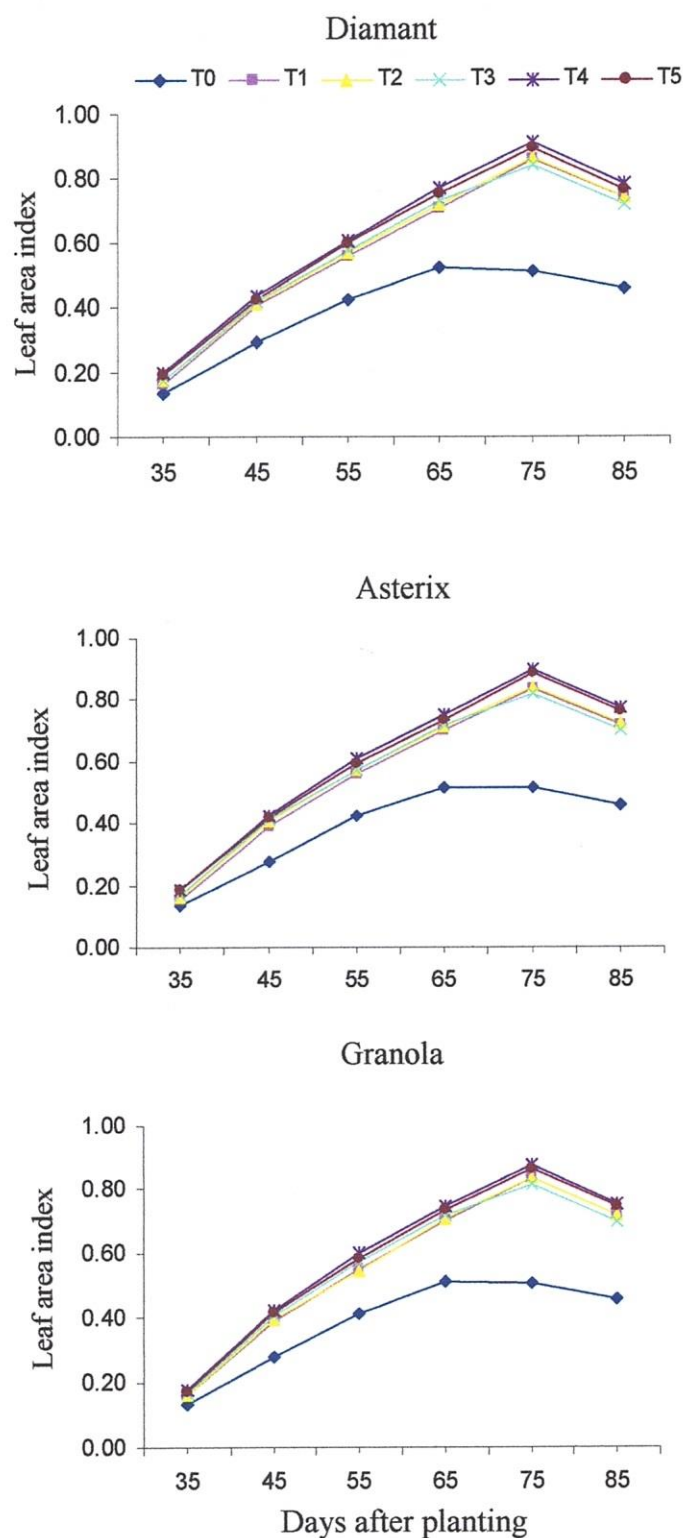


Figure 2a. Effect of plant growth regulators and micro nutrient treatments on leaf area index (LAI) of three potato cultivars at different stages of growth [1st year (2010-2011)].

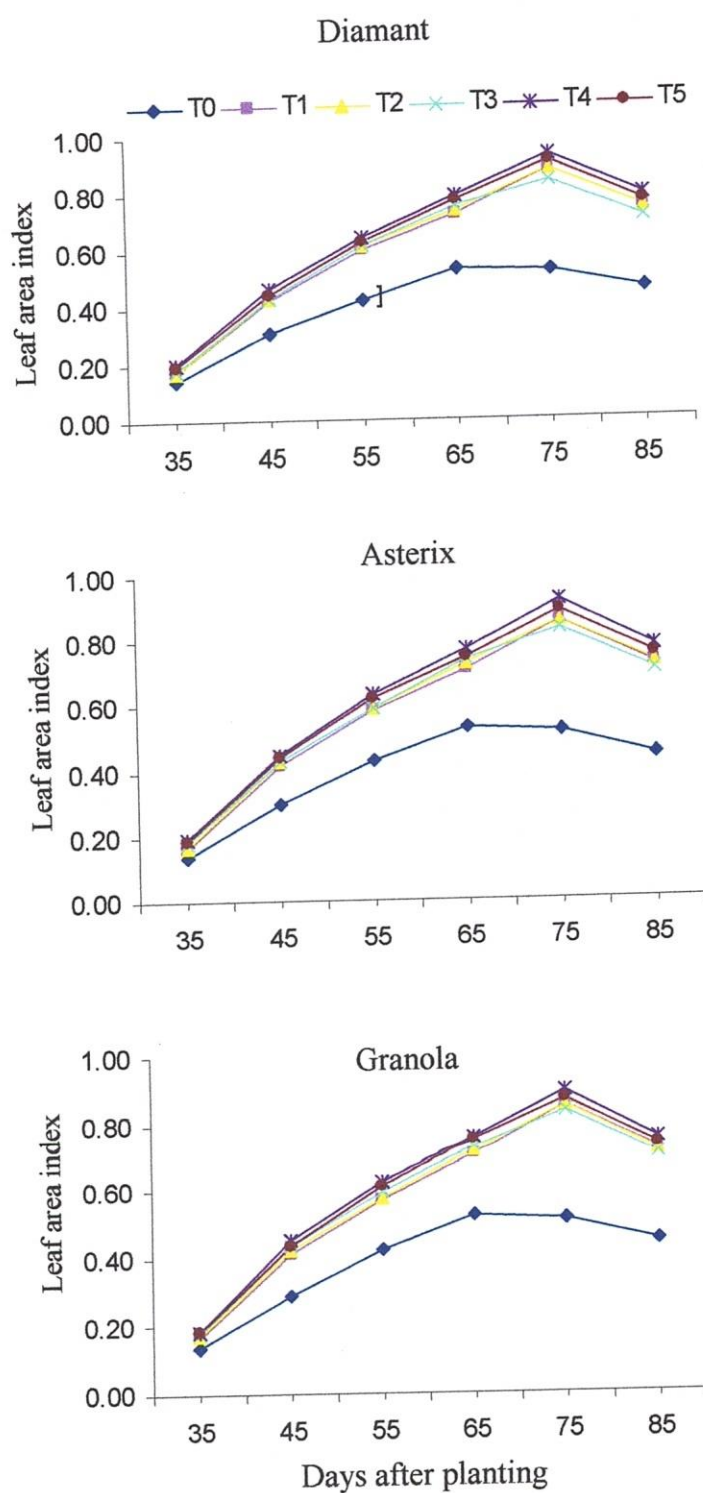


Figure 2b. Effect of plant growth regulators and micro nutrient treatments on leaf area index (LAI) of three potato cultivars at different stages of growth [2nd year (2011-2012)].

4.1.3 Crop growth rate (CGR)

The analysis of variation revealed that differences of cultivars were significant for CGR at 35-45, 65-75 and 75-85 DAP in both the years. Treatment differences were significant at 35-45, 45-55, 55-65 and 75-85 DAP except of 65-75 DAP in 2010-11 and 2011-12. Interaction effect between cultivars and treatments was not significant at all the harvests in both the years (Tables 8a and 8b).

Cultivar Diamant showed the highest CGR values at 35-45, 65-75 and 75-85 DAP in 2010-11 and 2011-12 while the second highest CGR values were found in the cultivar Asterix. The lowest CGR values were found in the cultivar Granola in both the years (Tables 9a and 9b).

Among the treatments, T₄ (Vitapplus + Wuxalsuper) showed the highest CGR values in both the years. The next highest CGR values were found in T₅ (Brassinosteroid + Wuxalsuper) at all the harvests. The highest CGR value T₄ (Vitapplus + Wuxalsuper) at 55-65 DAP was found statistically identical to the treatment of T₅ (Brassinosteroid and Wuxalsuper) in both the years. CGR values of the treatment T₃ (Wuxalsuper) and T₅ (Brassinosteroid + Wuxalsuper) were found statistically identical at 35-45 DAP in 2010-11. In 2010-11, CGR values of treatment T₁ (Vitapplus), T₂ (Brassinosteroid), T₃ (Wuxalsuper), T₄ (Vitapplus + Wuxalsuper) and T₅ (Brassinosteroid + Wuxalsuper) were found statistically identical at 45-55 DAP. Similarly, CGR values of the treatment T₁ (Vitapplus), T₂ (Brassinosteroid) and T₃ (Wuxalsuper) were found statistically identical at 55-65 DAP in 2010-11 and in 2011-12. However, the lowest CGR values were found in T₀ (control) treatment in both the years (Tables 10a and 10b).

The effect of different treatments on crop growth rate (CGR) of three cultivars at different stages of growth of both the years is shown in Figures 3a and 3b for 1st years and 2nd year, respectively. In both the years CGR values increased up to 65-75 DAP in all the treatments of three cultivars. In all the treatments, CGR of all the cultivars reached a certain peak at 65-75DAP and thereafter it declined to negative value at the later stages of growth.

Table 8a. Mean squares from analysis of variance for crop growth rate ($\text{g m}^{-2} \text{ day}^{-1}$) of potato
[1st year (2010-2011)]

Sources of variation	df	Days after planting				
		35-45	45-55	55-65	65-75	75-85
Replication	2	19.92	5.84	7.17	64.16	2.91
Cultivar (A)	2	39.42 ^{**}	0.17 ^{NS}	0.09 ^{NS}	24.05 [*]	2.49 ^{**}
Treatment (B)	5	92.59 ^{**}	97.72 ^{**}	131.90 ^{**}	12.63 ^{NS}	25.06 ^{**}
A×B	10	4.90 ^{NS}	3.07 ^{NS}	2.02 ^{NS}	5.79 ^{NS}	0.09 ^{NS}
Error	34	5.32	5.61	5.81	7.05	0.06
CV(%)		11.35	9.88	8.04	8.61	1.49

Table 8b. Mean squares from analysis of variance for crop growth rate ($\text{g m}^{-2} \text{ day}^{-1}$) of potato
[2nd year (2011-2012)]

Sources of variation	df	Days after planting				
		35-45	45-55	55-65	65-75	75-85
Replication	2	41.75	17.36	4.46	62.36	3.01
Cultivar (A)	2	63.29 ^{**}	3.70 ^{NS}	0.25 ^{NS}	27.42 [*]	2.59 ^{**}
Treatment (B)	5	115.70 ^{**}	69.18 ^{**}	134.43 ^{**}	14.34 ^{NS}	25.38 ^{**}
A×B	10	0.89 ^{NS}	1.41 ^{NS}	2.08 ^{NS}	5.77 ^{NS}	0.10 ^{NS}
Error	34	1.69	3.57	5.82	6.93	0.06
CV (%)		6.35	7.77	8.02	8.51	1.47

Table 9a. Effect of cultivars on crop growth rate ($\text{g m}^{-2} \text{ day}^{-1}$) at different days after planting [1st year (2010-11)]

Cultivars	Days after planting				
	35-45	45-55	55-65	65-75	75-85
Diamant (V_1)	21.679a	23.916	29.911	32.150a	-16.224c
Asterix (V_2)	20.535ab	24.087	30.006	30.397ab	-15.840b
Granola (V_3)	18.743b	23.921	30.049	29.968b	-15.480a
Level of significance	**	NS	NS	*	**

Table 9b. Effect of cultivars on crop growth rate ($\text{g m}^{-2} \text{ day}^{-1}$) at different days after planting [2nd year (2011-12)]

Cultivars	Days after planting				
	35-45	45-55	55-65	65-75	75-85
Diamant (V_1)	22.098a	23.893	29.957	32.351a	-16.323c
Asterix (V_2)	20.862b	24.276	30.194	30.376b	-15.918b
Granola (V_3)	18.414c	24.796	30.081	30.082b	-15.565a
Level of significance	**	NS	NS	*	**

Table 10a. Effect of treatments on crop growth rate ($\text{g m}^{-2} \text{ day}^{-1}$) at different days after planting [1st year (2010-11)]

Treatments	Days after planting				
	35-45	45-55	55-65	65-75	75-85
T ₀	15.124d	17.290b	24.083c	29.048	-12.813a
T ₁	18.423c	25.691a	28.952b	29.636	-15.497b
T ₂	20.140bc	25.168a	28.410b	31.600	-15.849c
T ₃	21.499ab	24.716a	30.260b	31.536	-16.292d
T ₄	24.030a	25.698a	34.723a	31.363	-17.503e
T ₅	22.699ab	25.286a	33.502a	31.848	-17.133f
Level of significance	**	**	**	NS	**

Table 10b. Effect of treatments on crop growth rate ($\text{g m}^{-2} \text{ day}^{-1}$) at different days after planting [2nd year (2011-12)]

Treatments	Days after planting				
	35-45	45-55	55-65	65-75	75-85
T ₀	14.270e	18.729b	24.186c	28.917	-12.878a
T ₁	18.802d	26.008a	28.886b	29.802	-15.574b
T ₂	20.553c	25.072a	28.447b	31.797	-15.944c
T ₃	21.768bc	24.863a	30.441b	31.782	-16.404d
T ₄	24.304a	25.766a	34.922a	31.433	-17.599f
T ₅	23.051ab	25.492a	33.582a	31.886	-17.213e
Level of significance	**	**	**	NS	**

T₀=Control, T₁ = Vitaplus, T₂= Brassinosteroid, T₃=Wuxalsuper

T₄= Vitaplus + Wuxalsuper, T₅= Brassinosteroid+ Wuxalsuper,

In a column, the figures bearing same letter(s) or without letters are identical and those having dissimilar letters differed significantly as per DMRT

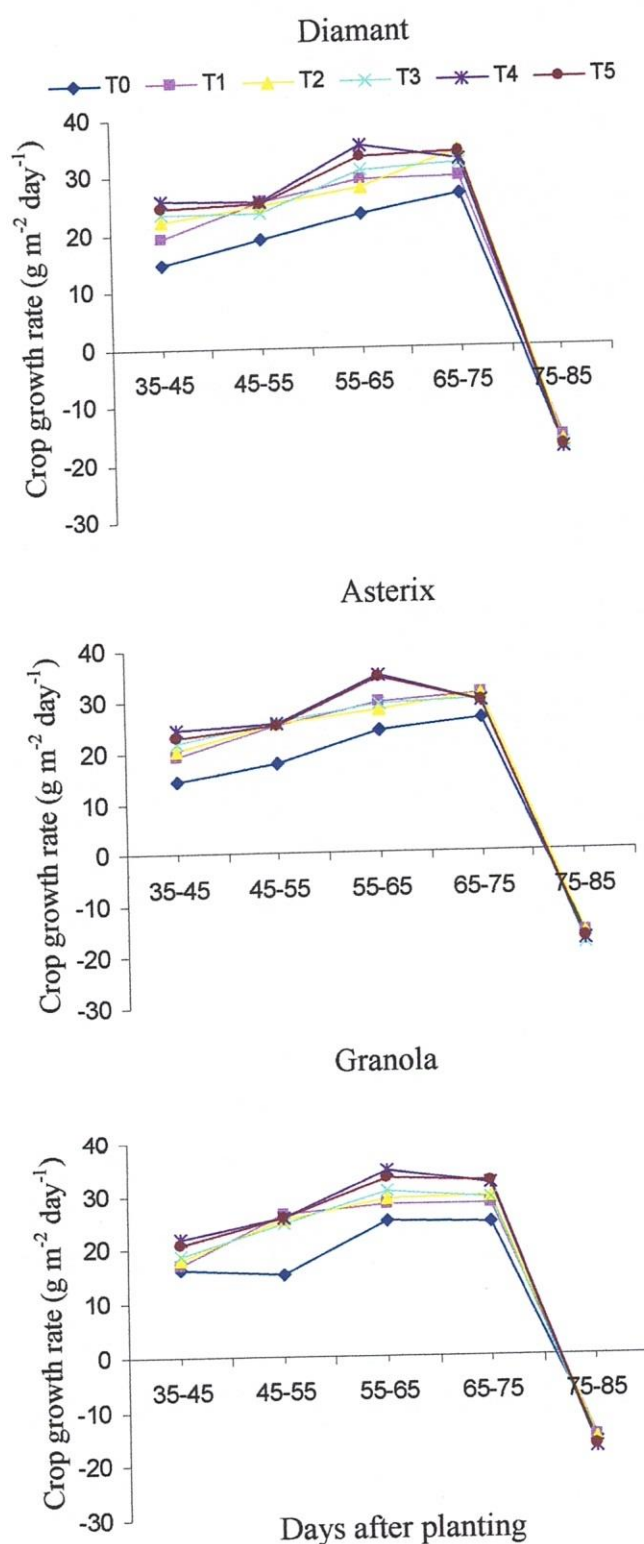


Figure 3a. Effect of plant growth regulators and micro nutrient treatments on crop growth rate (CGR) of three potato cultivars at different stages of growth [1st year (2010-2011)].

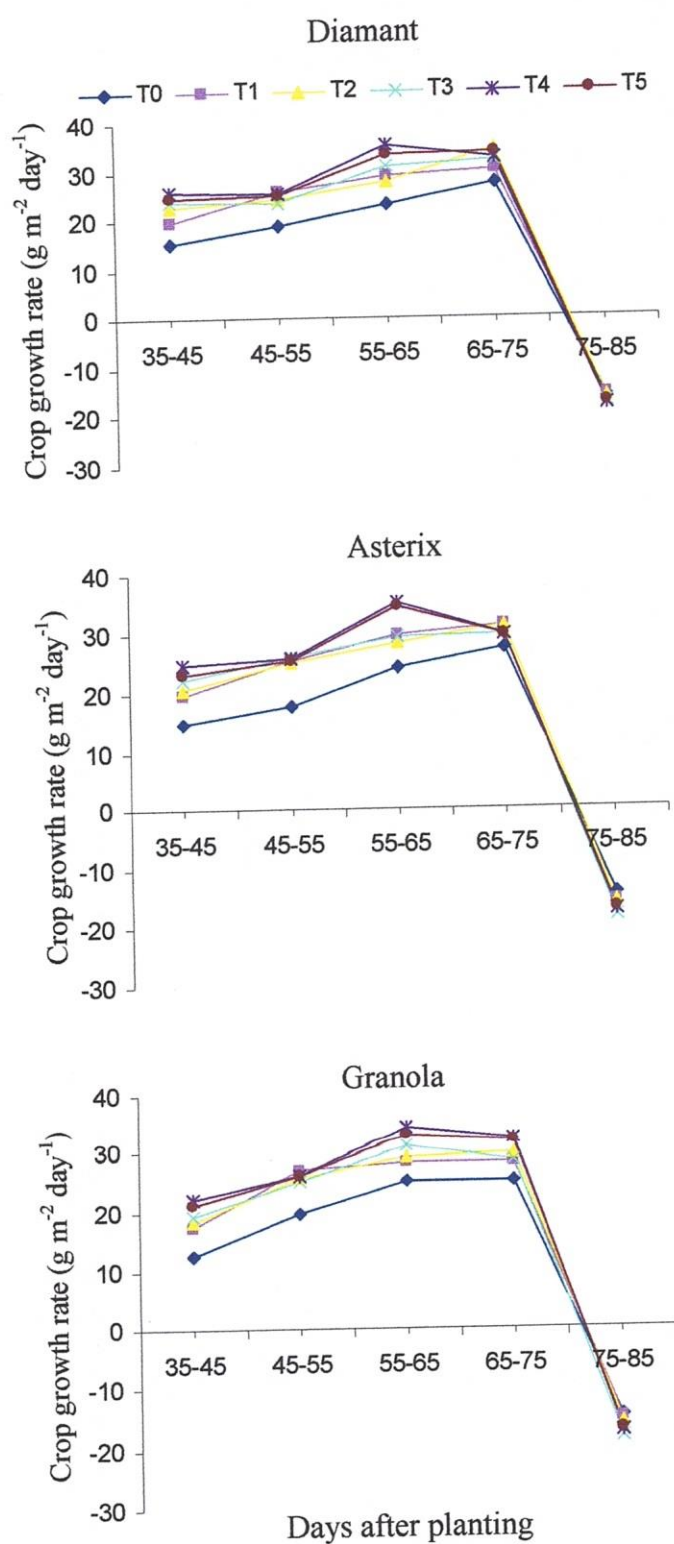


Figure 3b. Effect of plant growth regulators and micro nutrient treatments on crop growth rate (CGR) of three potato cultivars at different stages of growth [2nd year (2011-2012)].

4.1.4 Relative growth rate (RGR)

From the analysis of variance it is revealed that cultivar differences were non-significant at all the harvests in 2010-11 and 2011-12. Treatment differences were non-significant at all the harvests in both the years. Interaction effect between cultivars and treatments were non-significant at all the harvests in both the years (Tables 11a and 11b).

Cultivar Asterix showed the highest RGR values at 35-45 DAP in both the years. Cultivar Diamant showed the highest values at 65-75 DAP in both the years while the cultivar Granola showed the highest RGR values at 45-55 and 55-65 DAP in both the years. RGR values varied from cultivar to cultivar as no clear trend was indicated (Tables 12a and 12b)

Treatment T₄ (Vitapulus + Wuxalsuper) showed maximum RGR values at 35-45 DAP in 2010-11, while treatment T₁ (Vitapulus) showed the highest value at 45-55 DAP in both the years. On the other hand, treatment T₀ (control) showed maximum RGR values at 55-65 and 65-75 DAP in 2010-11 and at 45-55, 55-65 and 65-75 DAP in 2011-12. It does not follow any specific trend (Tables 13a and 13b)

Effect of different treatments on relative growth rate (RGR) of three cultivars at different stages of growth of both the years is shown in the Figures 4a and 4b. RGR values were found to be maximum at 35-45 DAP in all the treatments of three cultivars in both the years and then it gradually declined with negative value at the later stages of growth.

Table 11a. Mean squares from analysis of variance for relative growth rate ($\text{g g}^{-2} \text{ day}^{-1}$) of potato
[1st year (2010-2011)]

Sources of variation	df	Days after planting				
		35-45	45-55	55-65	65-75	75-85
Replication	2	0.000	0.000	0.000	0.000	0.000
Cultivar (A)	2	0.000 ^{NS}	0.000 ^{NS}	0.000 [*]	0.000 ^{NS}	0.000 ^{NS}
Treatment (B)	5	0.000 ^{NS}	0.000 ^{NS}	0.000 ^{**}	0.000 ^{**}	0.000 ^{NS}
A×B	10	0.000 ^{NS}	0.000 ^{NS}	0.000 ^{NS}	0.000 ^{NS}	0.000 ^{NS}
Error	34	0.000	0.000	0.000	0.000	0.000
CV (%)		9.09	14.23	7.24	9.35	0.00

Table 11b. Mean squares from analysis of variance for relative growth rate ($\text{g g}^{-2} \text{ day}^{-1}$)
[2nd year (2011-2012)]

Sources of variation	df	Days after planting				
		35-45	45-55	55-65	65-75	75-85
Replication	2	0.000	0.001	0.000	0.000	0.000
Cultivar (A)	2	0.000 ^{**}	0.000 ^{**}	0.000 ^{**}	0.000 ^{NS}	0.000 ^{NS}
Treatment (B)	5	0.000 [*]	0.000 ^{**}	0.000 ^{**}	0.000 ^{**}	0.000 ^{NS}
A×B	10	0.000 ^{NS}	0.000 ^{NS}	0.000 ^{NS}	0.000 ^{NS}	0.000 ^{NS}
Error	34	0.000	0.000	0.000	0.000	0.000
CV (%)		4.57	8.70	7.73	9.36	0.00

Table 12a. Effect of cultivars on relative growth rate ($\text{g g}^{-1} \text{ day}^{-1}$) at different days after planting [1st year (2010-11)]

Cultivars	Days after planting				
	35-45	45-55	55-65	65-75	75-85
Diamant (V_1)	0.126	0.059	0.044	0.033	-0.016
Asterix (V_2)	0.129	0.062	0.046	0.032	-0.015
Granola (V_3)	0.124	0.065	0.047	0.032	-0.015
Level of significance	NS	NS	NS	NS	NS

Table 12b. Effect of cultivars on relative growth rate ($\text{g g}^{-1} \text{ day}^{-1}$) at different days after planting [2nd year (2011-12)]

Cultivars	Days after planting				
	35-45	45-55	55-65	65-75	75-85
Diamant (V_1)	0.128	0.059	0.044	0.033	-0.017
Asterix (V_2)	0.129	0.062	0.045	0.031	-0.016
Granola (V_3)	0.122	0.068	0.047	0.032	-0.015
Level of significance	NS	NS	NS	NS	NS

Table 13a. Effect of treatments on relative growth rate ($\text{g g}^{-1} \text{day}^{-1}$) at different days after planting [1st year (2010-11)]

Treatments	Days after planting				
	35-45	45-55	55-65	65-75	75-85
T ₀	0.126	0.061	0.049	0.038	-0.015
T ₁	0.120	0.068	0.044	0.031	-0.015
T ₂	0.124	0.064	0.043	0.033	-0.016
T ₃	0.127	0.061	0.044	0.032	-0.017
T ₄	0.130	0.057	0.047	0.029	-0.018
T ₅	0.129	0.060	0.047	0.030	-0.018
Level of significance	NS	NS	NS	NS	NS

Table 13b. Effect of treatments on relative growth rate ($\text{g g}^{-1} \text{day}^{-1}$) at different days after planting [2nd year (2011-12)]

Treatments	Days after planting				
	35-45	45-55	55-65	65-75	75-85
T ₀	0.123	0.066	0.048	0.038	-0.015
T ₁	0.122	0.069	0.044	0.031	-0.016
T ₂	0.126	0.063	0.042	0.033	-0.016
T ₃	0.127	0.061	0.044	0.031	-0.015
T ₄	0.130	0.057	0.047	0.029	-0.018
T ₅	0.130	0.059	0.047	0.030	-0.017
Level of significance	NS	NS	NS	NS	NS

T₀=Control, T₁ = Vitapulus, T₂= Brassinosteroid, T₃=Wuxalsuper
 T₄= Vitapulus + Wuxalsuper, T₅= Brassinosteroid+ Wuxalsuper,

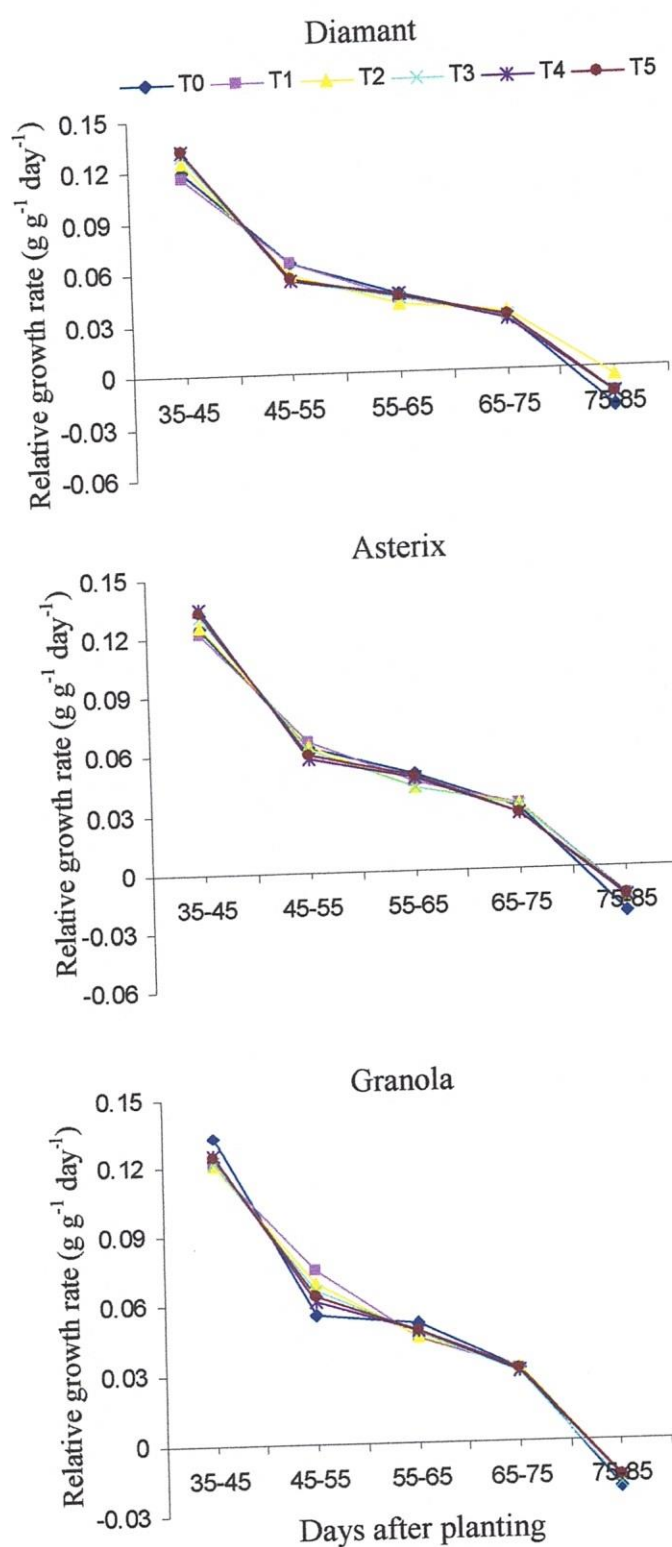


Figure 4a. Effect of plant growth regulators and micro nutrient treatments on relative growth rate (RGR) of three potato cultivars at different stages of growth [1st year (2010-2011)].

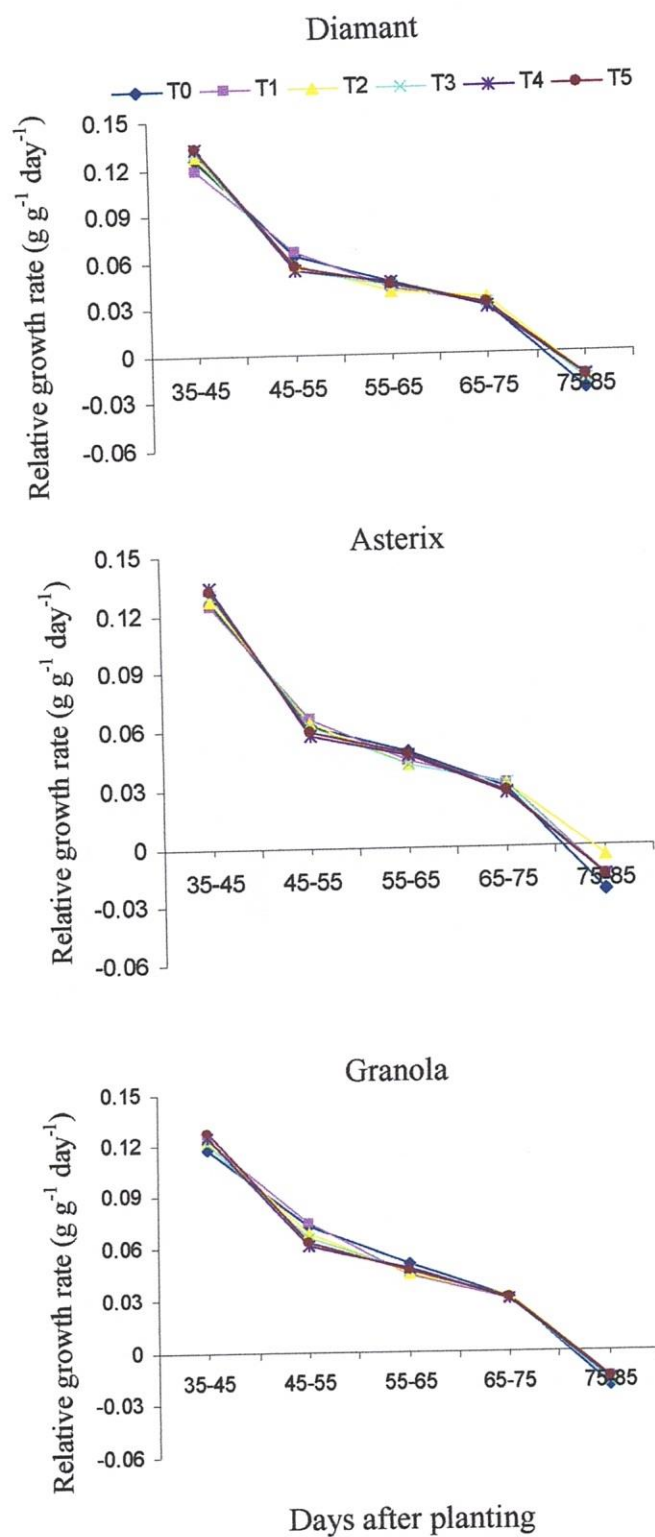


Figure 4b. Effect of plant growth regulators and micro nutrient treatments on relative growth rate (RGR) of three potato cultivars at different stages of growth [2nd year (2011-2012)].

4.1.5 Net assimilation rate (NAR)

Analysis of variation revealed that the cultivar differences for NAR were non-significant at all the harvests in both the years. Treatment differences were non-significant at all the harvests in 2010-11 and 2011-12. Interaction effect between cultivars and treatments was found non-significant at all the harvests in both the years (Tables 14a and 14b)

Cultivar Diamant (V_1) showed the highest NAR values at 35-45 and 65-75 DAP in both the years. Cultivar Granola showed the highest NAR values at 55-65 DAP in 2010-11 and at 45-55 DAP in 2011-12 (Tables 15a and 15b).

Treatment T_4 (Vitaplus + Wuxalsuper) showed the highest NAR values at 35-45 DAP in both the years. Control treatment (T_0) showed the highest NAR values at 65-75 DAP in 2010-11 and at 55-65 and 65-75 DAP in 2011-12 (Tables 16a and 16b)

The effect of different treatments on net assimilation rate (NAR) of three cultivars at different stages of growth of both the years is shown in the Figures 5a and 5b. In all the treatments of three cultivars and both the years NAR values fluctuated throughout the growing period. In both the years at all the treatments and cultivars NAR showed negative values at 75-85 DAP.

Table 14a. Mean squares from analysis of variance for net assimilation rate ($\text{g cm}^{-2} \text{ day}^{-1}$) of potato
[1st year (2010-2011)]

Sources of variation	df	Days after planting				
		35 -45	45-55	55-65	65-75	75-85
Replication	2	0.000	0.000	0.000	0.000	0.000
Cultivar (A)	2	0.000 ^{NS}	0.000 ^{NS}	0.000 ^{NS}	0.000 ^{NS}	0.000 ^{NS}
Treatment (B)	5	0.000 ^{NS}	0.000 ^{NS}	0.000 ^{**}	0.000 ^{**}	0.000 ^{**}
A×B	10	0.000 ^{NS}	0.000 ^{NS}	0.000 ^{NS}	0.000 ^{NS}	0.000 ^{NS}
Error	34	0.000	0.000	0.000	0.000	0.000
CV(%)		13.02	11.97	7.58	87.38	2.33

Table 14b. Mean squares from analysis of variance for net assimilation rate ($\text{g cm}^{-2} \text{ day}^{-1}$) of potato
[2nd year (2011-2012)]

Sources of variation	df	Days after planting				
		35 -45	45-55	55-65	65-75	75-85
Replication	2	0.000	0.000	0.000	0.000	0.000
Cultivar (A)	2	0.000 ^{**}	0.000 ^{NS}	0.000 ^{NS}	0.000 ^{NS}	0.000 [*]
Treatment (B)	5	0.000 ^{**}	0.000 ^{NS}	0.000 ^{**}	0.000 ^{**}	0.000 ^{**}
A×B	10	0.000 ^{NS}	0.000 ^{NS}	0.000 ^{NS}	0.000 ^{NS}	0.000 [*]
Error	34	0.000	0.000	0.000	0.000	0.000
CV(%)		5.87	8.33	7.81	8.81	2.23

Table 15a. Effect of cultivars on net assimilation rate ($\text{g cm}^{-2} \text{ day}^{-1}$) at different days after planting [1st year (2010-11)]

Cultivars	Days after planting				
	35-45	45-55	55-65	65-75	75-85
Diamant (V_1)	0.079	0.051	0.047	0.042	-0.021
Asterix (V_2)	0.078	0.052	0.049	0.041	-0.021
Granola (V_3)	0.073	0.052	0.050	0.041	-0.021
Level of significance	NS	NS	NS	NS	NS

Table 15b. Effect of cultivars on net assimilation rate ($\text{g cm}^{-2} \text{ day}^{-1}$) at different days after planting [2nd year (2011-12)]

Cultivars	Days after planting				
	35-45	45-55	55-65	65-75	75-85
Diamant (V_1)	0.079	0.048	0.046	0.042	-0.021
Asterix (V_2)	0.076	0.050	0.048	0.040	-0.021
Granola (V_3)	0.068	0.052	0.048	0.040	-0.020
Level of significance	NS	NS	NS	NS	NS

Table 16a. Effect of treatments on net assimilation rate ($\text{g cm}^{-2} \text{ day}^{-1}$) at different days after planting [1st year (2010-11)]

Treatments	Days after planting				
	35-45	45-55	55-65	65-75	75-85
T ₀	0.076	0.050	0.052	0.051	-0.022
T ₁	0.071	0.055	0.046	0.038	-0.020
T ₂	0.075	0.052	0.045	0.041	-0.020
T ₃	0.078	0.051	0.046	0.040	-0.020
T ₄	0.082	0.050	0.052	0.038	-0.021
T ₅	0.079	0.051	0.051	0.040	-0.021
Level of significance	NS	NS	NS	NS	NS

Table 16b. Effect of treatments on net assimilation rate ($\text{g cm}^{-2} \text{ day}^{-1}$) at different days after planting [2nd year (2011-12)]

Treatments	Days after planting				
	35-45	45-55	55-65	65-75	75-85
T ₀	0.069	0.053	0.051	0.049	-0.022
T ₁	0.069	0.053	0.044	0.038	-0.020
T ₂	0.074	0.050	0.043	0.040	-0.020
T ₃	0.076	0.049	0.046	0.040	-0.020
T ₄	0.080	0.048	0.050	0.038	-0.021
T ₅	0.078	0.049	0.050	0.039	-0.021
Level of significance	NS	NS	NS	NS	NS

T₀=Control, T₁ = Vitapulus, T₂= Brassinosteroid, T₃=Wuxalsuper
T₄= Vitapulus + Wuxalsuper, T₅= Brassinosteroid+ Wuxalsuper,

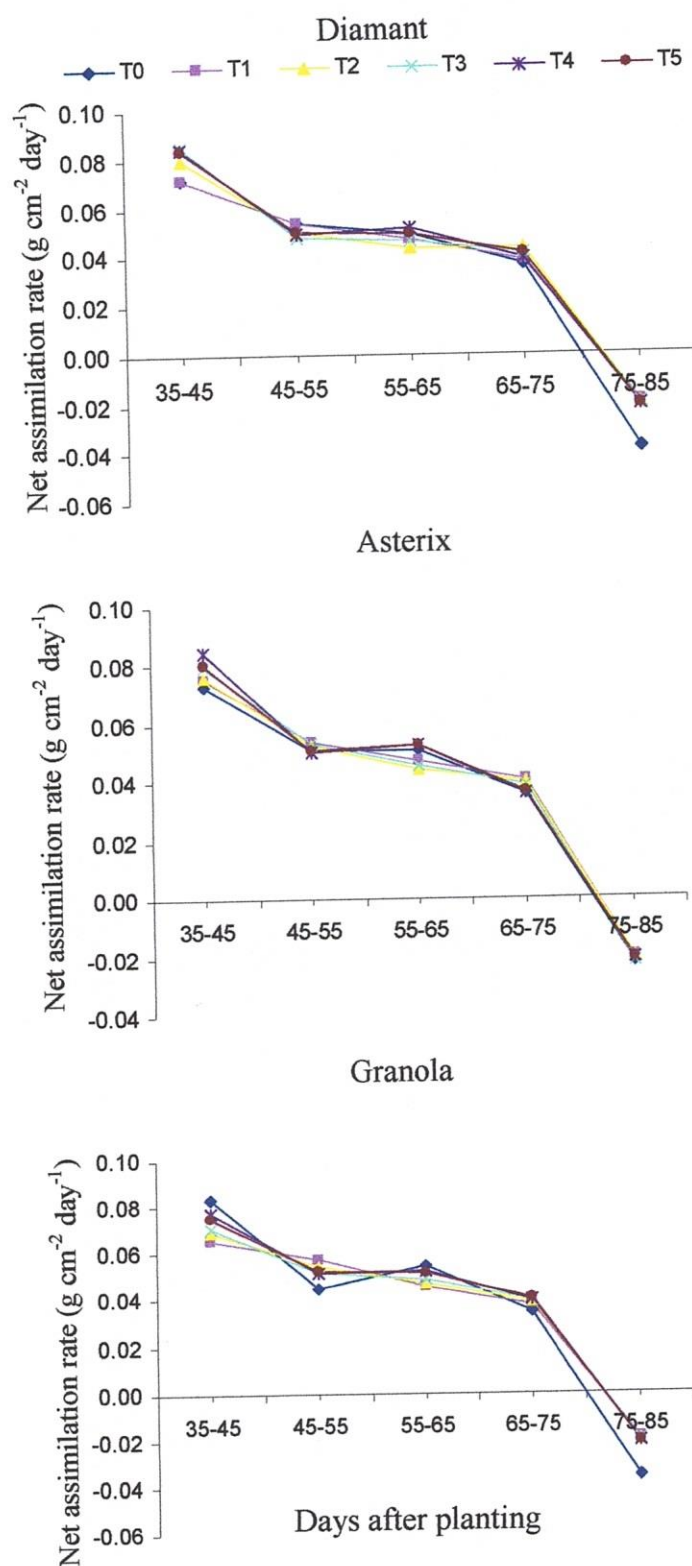


Figure 5a. Effect of plant growth regulators and micro nutrient treatments on net assimilation rate (NAR) of three potato cultivars at different stages of growth [1st year (2010-2011)]

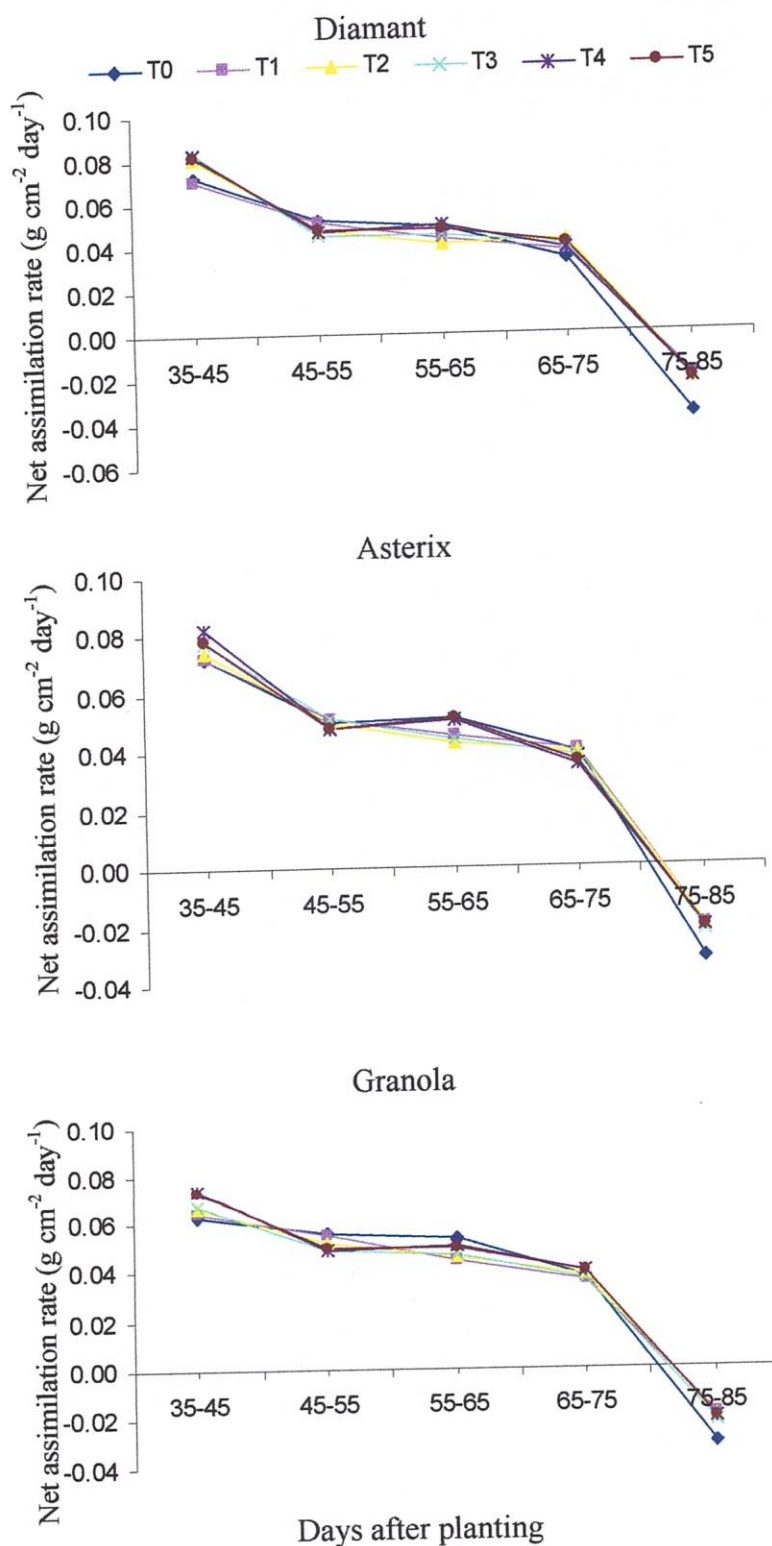


Figure 5b. Effect of plant growth regulators and micro nutrient treatments on net assimilation rate (NAR) of three potato cultivars at different stages of growth [2nd year (2011-2012)]

4.1.6 Leaf area ratio (LAR)

Analysis of variation indicated that the cultivar differences for LAR were significant at 35-45, 45-55, 55-65 and 65-75 DAP except 75-85 DAP in 2010-11 whereas in 2011-12 it was significant at all the harvests. Treatments differences were significant at all the harvests in both the years except at 35-45 DAP in 2010-11. Interaction effect between cultivars and treatments was non-significant at all the harvests but it was significant at 75-85 DAP in both the years (Tables 17a and 17b).

Cultivar Granola showed the highest leaf area ratio (LAR) values at all the harvests in both the years. LAR values of the cultivar Diamant and Asterix were found statistically significant at 55-65 and 65-75 DAP in both the years, while LAR values of the cultivar Granola and Asterix were found statistically identical at 75-85 DAP in 2011-12 (Tables 18a and 18b).

With a few exceptions, the highest LAR values were obtained from the treatment T_1 (Vitapulus) at all the harvests in both the years except 35-45 DAP in 2011-12. LAR values of the treatment T_1 (Vitapulus) and T_2 (Brassinosteroid) were found statistically identical at 65-75 DAP in 2010-11 and at 55-65 and 65-75 DAP in 2011-12. The LAR values of the treatment T_4 (Vitapulus + Wuxalsuper) and T_5 (Brassinosteroid + Wuxalsuper) were found statistically identical at 45-55, 55-65, 65-75 and 75-85 DAP in 2010-11 and at 65-75 and 75-85 DAP in 2011-12 (Tables 19a and 19b).

Effect of different treatments on LAR of three potato cultivars at different stages of growth of both the years is shown in Figures 6a and 6b. LAR values were higher at early stages of growth of both the years and then declined slowly with the increasing of plant age.

Table 17a. Mean squares from analysis of variance for leaf area ratio ($\text{cm}^2 \text{g}^{-1}$) of potato [1st year (2010-2011)]

Sources of variation	df	Days after planting				
		35-45	45-55	55-65	65-75	75-85
Replication	2	0.214	0.022	0.001	0.002	0.005
Cultivar (A)	2	0.069**	0.032**	0.004**	0.001*	0.000 ^{NS}
Treatment (B)	5	0.015 ^{NS}	0.010*	0.004**	0.006**	0.006**
A×B	10	0.011 ^{NS}	0.003 ^{NS}	0.000 ^{NS}	0.000 ^{NS}	0.000*
Error	34	0.007	0.003	0.000	0.000	0.000
CV(%)		4.97	4.74	2.19	1.74	1.77

Table 17b. Mean squares from analysis of variance for leaf area ratio ($\text{cm}^2 \text{g}^{-1}$) [2nd year (2011-2012)]

Sources of variation	df	Days after planting				
		35-45	45-55	55-65	65-75	75-85
Replication	2	0.167	0.041	0.003	0.002	0.003
Cultivar (A)	2	0.159**	0.050**	0.003**	0.001**	0.001*
Treatment (B)	5	0.030**	0.012**	0.004**	0.006**	0.006**
A×B	10	0.006 ^{NS}	0.001 ^{NS}	0.000 ^{NS}	0.000 ^{NS}	0.000*
Error	34	0.003	0.001	0.000	0.000	0.000
CV(%)		3.44	2.59	1.80	1.53	1.65

Table 18a. Effect of cultivars on leaf area ratio ($\text{cm}^{-2} \text{g}^{-1}$) at different days after planting [1st year (2010-11)]

Cultivars	Days after planting				
	35-45	45-55	55-65	65-75	75-85
Diamant (V_1)	1.590b	1.160b	0.9241b	0.7756b	0.723
Asterix (V_2)	1.652ab	1.193ab	0.9323b	0.7770b	0.729
Granola (V_3)	1.714a	1.243a	0.9514a	0.7869a	0.733
Level of significance	**	**	**	*	NS

Table 18b. Effect of cultivars on leaf area ratio ($\text{cm}^{-2} \text{g}^{-1}$) at different days after planting [2nd year (2011-12)]

Cultivars	Days after planting				
	35-45	45-55	55-65	65-75	75-85
Diamant (V_1)	1.631c	1.202c	0.949b	0.786b	0.726b
Asterix (V_2)	1.701b	1.237b	0.951b	0.788b	0.733a
Granola (V_3)	1.817a	1.306a	0.972a	0.798a	0.737a
Level of significance	**	**	**	**	*

Table 19a. Effect of treatments on leaf area ratio ($\text{cm}^{-2} \text{g}^{-1}$) at different days after planting [1st year (2010-11)]

Treatments	Days after planting				
	35-45	45-55	55-65	65-75	75-85
T ₀	1.690	1.206ab	0.9446a	0.7528c	0.6894d
T ₁	1.704	1.247a	0.9536a	0.8094a	0.7621a
T ₂	1.659	1.216ab	0.9533a	0.8043a	0.7468b
T ₃	1.633	1.199abc	0.9409a	0.7904b	0.7388b
T ₄	1.591	1.150c	0.9053b	0.7570c	0.7150c
T ₅	1.635	1.174bc	0.9181b	0.7651c	0.7192 c
Level of significance	NS	*	**	**	**

Table 19b. Effect of treatments on leaf area ratio ($\text{cm}^{-2} \text{g}^{-1}$) at different days after planting [2nd year (2011-12)]

Treatments	Days after planting				
	35-45	45-55	55-65	65-75	75-85
T ₀	1.792a	1.255bc	0.947c	0.763c	0.695d
T ₁	1.776ab	1.301a	0.981a	0.823a	0.770a
T ₂	1.719bc	1.271ab	0.982a	0.816a	0.751b
T ₃	1.689cd	1.243bc	0.966b	0.801b	0.739b
T ₄	1.643d	1.200d	0.928d	0.768c	0.721c
T ₅	1.679cd	1.221cd	0.941cd	0.771c	0.716c
Level of significance	**	**	**	**	**

T₀=Control, T₁ = Vitapulus, T₂= Brassinosteroid, T₃=Wuxalsuper

T₄= Vitapulus + Wuxalsuper, T₅= Brassinosteroid+ Wuxalsuper,

In a column, the figures bearing same letter(s) or without letters are identical and those having dissimilar letters differed significantly as per DMRT

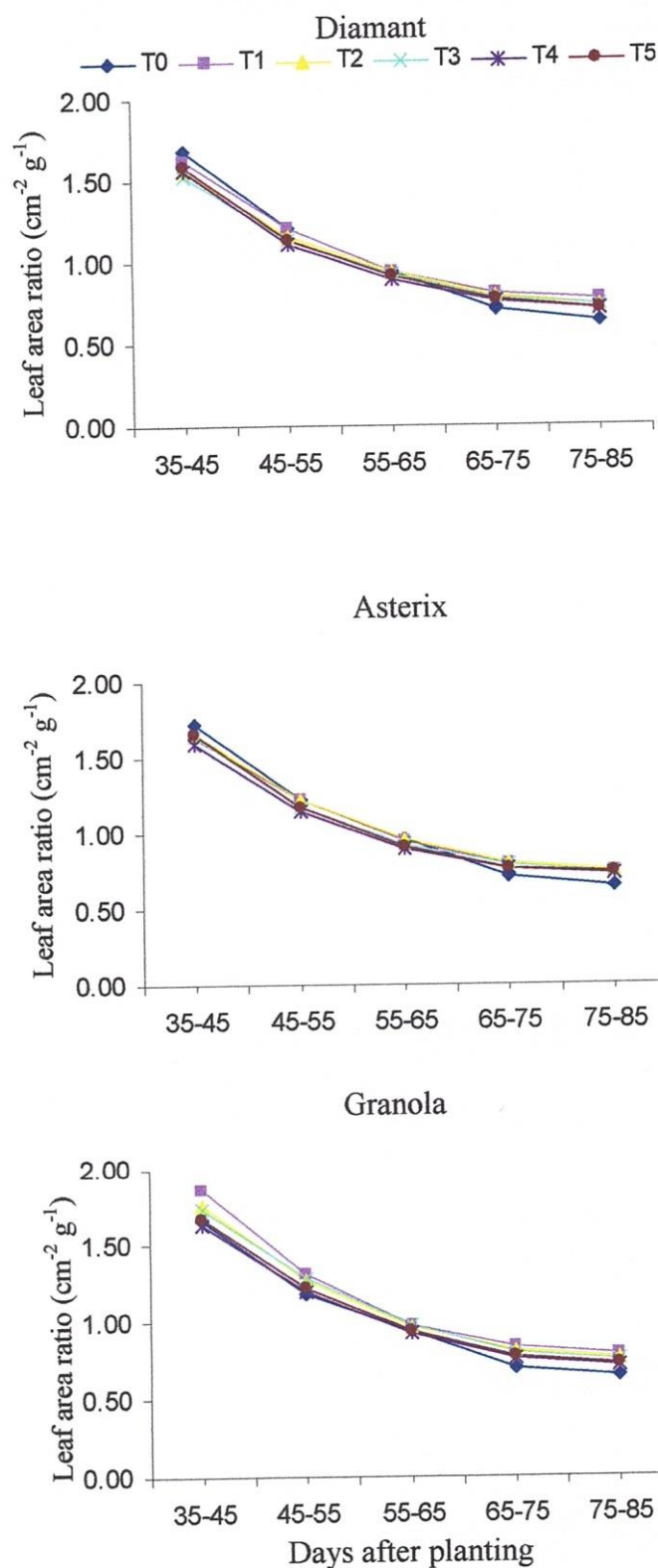


Figure 6a. Effect of plant growth regulators and micro nutrient treatments on leaf area ratio (LAR) of three potato cultivars at different stages of growth [1st year (2010-2011)].

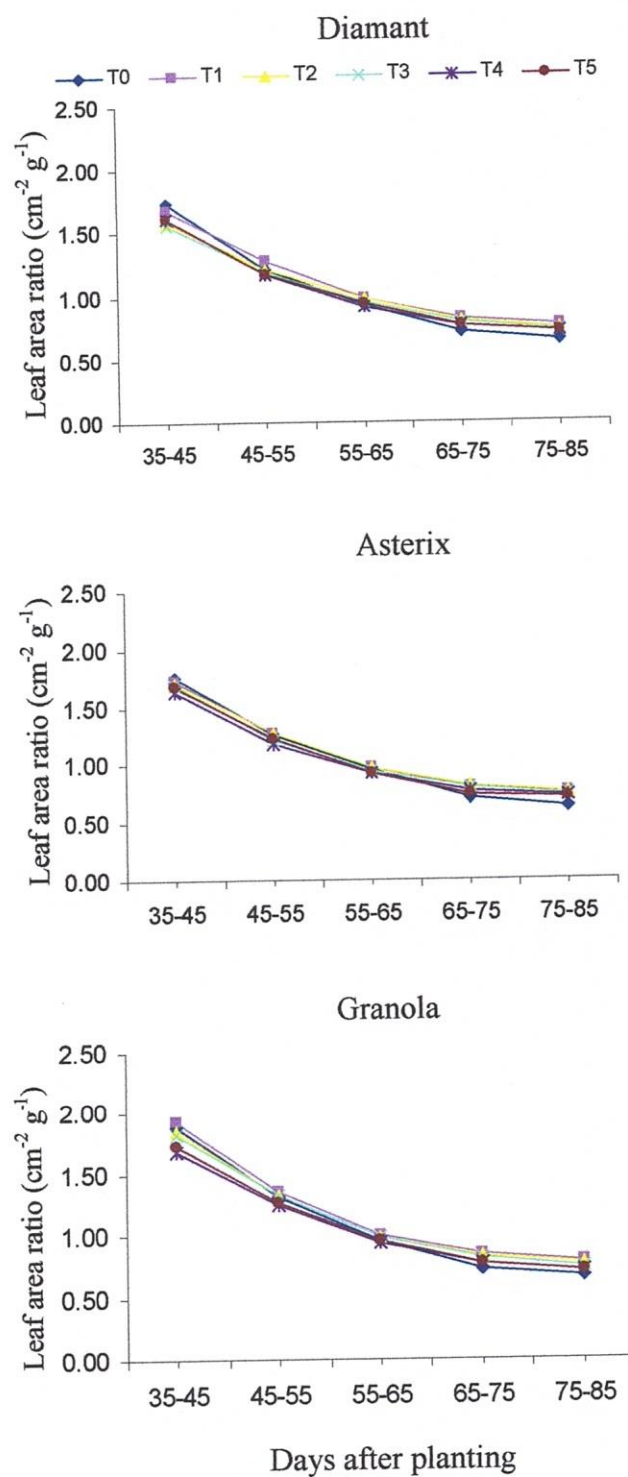


Figure 6b. Effect of plant growth regulators and micro nutrient treatments on leaf area ratio (LAR) of three potato cultivars at different stages of growth [2nd year (2011-2012)].

4.1.7 Relative leaf growth rate (RLGR)

Analysis of variation revealed that cultivar differences for relative leaf growth rate (RLGR) were non-significant at all the harvests in both the years. In both the years, the treatment differences were non-significant at all the harvests. Interaction effect between cultivars and treatments were also found non-significant in 2010-11 and 2011-12 (Tables 20a and 20b)

Cultivars Diamant, Asterix and Granola showed the highest values at some harvests in both the years. RLGR values of three cultivars were found negative at 75-85 DAP in both the years. No clear pattern of the effect of cultivars on RLGR was observed (Tables 21a and 21b).

Treatment T₁ (Vitapulus) and T₀ (control) showed highest RLGR values at different harvests. Negative RLGR values were recorded at 75-85 DAP in both the years. No clear pattern of the effect of treatments on RLGR was observed (Tables 22a and 22b).

Effect of cultivars and treatments on relative leaf growth rate (RLGR) of three cultivars at different stages of growth of both the years is shown in Figures 7a and 7b. For all the cultivars and treatments in both the years RLGR values showed maximum at first harvest (35-45) DAP and then gradually decreased with increasing of plant age. The RLGR values showed negative values at later stages of growth for all the cultivars and treatments in both the years.

Table 20a. Mean squares from analysis of variance for relative leaf growth rate ($\text{cm}^2 \text{cm}^{-2} \text{day}^{-1}$) of potato [1st year (2010-2011)]

[1 year (2010-2011)]		Days after planting				
Sources of variation	df	35-45	45-55	55-65	65-75	75-85
Replication	2	0.001	0.000	0.000	0.000	0.000
Cultivar (A)	2	0.000 ^{NS}	0.000 [*]	0.000 ^{NS}	0.000 [*]	0.000 ^{**}
Treatment (B)	5	0.000 ^{**}	0.000 ^{**}	0.000 ^{NS}	0.000 [*]	0.000 ^{**}
A×B	10	0.000 ^{NS}	0.000 ^{NS}	0.000 ^{NS}	0.000 ^{NS}	0.000 ^{NS}
Error	34	0.000	0.000	0.000	0.000	0.000
CV(%)		8.01	7.53	14.61	9.18	0.00

Table 20b. Mean squares from analysis of variance for relative leaf growth rate ($\text{cm}^2 \text{cm}^{-2} \text{day}^{-1}$) of potato [2nd year (2011-2012)]

2 year (2011-2012)]		Days after planting				
Sources of variation	df	35 -45	45-55	55-65	65-75	75-85
Replication	2	0.001	0.000	0.000	0.000	0.000
Cultivar (A)	2	0.000 ^{NS}	0.000 ^{NS}	0.000 ^{NS}	0.000 ^{**}	0.000 ^{NS}
Treatment (B)	5	0.000 ^{**}	0.000 ^{NS}	0.000 ^{NS}	0.000 ^{**}	0.000 ^{NS}
A×B	10	0.000 ^{NS}	0.000 ^{NS}	0.000 ^{NS}	0.000 ^{NS}	0.000 ^{NS}
Error	34	0.000	0.000	0.000	0.000	0.000
CV(%)		6.33	9.46	11.13	7.40	0.80

Table 21a. Effect of cultivars on relative leaf growth rate ($\text{cm}^2 \text{cm}^{-2} \text{day}^{-1}$) at different days after planting [1st year (2010-11)]

Cultivars	Days after planting				
	35-45	45-55	55-65	65-75	75-85
Diamant (V_1)	0.082	0.033	0.023	0.018	-0.015
Asterix (V_2)	0.085	0.036	0.021	0.018	-0.015
Granola (V_3)	0.086	0.035	0.023	0.017	-0.016
Level of significance	NS	NS	NS	NS	NS

Table 21b. Effect of cultivars on relative leaf growth rate ($\text{cm}^2 \text{cm}^{-2} \text{day}^{-1}$) at different days after planting [2nd year (2011-12)]

Cultivars	Days after planting				
	35-45	45-55	55-65	65-75	75-85
Diamant (V_1)	0.086	0.034	0.020	0.018	-0.017
Asterix (V_2)	0.088	0.034	0.020	0.018	-0.017
Granola (V_3)	0.088	0.033	0.021	0.017	-0.018
Level of significance	NS	NS	NS	NS	NS

Table 22a. Effect of treatments on relative leaf growth rate ($\text{cm}^2 \text{cm}^{-2} \text{day}^{-1}$) at different days after planting [1st year (2010-11)]

Treatments	Days after planting				
	35-45	45-55	55-65	65-75	75-85
T ₀	0.073	0.040	0.021	0.020	-0.017
T ₁	0.091	0.034	0.023	0.019	-0.016
T ₂	0.089	0.033	0.024	0.017	-0.015
T ₃	0.089	0.033	0.023	0.017	-0.015
T ₄	0.082	0.035	0.022	0.017	-0.014
T ₅	0.083	0.035	0.023	0.017	-0.014
Level of significance	NS	NS	NS	NS	NS

Table 22b. Effect of treatments on relative leaf growth rate ($\text{cm}^2 \text{cm}^{-2} \text{day}^{-1}$) at different days after planting [2nd year (2011-12)]

Treatments	Days after planting				
	35-45	45-55	55-65	65-75	75-85
T ₀	0.078	0.035	0.022	0.020	-0.017
T ₁	0.092	0.034	0.020	0.019	-0.019
T ₂	0.093	0.033	0.020	0.017	-0.018
T ₃	0.089	0.033	0.021	0.017	-0.017
T ₄	0.086	0.033	0.020	0.017	-0.015
T ₅	0.087	0.034	0.020	0.016	-0.015
Level of significance	NS	NS	NS	NS	NS

T₀=control, T₁ = Vitaplus, T₂= Brassinosteroid, T₃=Wuxalsuper
 T₄= Vitaplus + Wuxalsuper, T₅= Brassinosteroid+ Wuxalsuper,

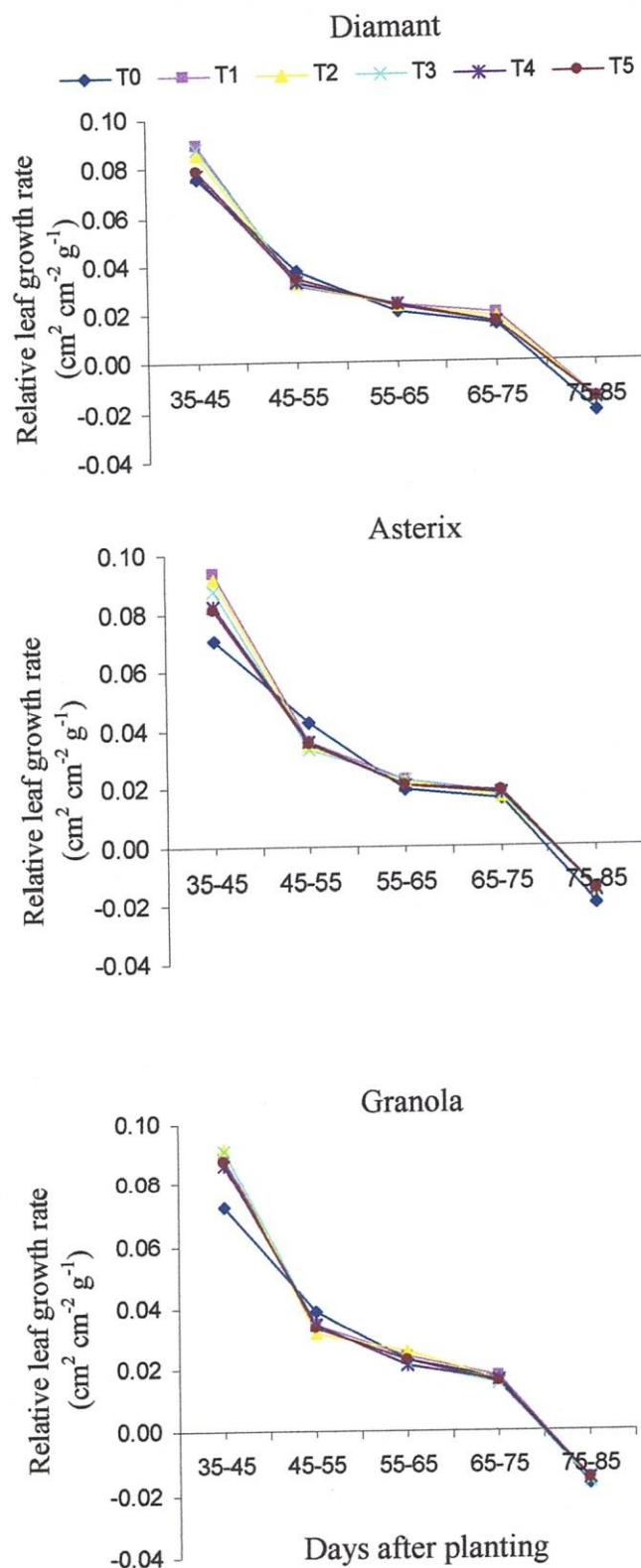


Figure 7a. Effect of plant growth regulators and micro nutrient treatments on relative leaf growth rate (RLGR) of three potato cultivars at different stages of growth [1st year (2010-2011)]

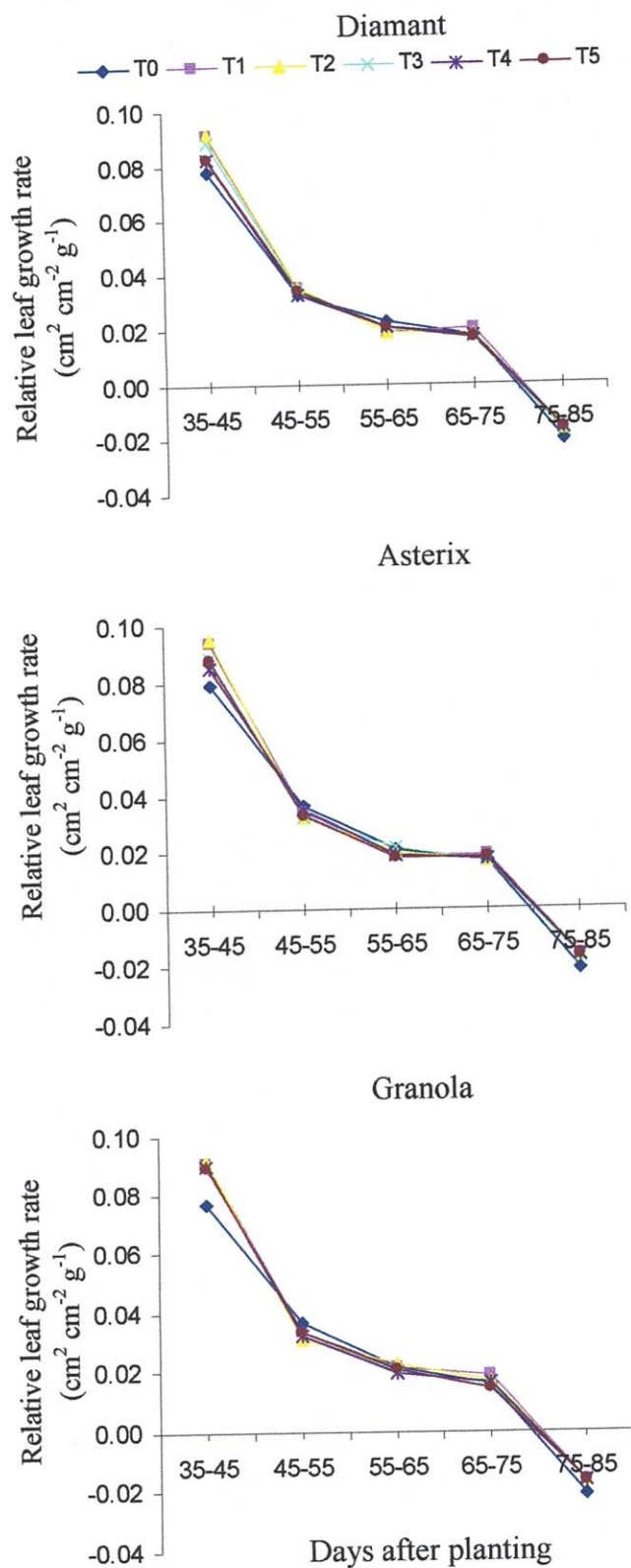


Figure 7b. Effect of plant growth regulators and micro nutrient treatments on relative leaf growth rate (RLGR) of three potato cultivars at different stages of growth [2nd year (2011-2012)]

4.1.8 Specific leaf area

From the analysis of variation it was revealed that cultivar differences for specific leaf area (SLA) were significant at 55, 65, 75 and 85 DAP in both the years. Treatment differences were significant at all the harvests in both the years. Interaction effect between cultivars and treatments was found significant at 65, 75 and 85 DAP in 2010-11 and at 75 and 85 DAP in 2011-12 (Tables 23a and 23b).

Cultivar Diamant showed the highest SLA values at 35 and 45 DAP in 2010-11. Cultivar Asterix showed the highest SLA values at 75 and 85 DAP in 2010-11 and at 45, 65, 75 and at 85 DAP in 2011-12. On the other hand, cultivar Granola showed the highest SLA values at 55 and 65 DAP in 2010-11 and at 55 DAP in 2011-12. The SLA values of the cultivar Asterix and Granola were found statistically identical at 55, 65, 75 and 85 DAP in 2010-11 and 2011-12. It is revealed from the table that no clear pattern of the effect of cultivar on SLA was observed (Tables 24a and 24b).

Unsprayed control T_0 treatment produced highest SLA at 35 DAP in 2010-11 and at 35 and 45 DAP in 2011-12. Treatment T_2 (Brassinosteroid) produced highest SLA at 75 and 85 DAP in 2010-11 and at 55, 65, 75 and 85 DAP in 2011-12. The treatment T_1 (Vitaplus) and T_2 (Brassinosteroid) were found statistically identical at 75 and 85 DAP in 2010-11 and at 35, 75 and 85 DAP in 2011-12. The treatment T_4 (Vitaplus+Wuxalsuper) and T_5 (Brassinosteroid+Wuxalsuper) were found statistically identical at 35 and 55 DAP in 2010-11 and at 35, 55, 65 and 75 DAP in 2011-12.

Effect of different treatments on specific leaf area (SLA) of three cultivars at different stages of growth of both the years is shown in the Figures 8a and 8b. For all the cultivars and treatments SLA showed maximum values at early stages of growth, declined at middle stages and again it increased at later stages of growth in both the years.

Table 23a. Mean squares from analysis of variance for specific leaf area ($\text{cm}^2 \text{g}^{-1}$) of potato
[1st year (2010-2011)]

Sources of variation		df	Days after planting					
			35	45	55	65	75	85
Replication		2	46.18	0.60	1.24	2.91	1.28	1.25
Cultivar (A)		2	0.13 ^{NS}	0.22 ^{NS}	4.42 ^{**}	14.42 ^{**}	30.52 ^{**}	29.87 ^{**}
Treatment (B)		5	21.93 ^{**}	0.85 ^{**}	3.63 ^{**}	1.85 ^{**}	4.34 ^{**}	4.25 ^{**}
A×B		10	1.07 ^{NS}	0.14 ^{NS}	0.51 ^{NS}	0.81 [*]	1.51 ^{**}	1.48 ^{**}
Error		34	2.05	0.18	0.32	0.33	0.40	0.39
CV(%)			8.23	2.51	2.90	3.04	2.95	2.95

Table 23b. Mean squares from analysis of variance for specific leaf area ($\text{cm}^2 \text{g}^{-1}$) of potato
[2nd year (2011-2012)]

Sources of variation	df	Days after planting					
		35	45	55	65	75	85
Replication	2	43.21	2.20	1.02	1.05	1.81	1.76
Cultivar (A)	2	0.91 ^{NS}	0.03 ^{NS}	2.58 ^{**}	18.49 ^{**}	22.99 ^{**}	21.49 ^{**}
Treatment (B)	5	17.41 ^{**}	1.38 ^{**}	3.39 ^{**}	1.97 ^{**}	4.76 ^{**}	4.88 ^{**}
A×B	10	1.24 ^{NS}	0.12 ^{NS}	0.22 ^{NS}	0.61 ^{NS}	1.30 ^{**}	1.23 ^{**}
Error	34	1.46	0.20	0.21	0.34	0.30	0.28
CV(%)		7.00	2.60	2.29	3.06	2.72	2.73

Table 24a. Effect of cultivars on specific leaf area ($\text{cm}^{-2} \text{ day}^{-1}$) at different days after planting [1st year (2010-11)]

Cultivars	Days after planting					
	35	45	55	65	75	85
Diamant (V_1)	17.45	16.92	19.08b	17.77b	19.89b	19.66b
Asterix (V_2)	17.29	16.83	19.93a	19.29a	22.33a	22.07a
Granola (V_3)	17.40	16.70	19.95a	19.35a	21.90a	21.65a
Level of significance	NS	NS	**	**	**	**

Table 24b. Effect of cultivars on specific leaf area ($\text{cm}^{-2} \text{ day}^{-1}$) at different days after planting [2nd year (2011-12)]

Cultivars	Days after planting					
	35	45	55	65	75	85
Diamant (V_1)	17.17	17.19	19.49b	17.76b	18.66b	18.11b
Asterix (V_2)	17.08	17.28	20.00a	19.57a	20.76a	20.15a
Granola (V_3)	17.51	17.22	20.23a	19.46a	20.43a	19.83a
Level of significance	NS	NS	**	**	**	**

Table 25a. Effect of treatments on specific leaf area ($\text{cm}^{-2} \text{ day}^{-1}$) at different days after planting [1st year (2010-11)]

Treatments	Days after planting					
	35	45	55	65	75	85
T ₀	19.47a	16.77a-c	20.45a	18.82a-c	20.56c	20.32c
T ₁	18.19ab	17.24a	19.89a	19.43a	22.08a	21.82a
T ₂	18.51a	16.97ab	19.85a	19.19ab	22.21a	21.95a
T ₃	16.57bc	16.95ab	19.94a	18.67bc	21.62ab	21.37ab
T ₄	15.63c	16.38c	18.75b	18.20c	20.77c	20.52c
T ₅	15.90c	16.58bc	19.04b	18.48bc	21.03bc	20.78bc
Level of significance	**	**	**	**	**	**

Table 25b. Effect of treatments on specific leaf area ($\text{cm}^{-2} \text{ day}^{-1}$) at different days after planting [2nd year (2011-12)]

Treatments	Days after planting					
	35	45	55	65	75	85
T ₀	18.78a	17.88a	19.95b	18.81bc	18.91c	18.26d
T ₁	18.21ab	17.05bc	20.39ab	19.32ab	20.67a	20.07a
T ₂	18.28ab	17.46ab	20.54a	19.56a	20.73a	20.13a
T ₃	16.99bc	17.24bc	20.23ab	19.01a-c	20.29ab	19.71ab
T ₄	15.60c	16.85c	19.04c	18.31c	19.59bc	19.050bc
T ₅	15.64c	16.89bc	19.28c	18.55c	19.49bc	18.94c
Level of significance	**	**	**	**	**	**

T₀=Control, T₁ = Vitapplus, T₂= Brassinosteroid, T₃=Wuxalsuper
 T₄= Vitapplus + Wuxalsuper, T₅= Brassinosteroid+ Wuxalsuper,

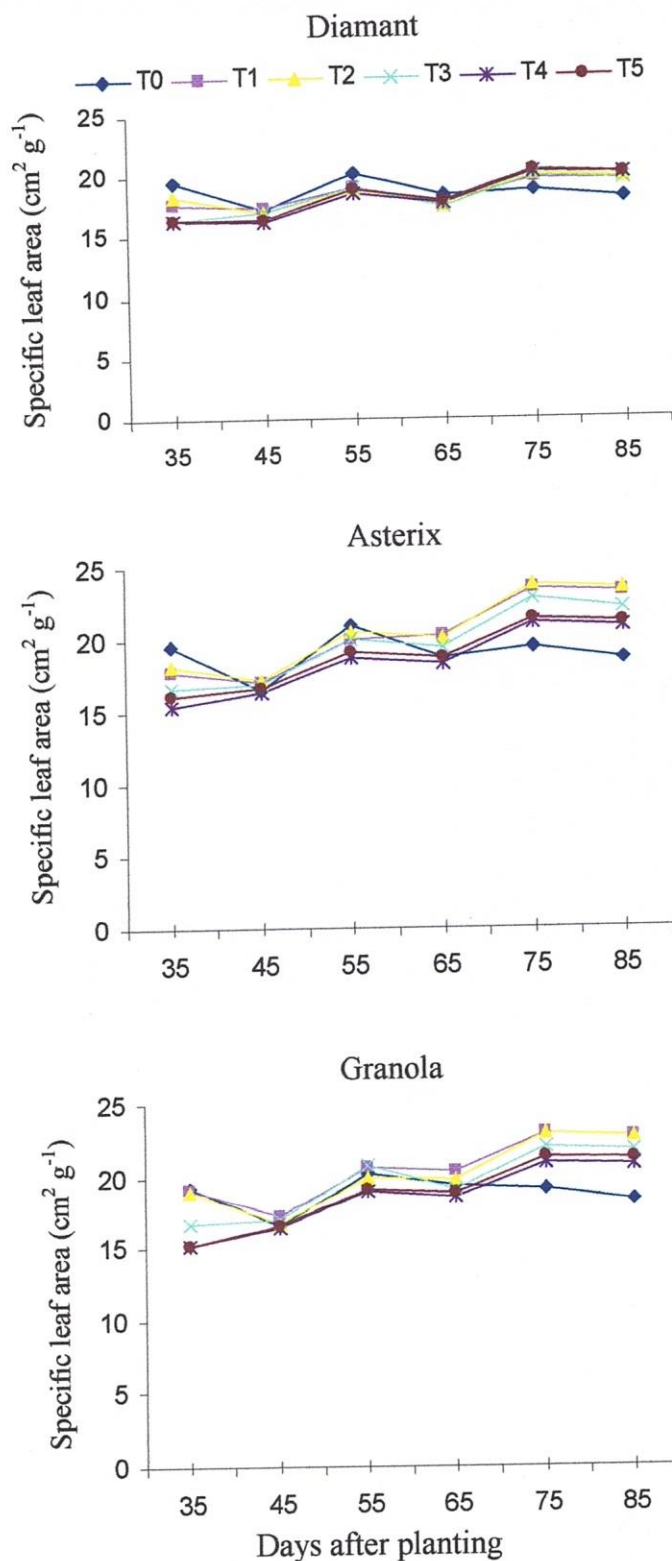


Figure 8a. Effect of plant growth regulators and micro nutrient treatments on specific leaf area (SLA) of three potato cultivars at different stages of growth [1st year (2010-2011)]

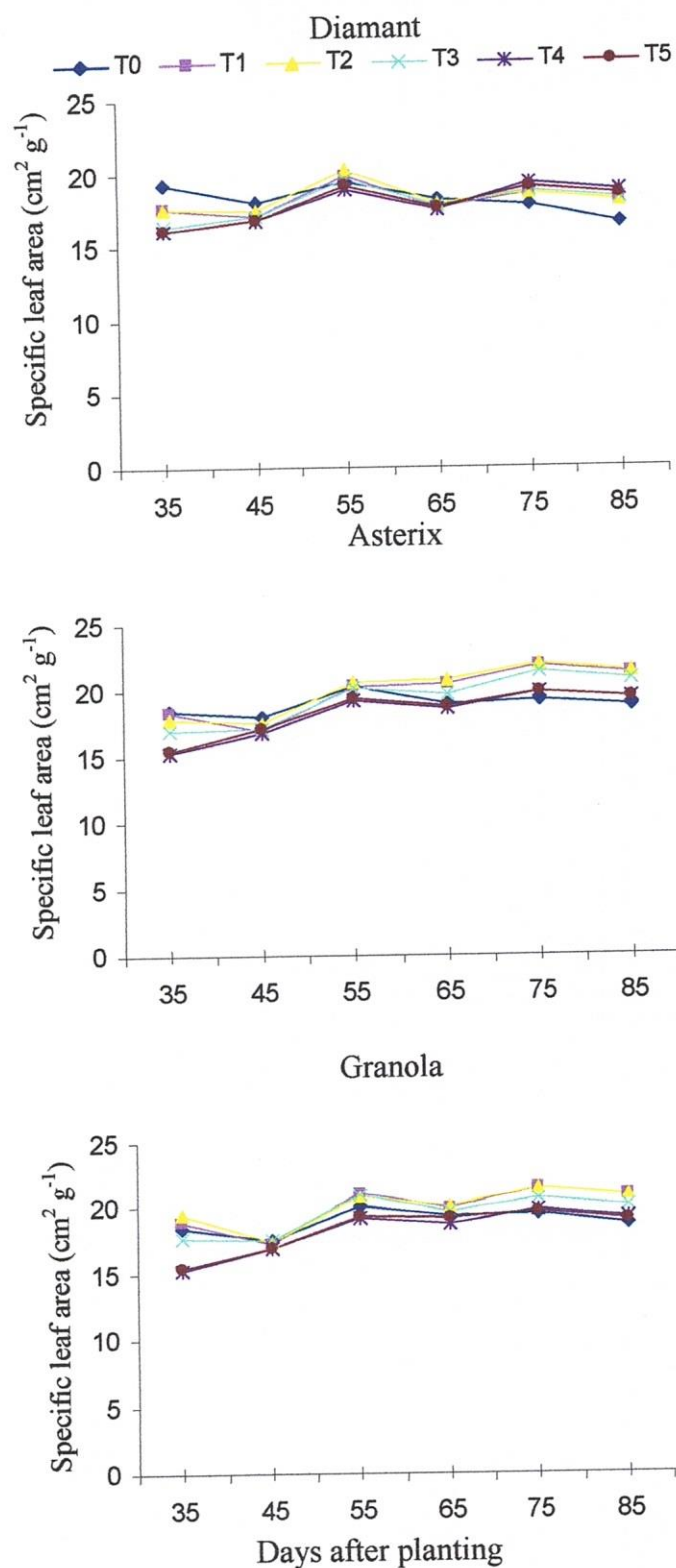


Figure 8b. Effect of plant growth regulators and micro nutrient treatments on specific leaf area (SLA) of three potato cultivars at different stages of growth [2nd year (2011-2012)]

4.1.9 Leaf weight ratio (LWR)

From the analysis of variation it was revealed that cultivar differences for leaf weight ratio (LWR) were significant at all the harvests in both the years. Similarly, treatment differences were significant at all the harvests in both the years. Interaction effect between cultivars and treatments was non-significant in most of the harvests but were significant at 45 and 85 DAP in 2010-11 and at 85 DAP in 2011-12 (Tables 26a and 26b).

Cultivar Granola showed the highest LWR values at 45, 55, 65, 75 and 85 DAP in 2010-11 and at all the harvests in 2011-12. But the LWR values of the cultivar Granola and Asterix were found statistically identical at 35 and 45 DAP in both the years. The LWR values of the cultivar Diamant and Asterix were also found statistically identical at 85 DAP in both the years (Tables 27a and 27b).

Different treatments showed the highest LWR values at different harvests in both the years. Treatment T₃ (Wuxalsuper) produced the maximum LWR at 65, 75 and 85 DAP in 2010-11 and at 65 and 85 DAP in 2011-12. No clear pattern of the effect of treatments on LWR was observed (Tables 28a and 28b)

Effect of different treatments on leaf weight ratio (LWR) of three cultivars at different stages of growth is shown in Figures 9a and 9b. In both the years all the cultivars and treatments LWR showed the maximum values at the beginning of plant growth and gradually declined with the increasing of plant age.

Table 26a. Mean squares from analysis of variance for leaf weight ratio (g g^{-1}) of potato [1st year (2010-2011)]

Sources of variation	df	Days after planting					
		35	45	55	65	75	85
Replication	2	0.03	0.004	0.001	0.005	0.000	0.000
Cultivar (A)	2	0.06**	0.011**	0.043**	0.009**	0.018**	0.011**
Treatment (B)	5	0.05**	0.007**	0.001**	0.003**	0.001**	0.000*
A×B	10	0.008 ^{NS}	0.003**	0.000 ^{NS}	0.000 ^{NS}	0.000 ^{NS}	0.000**
Error	34	0.005	0.001	0.000	0.000	0.000	0.000
CV(%)		10.18	8.13	5.98	5.71	5.27	4.19

Table 26b. Mean squares from analysis of variance for leaf weight ratio (g g^{-1}) of potato [2nd year (2011-2012)]

Sources of variation		df	Days after planting					85
			35	45	55	65	75	
Replication		2	0.042	0.000	0.001	0.003	0.00	0.001
Cultivar (A)		2	0.117**	0.036**	0.036**	0.01**	0.015**	0.01**
Treatment (B)		5	0.032**	0.003**	0.009**	0.00**	0.001**	0.000**
A×B		10	0.007 ^{NS}	0.001 ^{NS}	0.002 ^{NS}	0.00 ^{NS}	0.000 ^{NS}	0.000**
Error		34	0.008	0.001	0.000	0.00	0.000	0.000
CV(%)			121.59	8.64	6.11	5.27	5.31	4.53

Table 27a. Effect of cultivars on leaf weight ratio (g g^{-1}) at different days after planting [1st year (2010-11)]

Cultivars	Days after planting					
	35	45	55	65	75	85
Diamant (V_1)	0.623b	0.315b	0.204c	0.236c	0.203c	0.209b
Asterix (V_2)	0.733a	0.344a	0.280b	0.263b	0.217b	0.209b
Granola (V_3)	0.716a	0.365a	0.295a	0.281a	0.264a	0.251a
Level of significance	**	**	**	**	**	**

Table 27b. Effect of cultivars on leaf weight ratio (g g^{-1}) at different days after planting [2nd year (2011-12)]

Cultivars	Days after planting					
	35	45	55	65	75	85
Diamant (V_1)	0.602b	0.269b	0.208c	0.228c	0.202c	0.216b
Asterix (V_2)	0.737a	0.340a	0.273b	0.245b	0.215b	0.218b
Granola (V_3)	0.746a	0.351a	0.293a	0.272a	0.257a	0.256a
Level of significance	**	**	**	**	**	**

Table 28a. Effect of treatments on leaf weight ratio (g g^{-1}) at different days after planting [1st year (2010-11)]

Treatments	Days after planting					
	35	45	55	65	75	85
T ₀	0.583c	0.338bc	0.236c	0.245c	0.236a	0.228ab
T ₁	0.652bc	0.382a	0.258b	0.269b	0.235ab	0.228ab
T ₂	0.658bc	0.367ab	0.271a	0.272ab	0.223bc	0.218bc
T ₃	0.714ab	0.326bc	0.262ab	0.282a	0.242a	0.231a
T ₄	0.770a	0.317c	0.264ab	0.243c	0.216c	0.214c
T ₅	0.767a	0.318c	0.267ab	0.248c	0.216c	0.220ab c
Level of significance	**	**	**	**	**	**

Table 28b. Effect of treatments on leaf weight ratio (g g^{-1}) at different days after planting [2nd year (2011-12)]

Treatments	Days after planting					
	35	45	55	65	75	85
T ₀	0.609c	0.305b	0.238c	0.239cd	0.239a	0.237a
T ₁	0.649bc	0.350a	0.261ab	0.250bc	0.232ab	0.234a
T ₂	0.692abc	0.338ab	0.272a	0.259ab	0.223bc	0.230ab
T ₃	0.701abc	0.311ab	0.258b	0.270a	0.231ab	0.235a
T ₄	0.754ab	0.309b	0.254b	0.233d	0.211c	0.218b
T ₅	0.765a	0.308b	0.265ab	0.239cd	0.212c	0.226ab
Level of significance	**	**	**	**	**	**

T₀=Control, T₁ = Vitaplus, T₂= Brassinosteroid, T₃=Wuxalsuper

T₄= Vitaplus + Wuxalsuper, T₅= Brassinosteroid+ Wuxalsuper,

In a column, the figures bearing same letter(s) or without letters are identical and those having dissimilar letters differed significantly as per DMRT

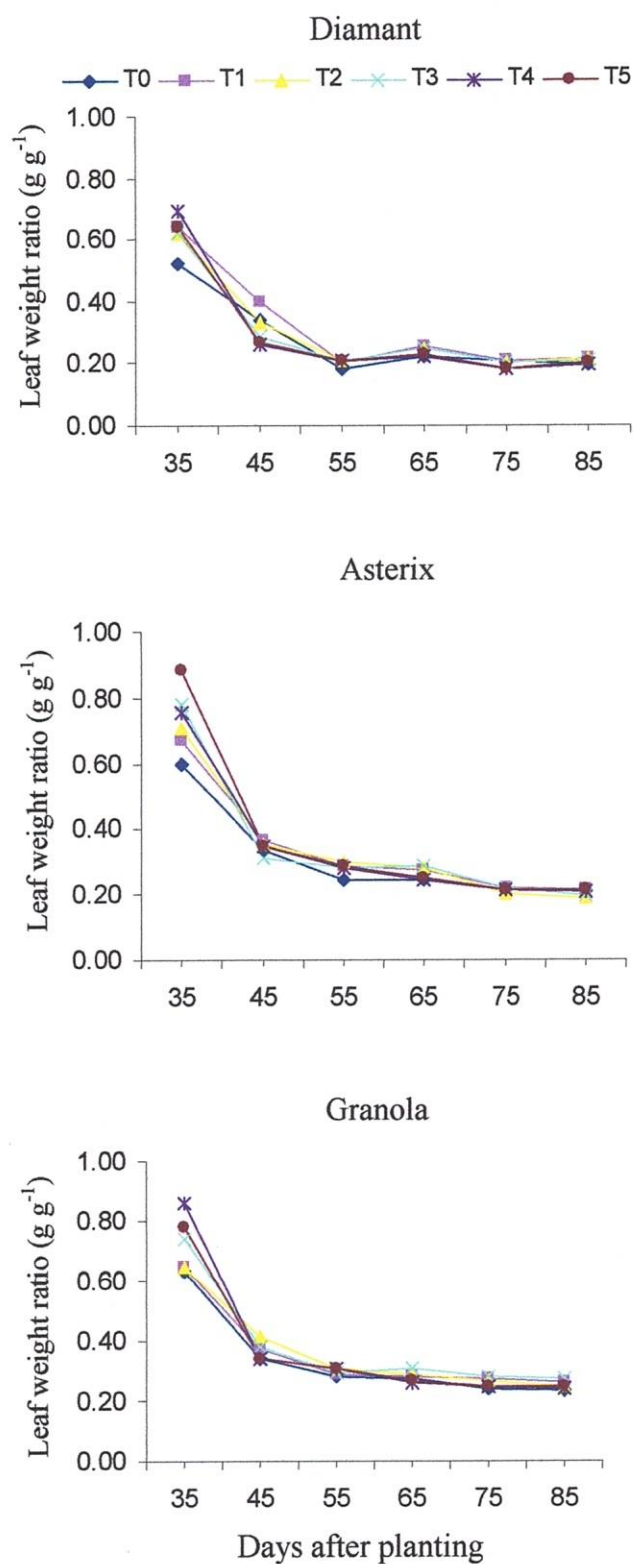


Figure 17. Effect of plant growth regulators and micro nutrient treatments on leaf weight ratio (LWR) of three potato cultivars at different stages of growth [1st year (2010-2011)]

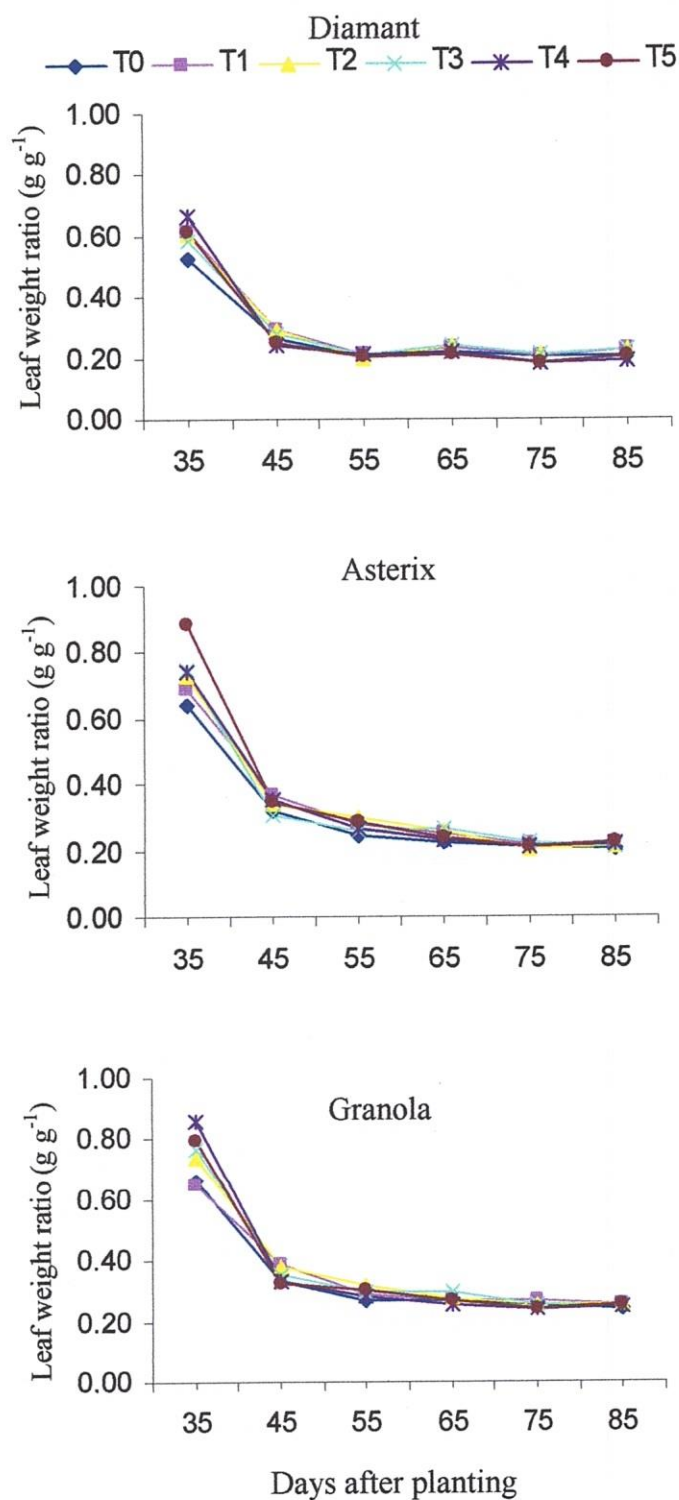


Figure 18. Effect of plant growth regulators and micro nutrient treatments on leaf weight ratio (LWR) of three potato cultivars at different stages of growth [2nd year (2011-2012)]

4.1.10 Plant height

From the analysis of variation it was revealed that the cultivar differences for plant height were significant at all the harvests in both the years except at 45 DAP in 2011-12. Treatment were significantly different at all the harvests in both the years except at 75 DAP in 2011-12. Interaction effect between cultivars and treatments was found non-significant at all the harvests in both the years (Tables 29a and 29b).

Cultivar Diamant showed the highest plant height at all the harvests in both the years. The plant height of the cultivar Diamant and Asterix was found statistically identical at 55 and 65 DAP in 2010-11 and at 55 DAP in 2011-12. The plant height of the cultivar Asterix and Granola was found statistically identical at 45 and 85 DAP in both the years (Tables 30a and 30b)

Treatment T₄ (Vitapulus + Wuxalsuper) showed the highest plant height at all the harvests in both the years. The plant of the treatment T₁ (Vitapulus) and T₂ (Brassinosteroid) was found statistically identical at 35 and 75 DAP in both the years. The treatments T₁(Vitapulus), T₂(Brassinosteroid), T₃(Wuxalsuper), T₄ (Vitapulus + Wuxalsuper) and T₅(Brassinosteroid + Wuxalsuper) were found statistically identical at 55 and 85 DAP in both the years. Similarly, the treatments T₂ (Brassinosteroid), T₃(Wuxalsuper), and T₅(Brassinosteroid+Wuxalsuper) were found statistically identical at 45 DAP in both the years (Tables 31a and 31b).

Effect of different treatments on plant height of three cultivars at different stages of growth of both the years is shown in Figures 10a and 10b. For all the cultivars and treatments plant height increased progressively with the advancement of growth period up to 75 DAP and later on, it decreased gradually.

Table 29a. Mean squares from analysis of variance for plant height (cm) of potato [1st year (2010-2011)]

Sources of variation	df	Days after planting					
		35	45	55	65	75	85
Replication	2	141.17	2.17	7.91	25.91	120.24	3.91
Cultivar (A)	2	58.39 [*]	126.39 ^{**}	176.80 ^{**}	175.13 ^{**}	401.46 ^{**}	172.80 ^{**}
Treatment (B)	5	44.52 ^{**}	89.07 ^{**}	78.64 ^{**}	91.00 ^{**}	139.62 ^{**}	122.11 ^{**}
A×B	10	6.94 ^{NS}	6.99 ^{NS}	11.11 ^{NS}	12.86 ^{NS}	8.17 ^{NS}	5.26 ^{NS}
Error	34	12.05	8.81	15.20	9.77	11.30	14.50
CV(%)		8.45	5.24	6.51	5.10	5.06	6.09

Table 29b. Mean squares from analysis of variance for plant height (cm) of potato [2nd year (2011-2012)]

Sources of variation	df	Days after planting					
		35	45	55	65	75	85
Replication	2	219.56	26.39	45.06	46.74	29.57	34.06
Cultivar (A)	2	68.72 ^{**}	128.39 ^{**}	160.17 ^{**}	128.07 ^{**}	335.35 ^{**}	156.72 ^{**}
Treatment (B)	5	49.59 ^{**}	80.08 ^{**}	72.58 ^{**}	78.12 ^{**}	170.21 ^{**}	100.21 ^{**}
A×B	10	5.14 ^{NS}	4.90 ^{NS}	10.74 ^{NS}	12.47 ^{NS}	17.33 ^{NS}	6.37 ^{NS}
Error	34	11.73	7.31	13.43	10.55	13.14	13.37
CV(%)		8.55	4.90	6.33	5.46	5.61	5.97

Table 30a. Effect of cultivars on plant height (cm) at different days after planting [1st year (2010-11)]

Cultivars	Days after planting					
	35	45	55	65	75	85
Diamant (V ₁)	43.00a	59.72a	62.67a	64.22a	68.22a	65.94a
Asterix (V ₂)	40.72ab	55.28b	60.56a	61.50a	64.39b	61.78b
Granola (V ₃)	39.44b	55.00b	56.50b	58.00b	61.78c	59.89b
Level of significance	**	**	**	**	**	**

Table 30b. Effect of cultivars on plant height (cm) at different days after planting [2nd year (2011-12)]

Cultivars	Days after planting					
	35	45	55	65	75	85
Diamant (V ₁)	41.89a	58.22a	60.44a	62.11a	67.72a	64.56a
Asterix (V ₂)	40.28ab	54.00b	58.61a	59.56ab	63.94b	60.44b
Granola (V ₃)	38.00b	53.28b	54.61b	56.78b	60.11c	58.83b
Level of significance	**	**	**	**	**	**

Table 31a. Effect of treatments on plant height (cm) at different days after planting [1st year (2010-11)]

Treatments	Days after planting					
	35	45	55	65	75	85
T ₀	37.00b	51.22c	54.00b	55.11b	60.00c	55.44b
T ₁	40.44ab	55.44b	61.44a	61.00a	65.56b	62.44a
T ₂	41.11ab	57.11ab	61.33a	61.56a	65.67b	63.00a
T ₃	42.22a	58.22ab	60.33a	62.89a	68.11ab	64.11a
T ₄	43.33a	60.56a	61.89a	63.89a	70.00a	66.00a
T ₅	42.22a	57.44ab	60.444a	63.000a	67.44b	64.22a
Level of significance	**	**	**	**	**	**

Table 31b. Effect of treatments on plant height (cm) at different days after planting [2nd year (2011-12)]

Treatments	Days after planting					
	35	45	55	65	75	85
T ₀	35.78b	50.00c	52.22b	53.89a	57.11c	55.00b
T ₁	39.56ab	53.89b	58.78a	59.22ab	63.67b	60.78a
T ₂	40.00ab	55.33ab	59.11a	59.56b	64.00b	61.56a
T ₃	41.33a	56.67ab	58.33a	60.67c	66.22ab	62.89a
T ₄	42.56a	58.67a	60.11a	62.00ab	70.22a	64.56a
T ₅	41.11a	56.44ab	58.78a	61.56ab	66.33ab	62.89a
Level of significance	**	**	**	**	**	**

T₀=Control, T₁ = Vitaplus, T₂= Brassinosteroid, T₃=Wuxalsuper

T₄= Vitaplus + Wuxalsuper, T₅= Brassinosteroid+ Wuxalsuper,

In a column, the figures bearing same letter(s) or without letters are identical and those having dissimilar letters differed significantly as per DMRT

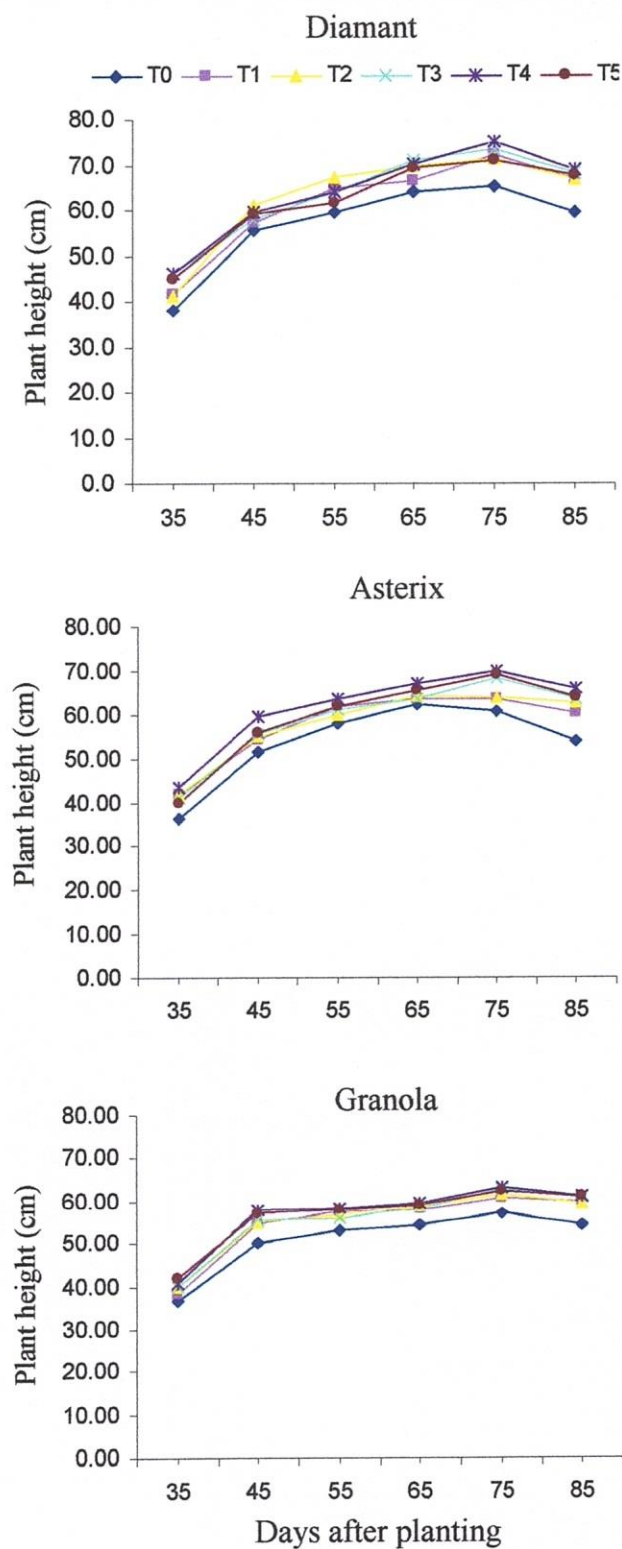


Figure 10a. Effect of plant growth regulators and micro nutrient treatments on plant height (PH) of three potato cultivars at different stages of growth [1st year (2010-2011)]

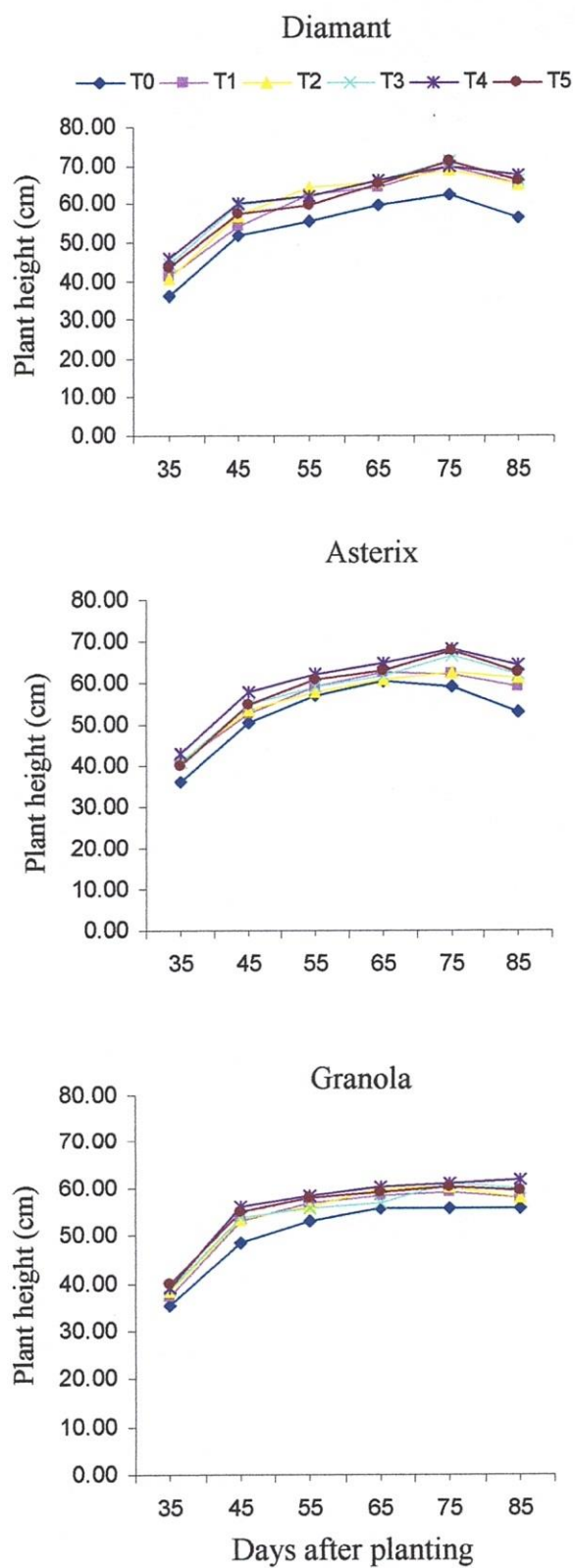


Figure 10b. Effect of plant growth regulators and micro nutrient treatments on plant height (PH) of three potato cultivars at different stages of growth [2nd year (2011-2012)]

4.1.11 Number of haulms plant⁻¹

Analysis of variation revealed that cultivar differences for number of haulms were significant at all the harvests in both the years. Treatment differences were also significant at all the harvests in both the years except at 75 DAP in 2011-12. Interaction effect between cultivars and treatments for number of haulms was non-significant at all the harvests in both the years (Tables 32a and 32b).

Cultivar Diamant showed the highest number of haulms at all the harvests in both the years. On the other hand, cultivar Asterix showed the lowest number of haulms at all the harvests in both the years. Number of haulms per plant of the cultivar Asterix and Granola were found statistically identical at 35, 65 and 85 DAP in 2010-11 and at all the harvests in 2011-12 (Tables 33a and 33b).

Treatment T₄ (Vitaplust+Wuxalsuper) showed the highest number of haulms at all the harvests in both the years. Treatments T₁ (Vitaplust) and T₂ (Brassinosteroid) were found statistically identical at 65, 75 and 85 DAP in 2010-11 and at 75 and 85 DAP in 2011-12. Similarly, the treatments T₃ (Wuxalsuper) and T₅ (Brassinosteroid+ Wuxalsuper) were found statistically identical at 65 and 85 DAP in 2010-11 and at 55 and 85 DAP in 2011-12. All treatments showed the significant differences in respect of number of haulms per tuber over control at all the harvests in both the years (Tables 34a and 34b).

Effect of different treatments on the number of haulms per plant of three cultivars at different stages of growth of both the years is shown in Figures 11a and 11b. For all the cultivars and treatments no. of haulms plant⁻¹ increased slightly with the advancement of growth period up to 75 DAP and later on, it decreased gradually.

Table 32a. Mean squares from analysis of variance for number of haulms plant⁻¹ of potato
[1st year (2010-2011)]

Sources of variation		df	Days after planting				
			35	45	55	65	75
Replication	2	0.10	0.17	0.07	0.77	0.45	0.28
Cultivar (A)	2	2.51**	1.53**	6.48**	7.60**	7.35**	5.24**
Treatment (B)	5	1.25**	0.84**	1.45**	1.81**	0.81**	1.86**
A×B	10	0.09 ^{NS}	0.06 ^{NS}	0.23 ^{NS}	0.07 ^{NS}	0.26 ^{NS}	0.10 ^{NS}
Error	34	0.23	0.05	0.21	0.12	0.21	0.15
CV(%)		9.22	4.18	7.98	5.86	7.79	6.50

Table 32b. Mean squares from analysis of variance for number of haulms plant⁻¹ of potato
[2nd year (2011-2012)]

[2 nd year (2011-2012)]		Days after planting					
Sources of variation	df	35	45	55	65	75	85
Replication	2	2.06	1.35	2.06	5.72	3.78	3.04
Cultivar (A)	2	2.17**	2.95**	4.67**	7.37**	4.92**	4.67**
Treatment (B)	5	1.25**	0.45**	1.34**	1.63**	0.74 ^{NS}	1.91**
A×B	10	0.09 ^{NS}	0.16 ^{NS}	0.36 ^{NS}	0.19 ^{NS}	0.20 ^{NS}	0.08 ^{NS}
Error	34	0.22	0.10	0.19	0.15	0.38	0.16
CV(%)		9.38	6.10	7.83	6.90	10.69	7.01

Table 33a. Effect of cultivars on number of haulms plant⁻¹ at different days after planting [1st year (2010-11)]

Cultivars	Days after planting					
	35	45	55	65	75	85
Diamant (V ₁)	5.61a	5.58a	6.39a	6.58a	6.61a	6.56a
Asterix (V ₂)	4.89b	5.00c	5.19c	5.31b	5.39c	5.32b
Granola (V ₃)	5.08b	5.28b	5.49b	5.62b	5.92b	5.83b
Level of significance	**	**	**	**	**	**

Table 33b. Effect of cultivars on number of haulms plant⁻¹ at different days after planting [2nd year (2011-12)]

Cultivars	Days after planting					
	35	45	55	65	75	85
Diamant (V ₁)	5.42a	5.69a	6.17a	6.31a	6.43a	6.33a
Asterix (V ₂)	4.75b	4.94b	5.17b	5.21b	5.39b	5.33b
Granola (V ₃)	4.92b	5.06b	5.31b	5.50b	5.67b	5.47b
Level of significance	**	**	**	**	**	**

Table 34a. Effect of treatments on number of haulms plant⁻¹ at different days after planting [1st year (2010-11)]

Treatments	Days after planting					
	35	45	55	65	75	85
T ₀	4.56b	4.83c	5.11c	5.11c	5.44b	5.17c
T ₁	5.22a	5.39b	5.72ab	5.78b	6.00ab	5.89ab
T ₂	5.06ab	5.28b	5.56bc	5.72b	5.94ab	5.78b
T ₃	5.22a	5.22b	6.00ab	6.11ab	6.11ab	6.06ab
T ₄	5.61a	5.78a	6.28a	6.40a	6.56a	6.33a
T ₅	5.50a	5.22b	5.89ab	6.11ab	6.11ab	6.00ab
Level of significance	**	**	**	**	**	**

Table 34b. Effect of treatments on number of haulms plant⁻¹ at different days after planting [2nd year (2011-12)]

Treatments	Days after planting					
	35	45	55	65	75	85
T ₀	4.39b	4.83b	4.94c	4.78b	5.22b	4.94c
T ₁	5.06a	5.28a	5.61ab	5.61a	5.83ab	5.72b
T ₂	4.89ab	5.28a	5.44bc	5.56a	5.78ab	5.61b
T ₃	5.06a	5.33a	5.83ab	5.83a	5.94ab	5.83ab
T ₄	5.44a	5.50a	6.06a	6.01a	6.33a	6.06a
T ₅	5.33a	5.17b	5.78ab	5.67a	5.94ab	5.83ab
Level of significance	**	**	**	**	**	**

T₀=Control, T₁ = Vitapplus, T₂= Brassinosteroid, T₃=Wuxalsuper

T₄= Vitapplus + Wuxalsuper, T₅= Brassinosteroid+ Wuxalsuper,

In a column, the figures bearing same letter(s) or without letters are identical and those having dissimilar letters differed significantly as per DMRT

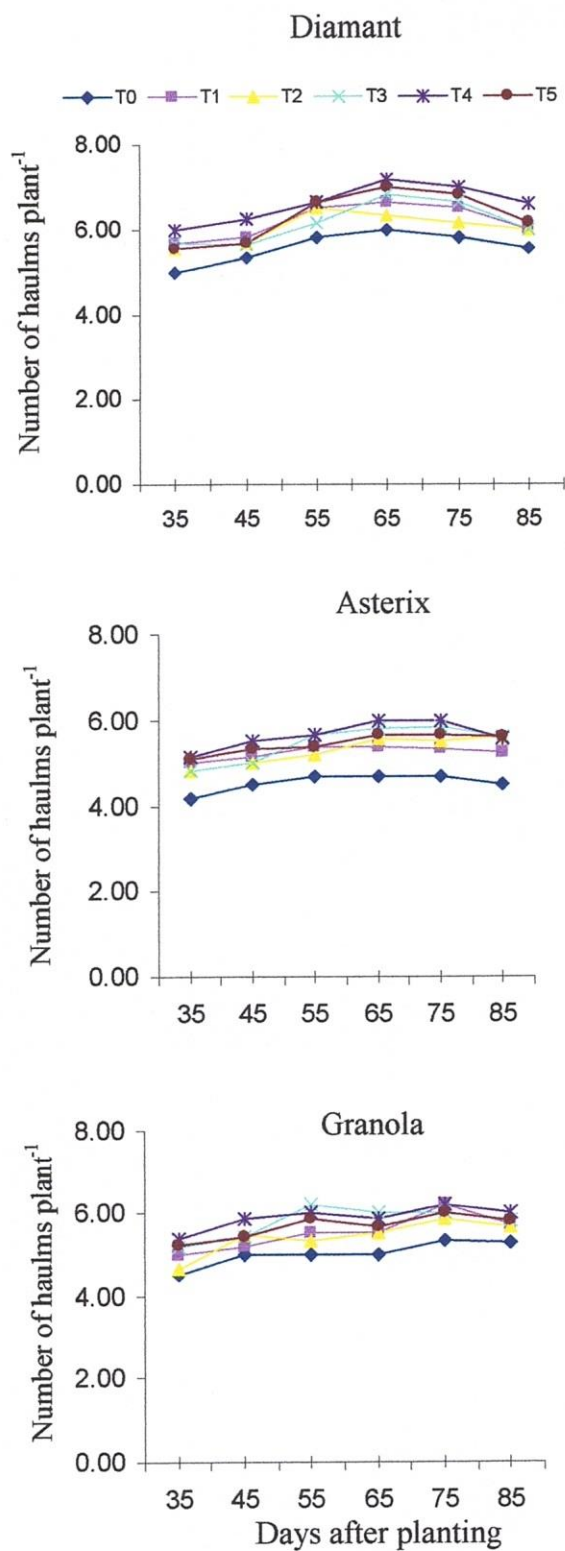


Figure 11a. Effect of plant growth regulators and micro nutrient treatments on number of haulms of three potato cultivars at different stages of growth [1st year (2010-2011)]

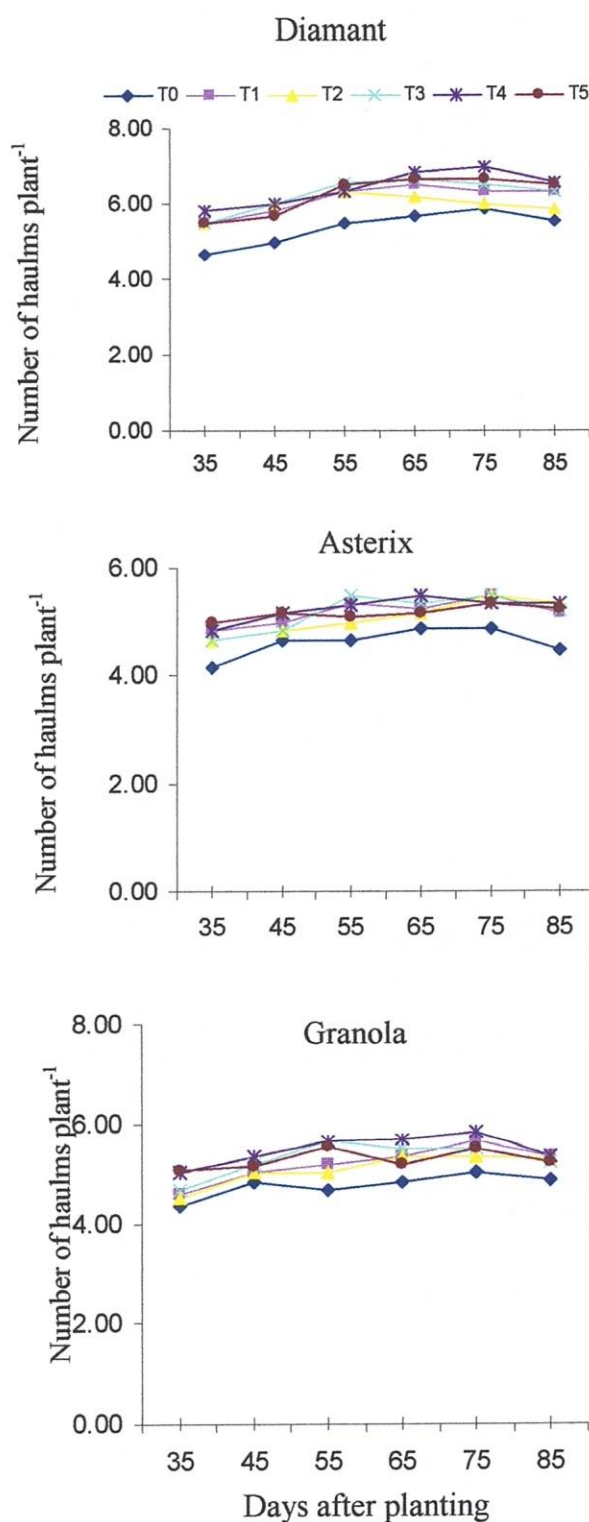


Figure 11b. Effect of plant growth regulators and micro nutrient treatments on number of haulms of three potato cultivars at different stages of growth [2nd year (2011-2012)]

YIELD AND YIELD COMPONENT

In the years 2010-11, the results showed that all the yield and yield contributing characters were significantly influenced by the cultivars. All the yield and yield contributing characters studied were significantly influenced by the different plant growth regulators and micronutrient treatments. The yield and yield contributing characters like number of leaves per plant, and yield per plant were significantly influenced due to the interaction of the cultivars and treatments. The rest of the yield and yield contributing characters like plant height, number of haulms per plant, number of tubers per plant, yield per hectare and crop harvest index were non- significant due to the interaction effect between cultivars and treatments.

In the next year (2011-12), results revealed that all the yield and yield contributing characters varied significantly due to the cultivars. All the yield and yield contributing characters also varied significantly due to the different plant growth regulators and micronutrients. The yield and yield contributing characters like number of leaves per plant, number of tuber per plant, yield per plant and crop harvest index were significantly influenced by the interaction effect of the cultivars and treatments, while the rest of the yield and yield contributing characters like plant height, number of haulms per plant and yield per hectare were not significant due to the interaction effect of cultivars and treatments.

4.2 Plant height

4.2.1 Effect of cultivars

The plant height was significantly influenced by the cultivars in both the years of 2010-11 and 2011-12. The highest plant heights (69.28cm in first

year and 66.22cm in second year) were obtained from Diamant (V_1) cultivar in both the years. The lowest plant heights (59.67cm in first year and 58.06 cm in second year) were obtained from the cultivar Granola (V_3) (Tables 35a and 35b).

4.2.2 Effect of (plant growth regulators and micro-nutrient) treatments

Different treatments had significant effects on plant heights in both the years. The highest plant height (70.00cm in first year and 65.44cm in second year) was obtained from the treatment T_4 (Vitaplus + Wuxalsuper) in both the years. On the other hand, the lowest plant height (57.56cm in first year and 55.78 cm in second year) was obtained from the treatment T_0 (control) in both the years (Tables 36a and 36b).

4.2.3 Interaction effect between cultivars and treatments

Interaction effect between cultivars and treatments was not significant for plant height in 2010-11 and 2011-12. However, the highest plant height (76.00cm in first year and 71.00 cm in second year) were recorded in V_1T_4 (Diamant+ Vitaplus +Wuxalsuper) treatment combination. On the other hand, the lowest plant height (56.00cm and 53.33cm) were recorded in V_3T_0 (Granola+control) treatment combination in 2010-11 and 2011-12 respectively (Tables 37a and 37b).

4.3 Number of leaves per plant

4.3.1 Effect of cultivars

The number of leaves per plant had significant effect on the cultivars in both the years. The highest number of leaves (29.06 in first year and 31.97 in second years) per plant was obtained from Diamant (V_1) cultivar,

while the lowest number of leaves (20.36 and 21.96) per plant was recorded from Granola (V_3) cultivar (Tables 35a and 35b).

4.3.2 Effect of treatments

Number of leaves per plant was significantly influenced by the treatments in both the years. The highest number of leaves (27.47 in first year and 31.18 in second years) per plant was obtained from the treatment T_4 (Vitapulus + Wuxalsuper). The treatments T_4 (Vitapulus + Wuxalsuper) and T_5 (Brassinosteroid + Wuxalsuper) were found statistically identical in 2010-11. On the contrary, the lowest number of leaves (21.16 in first year and 21.22 in second year) per plant was obtained from the treatment T_0 (control) (Tables 36a and 36b).

4.3.3 Interaction effect between cultivars and treatments

Number of leaves per plant was significantly influenced by the interaction of treatments and cultivars in the experimentation years of 2010-11 and 2011-12. However, the highest number of leaves (30.80 in first year and 37.40 in second year) per plant was recorded from V_1T_1 (Diamant + Vitapulus) treatment combination in 2010-11 and from V_1T_4 (Diamant + Vitapulus + Wuxalsuper) in 2011-12. The treatment combinations V_1T_2 (Diamant + Brassinosteroid), V_1T_4 (Diamant + Vitapulus + Wuxalsuper), V_1T_5 (Diamant + Brassinosteroid + Wuxalsuper), V_2T_4 (Asterix + Vitapulus + Wuxalsuper) and V_2T_5 (Asterix + Brassinosteroid + Wuxalsuper) were found statistically identical in the years of 2010-11. Similarly, the treatment combinations V_2T_3 (Asterix + Wuxalsuper), V_3T_2 (Granola + Brassinosteroid), V_3T_4 (Granola + Vitapulus + Wuxalsuper) and V_3T_5 (Granola + Brassinosteroid + Wuxalsuper) were also found statistically identical in the same year. The treatment combinations V_2T_0 (Asterix + control), V_3T_1 (Granola + Vitapulus), V_3T_2 (Granola + Brassinosteroid) and V_3T_3 (Granola + Wuxalsuper) were also found

statistically identical the years of in 2011-12. The lowest number of leaves (16.93 in first year and 16.40 in second year) per plant was observed from the treatment combination V_3T_0 (Granola + control) in both the years (Tables 37a and 37b).

4.4 Number of haulms per plant

4.4.1 Effect of cultivars

The number of haulms per plant was significantly influenced by the cultivars in 2010-11 and 2011-12. The highest number of haulms (6.69 in first year and 6.58 in second years) per plant was obtained from Diamant (V_1) cultivar and the lowest number of haulms (5.89 and 5.72) per plant was obtained from Asterix (V_2) cultivar in 2010-11 and 2011-12. The number of haulms (5.72 in first year and 6.00 in second years) of the cultivar Asterix (V_2) and Granola (V_3) were found statistically identical in 2011-12 (Tables 35a and 35b).

4.4.2 Effect of treatments

The number of haulms per plant was significantly influenced by the treatments in 2010-11 and 2011-12. The highest number of haulms (6.83 in first year and 6.56 in second years) per plant was recorded from the treatment T_4 (Vitaplus + Wuxalsuper) in both the years. The treatments T_1 (Vitaplus), T_3 (Wuxalsuper) and T_5 (Brassinosteroid + Wuxalsuper) were found statistically identical in 2010-11. The treatments T_1 (Vitaplus), T_2 (Brassinosteroid), and T_5 (Brassinosteroid + Wuxalsuper) were found statistically identical in 2011-12. On the contrary, the lowest number of haulms (5.50 in first year and 5.28 in second years) per plant was obtained from the treatment T_0 (control) (Tables 36a and 36b).

4.4.3 Interaction effect between cultivars and treatments

Interaction effect between cultivars and treatments for the number of haulms plant⁻¹ was found statistically non-significant. However, the highest number of haulms (7.33) was recorded from V₁T₄ (Diamant+ Vitapulus + Wuxalsuper) treatment combination, while the lowest number of haulms (5.33 and 5.00) per plant was recorded from the V₃T₀ (Granola+control) treatment combination in 2010-11 and 2011-12 (Tables 37a and 37b).

4.5 Number of tubers plant⁻¹

4.5.1 Effect of cultivars

The number of tubers per plant was significantly influenced by the cultivars in the year 2010-11. The highest number of tubers (10.59 in first year and 11.34 in second year) per plant was observed in Diamant (V₁) cultivar while the lowest number of tubers (7.42 in first year and 7.91 in second year) per plant was recorded from V₂ (Asterix) cultivar. The number of tubers (10.59 in first year and 10.36 in second year) of cultivar V₁ (Diamant) and V₃ (Granola) was found statistically identical in 2010-11 (Tables 35a and 35b).

4.5.2 Effect of treatments

The number of tubers per plant was statistically significant due to the treatments in 2010-11 and 2011-12. The highest number of tubers (10.69 in first year and 10.80 in second years) per plant were obtained from the treatment T₄ (Vitapulus + Wuxalsuper) and the lowest number of tubers (7.96 in first year and 7.76 in second year) per plant were recorded from T₀ (control) treatment. However the treatments T₁ (Vitapulus) and T₂ (Brassinosteroid) were found statistically identical in the 1st year and in the second year respectively (Tables 36a and 36b).

4.5.3 Interaction effect between cultivars and treatments

Interaction effect between cultivars and treatments was not significant for the number of tubers per plant in first year 2010-11, but it was significant in 2011-12. The highest number of tubers (11.33 and 12.93) per plant was obtained from V_1T_3 (Diamant + Wuxalsuper) treatment combination in 2010-11 and from treatment combination V_1T_4 (Diamant + Vitapulus + Wuxalsuper) in the year 2011-12. On the contrary, the lowest number of tubers (5.93 and 6.73) per plant were obtained from V_3T_0 (Granola + control) treatment combination in 2010-11 and 2011-12. In 2011-12, the treatment combinations V_1T_1 (Diamant + Vitapulus) and V_1T_2 (Diamant + Brassinosteroid), V_2T_2 (Asterix + Brassinosteroid) and V_2T_3 (Asterix + Wuxalsuper) and were found statistically identical (Tables 37a and 37b).

4.6. Yield per plant

4.6.1 Effect of cultivars

Yield per plant was significantly influenced by the cultivars in both the years. However, the highest yield (540.8g in first year and 568.5g in second years) per plant was obtained from Diamant (V_1) cultivar while the lowest yield (487.2g in first year and 512.8g in second years) per plant was recorded from Granola (V_3) cultivar in both the years. The yield (499.2g in Asterix and 487.2g in Granola) per plant of the cultivar Asterix (V_2) and Granola (V_3) was found statistically identical in 2010-11 (Tables 35a and 35b).

4.6.2 Effect of treatments

Yield per plant was significantly influenced by the treatments in the years of 2010-11 and 2011-12. The highest yield (587.8g in first year and 621.9g in second years) per plant were obtained from the treatment T_4 (Vitapulus + Wuxalsuper). The treatments T_1 (Vitapulus) and T_2

(Brassinosteroid) were found statistically identical in respect of yield per plant in both the years. The lowest yields of 365.0g and 377.7g per plant were obtained from T_0 (control) treatment in 2010-11 and 2011-12 respectively (Tables 36a and 36b).

4.6.3 Interaction effect between cultivars and treatments

Interaction effect between cultivars and treatments was significant for yield per plant in both the years. The highest amount of yield (646.7g and 676.7g) per plant was recorded from V_1T_4 (Diamant + Vitapulus + Wuxalsuper) treatment combination while the lowest amount of yield (363.3 and 369.7g) per plant were obtained from V_1T_0 (Diamant+control) and V_3T_0 (Granola + control) treatment combination in both the years. The treatment combination V_1T_3 (Diamant+Wuxalsuper) and V_1T_5 (Diamant + Brassinosteroid + Wuxalsuper) were found statistically identical. Similarly, the treatment combinations V_1T_1 (Diamant + Vitapulus), V_2T_2 (Asterix + Brassinosteroid), V_2T_3 (Asterix + Wuxalsuper) and V_3T_5 (Granola + Brassinosteroid + Wuxalsuper) were found statistically identical in 2010-11. The treatment combinations V_1T_2 (Diamant + Brassinosteroid), V_2T_1 (Asterix + Vitapulus), V_2T_5 (Asterix + Brassinosteroid + Wuxalsuper) and V_3T_4 (Granola + Vitapulus + Wuxalsuper) were found statistically identical. The treatment combinations V_1T_1 (Diamant + Vitapulus), V_2T_2 (Asterix+ Brassinosteroid), V_2T_3 (Asterix + Wuxalsuper), V_3T_3 (Granola+ Wuxalsuper) and V_3T_5 (Granola + Brassinosteroid + Wuxalsuper) were also found statistically identical in 2011-12. The lowest amount of yield (363.3g and 369.7g) per plant was obtained from V_1T_0 (Diamant + control) treatment combination in the 1st year and V_3T_0 (Granola + control) treatment combination in 2nd year (Tables 37a and 37b).

4.7. Yield per hectare

4.7.1 Effect of cultivars

The cultivars showed significant difference in respect of yield per hectare in the experimentation years 2010-11 and 2011-12. The highest amount of yield (28.20 t ha^{-1} in first year and 28.01 t ha^{-1} in second years) was obtained from Diamant (V_1) cultivar while the lowest amount of yield (26.49 t ha^{-1} in first year and 26.26 t ha^{-1} in second years) were recorded in Granola (V_3) cultivar. Yield of two cultivars Diamant (V_1) and Asterix (V_2) were found statistically identical in 2010-11 (Tables 35a and 35b).

4.7.2 Effect of treatments

Yield per hectare was significantly influenced by the treatments in both the years. The highest amount of yield (30.47 t ha^{-1} in first year and 30.79 t ha^{-1} in second years) was recorded from the treatment T_4 (Vitaplus + Wuxalsuper) and the lowest amount of yield (20.72 t ha^{-1} in first year and 18.49 t ha^{-1} in second years) was recorded from unsprayed T_0 (control) treatment. The treatments T_1 (Vitaplus), T_2 (Brassinosteroid) and T_3 (Wuxalsuper) were found statistically identical in 2010-11. However, the treatment T_4 (Vitaplus + Wuxalsuper) and T_5 (Brassinodteroid + Wuxalsuper) were found statistically identical in both the years of 2011-12 and 2011-12 (Tables 36a and 36b).

4.7.3 Interaction effect between cultivars and treatments

There was no significant difference due to interaction between cultivars and treatments in respect of yield (ton) per hectare. However, the highest amount of yield (31.34 t ha^{-1} in first year and 31.93 t ha^{-1} in second years) was obtained from V_1T_4 (Asterix+ Vitaplus +Wuxalsuper) treatment combination while the lowest amount of yield 20.31 t ha^{-1} was recorded

from V_3T_0 (Granola+control) treatment combination in first year and 18.33 t ha^{-1} from V_2T_0 (Asterix + control) treatment combination in the second year (Tables 37a and 37b).

4.8 Harvest index (%)

4.8.1 Effect of cultivars

The cultivars responded significantly in respect of harvest index in both the years. The highest index (74.60% in first year and 75.66% in second years) were obtained from Granola (V_3) cultivar and the lowest index (68.33% in first year and 68.57% in second years) was recorded from Diamant (V_1) cultivar (Tables 35a and 35b).

4.8.2 Effect of treatments

The harvest index was found to differ significantly due to treatments in both the years.

The highest harvest index (72.58% in first year and 73.35% in second years) was recorded from the treatment T_5 (Brassinosteroid + Wuxalsuper) while the lowest harvest index (69.91 in first year and 70.96 in second years) index was observed in T_0 (control). The treatments Vitaplus (T_1) and Wuxalsuper (T_3) was found statistically identical in 2010-11. The crop harvest index (73.07%, 72.46% and 73.35%) were obtained from the treatment Vitaplus (T_1), Brassinosteroid (T_2) and T_5 (Brassinosteroid + Wuxalsuper) were found statistically identical. Similarly, the crop harvest index (72.38% and 72.13%) were found statistically identical and were obtained from the treatment Wuxalsuper (T_3) and T_4 (Vitaplus + Wuxalsuper) in 2011-12 (Tables 36a and 36b).

4.8.3 Interaction effect between cultivars and treatments

There were no significant differences due to the interaction effect between cultivars and treatments on crop harvest index in 2010-11. Numerically the highest index (75.53%) was found in V_3T_3 (Granola+Wuxalsuper) treatment combination while the lowest crop harvest index (67.29%) was found in V_1T_0 (Diamant+control) treatment combination. In 2011-12, significant differences due to the interaction effect between cultivars and treatments were observed in respect of crop harvest index. However, the highest crop harvest index (77.17%) was recorded in V_3T_3 (Granola+Wuxalsuper) treatment combination. The treatment combinations V_3T_3 (Granola + Wuxalsuper), V_3T_4 (Granola+ Vitapulus + Wuxalsuper) and V_3T_5 (Granola + Brassinosteroid + Wuxalsuper) were found statistically identical. The treatment combinations V_3T_1 (Granola+ Vitapulus) and V_3T_2 (Granola + Brassinosteroid) were found statistically identical. Similarly, the treatment combinations V_2T_0 (Asterix + control), V_2T_3 (Asterix + Wuxalsuper), V_2T_4 (Asterix + Vitapulus + Wuxalsuper) and V_3T_0 (Granola + control) treatment combination were found statistically identical. The lowest crop harvest index (67.45%) was obtained from V_1T_0 (Diamant + control) treatment combination. The treatment combinations V_1T_0 (Diamant + control) V_1T_1 (Diamant + Vitapulus) and V_1T_3 (Diamant + Wuxalsuper) and V_1T_4 (Diamant + Vitapulus + Wuxalsuper) treatment combination was found statistically identical in 2011-12 (Tables 37a and 37b).

Table 35a. Effect of cultivars on yield and yield contributing characters of potato [1st year (2010-2011)].

Cultivars	Plant height (cm)	No. of leaves plant ⁻¹	No. of haulms plant ⁻¹	No. of tubers plant ⁻¹	Yield plant ⁻¹ (g)	Yield (t ha ⁻¹)	Harvest index (%)
Diamant (V ₁)	69.28a	29.06a	6.69a	10.59a	540.8a	28.20a	68.33c
Asterix (V ₂)	65.22b	24.49b	5.89c	7.42b	499.2b	27.70a	70.96b
Granola (V ₃)	59.67c	20.36c	6.28b	10.36a	487.2b	26.49b	74.60a
Level of significance	**	**	**	**	**	**	**
CV (%)	4.94	4.41	6.26	5.35	3.53	3.37	2.28

Table 35b. Effect of cultivars on yield and yield contributing characters of potato [2nd year (2011-2012)].

Cultivars	Plant height (cm)	No. of leaves plant ⁻¹	No. of haulms plant ⁻¹	No. of tubers plant ⁻¹	Yield plant ⁻¹ (g)	Yield (t ha ⁻¹)	Harvest index (%)
Diamant (V ₁)	66.22a	31.97a	6.58a	11.34a	568.5a	28.01a	68.57c
Asterix (V ₂)	60.78b	27.42b	5.72b	7.91c	539.1b	27.11b	72.94b
Granola (V ₃)	58.06c	21.96c	6.00b	9.93b	512.8c	26.26c	75.66a
Level of significance	**	**	**	**	**	**	**
CV (%)	3.57	5.09	5.65	5.28	4.22	2.99	1.96

In a column, the figures bearing same letter(s) or without letters are identical and those having dissimilar letters differed significantly as per DMRT

Table 36a. Effect of plant growth regulators and micronutrients on yield and yield contributing characters of potato [1st year (2010-2011)].

Treatment	Plant height (cm)	No. of leaves plant ⁻¹	No. of haulms plant ⁻¹	No. of tubers plant ⁻¹	Yield plant ⁻¹ (g)	Yield (t ha ⁻¹)	Harvest index (%)
T ₀	57.56d	21.16d	5.50c	7.96d	365.0e	20.72c	69.91c
T ₁	63.44bc	23.76c	6.33ab	8.80c	505.6d	27.97b	71.41a-c
T ₂	63.00c	25.22b	6.22b	9.16c	507.8d	27.58b	70.82bc
T ₃	67.56ab	23.47c	6.33ab	9.82b	531.1c	28.09b	71.21a-c
T ₄	70.00a	27.47a	6.83a	10.69a	587.8a	30.47a	71.86ab
T ₅	66.78a-c	26.73a	6.50ab	10.31ab	557.2b	29.95a	72.58a
Level of significance	**	**	**	**	**	**	*
CV(%)	4.94	4.41	6.26	5.35	3.53	3.37	2.28

Table 36b. Effect of plant growth regulators and micronutrients on yield and yield contributing characters of potato [2nd year (2011-2012)]

Treatment	Plant height (cm)	No. of leaves plant ⁻¹	No. of haulms plant ⁻¹	No. of tubers plant ⁻¹	Yield plant ⁻¹ (g)	Yield (t ha ⁻¹)	Harvest index (%)
T ₀	55.78d	21.22e	5.28c	7.76d	377.7d	18.49d	70.96b
T ₁	61.33bc	25.36d	6.22ab	9.47c	536.6c	27.25c	72.46a
T ₂	60.56c	26.89cd	6.17ab	9.80c	555.6c	27.81bc	73.07a
T ₃	63.78ab	28.40bc	6.06b	10.09bc	560.6bc	28.32b	72.38ab
T ₄	65.44a	31.18a	6.56a	10.80a	621.9a	30.79a	72.13ab
T ₅	63.22a-c	29.64ab	6.33ab	10.47ab	588.6b	30.13a	73.35a
Level of significance	**	**	**	**	**	**	*
CV(%)	3.57	5.09	5.65	5.28	4.22	2.99	1.96

T₀=Control, T₁ = Vitaplus, T₂= Brassinosteroid, T₃= Wuxalsuper

T₄= Vitaplus + Wuxalsuper, T₅=Brassinosteroid+ Wuxalsuper,

In a column, the figures bearing same letter(s) or without letters are identical and those having dissimilar letters differed significantly as per DMRT

Table 37a. Effect of interaction between cultivars and plant growth regulators & micronutrients on yield and yield contributing characters of potato [1st year (2010-2011)].

Cultivars × Treatments	Plant height (cm)	No. of leaves plant ⁻¹	No. of haulms plant ⁻¹	No. of tubers plant ⁻¹	Yield plant ⁻¹ (g)	Yield (t ha ⁻¹)	Harvest index (%)
V ₁ T ₀	58.33	27.53b	5.67	8.93	363.3h	21.09	67.29
V ₁ T ₁	69.00	30.80a	6.83	8.47	515.0d-g	28.97	69.03
V ₁ T ₂	68.00	29.47ab	6.67	8.60	530.0c-f	28.30	67.41
V ₁ T ₃	72.67	27.47b	6.67	11.33	588.3b	28.81	68.18
V ₁ T ₄	76.00	29.80ab	7.33	9.07	646.7a	31.34	68.94
V ₁ T ₅	71.67	29.27ab	7.00	9.00	601.7b	30.70	68.15
V ₂ T ₀	58.33	19.00e	5.50	5.93	366.7h	20.76	71.05
V ₂ T ₁	62.33	21.67d	6.00	7.47	496.7fg	28.30	71.24
V ₂ T ₂	62.00	24.27c	5.83	7.80	506.7d-g	28.30	69.83
V ₂ T ₃	68.00	23.93cd	6.00	8.53	511.7d-g	27.81	69.92
V ₂ T ₄	71.33	29.33ab	6.17	7.33	570.0bc	31.01	70.25
V ₂ T ₅	69.33	28.73ab	5.83	6.97	543.3c-e	30.03	71.81
V ₃ T ₀	56.00	16.93e	5.33	9.33	365.0h	20.31	71.38
V ₃ T ₁	59.00	18.80e	6.17	10.33	505.0e-g	27.00	73.95
V ₃ T ₂	59.00	21.93cd	6.17	10.53	486.7g	26.14	75.21
V ₃ T ₃	62.00	19.00e	6.33	10.60	493.3fg	27.29	75.53
V ₃ T ₄	62.67	23.27cd	7.00	10.40	546.7cd	29.07	73.06
V ₃ T ₅	59.33	22.20cd	6.67	11.27	526.7d-g	29.11	73.46
Level of significance	NS	**	NS	NS	**	NS	NS
CV (%)	4.94	4.41	6.26	5.35	3.53	3.37	2.36

V₁=Diamant, V₂=Asterix, V₃=Granola

T₀=Control, T₁ = Vitaplus, T₂= Brassinosteroid, T₃= Wuxalsuper,

T₄= Vitaplus + Wuxalsuper, T₅= Brassinosteroid+ Wuxalsuper,

In a column, the figures bearing same letter(s) or without letters are identical and those having dissimilar letters differed significantly as per DMRT

Table 37b. Effect of interaction between cultivars and plant growth regulators & micronutrients on yield and yield contributing characters of potato [2nd year (2011-2012)]

Cultivars × Treatments	Plant height (cm)	No. of leaves plant ⁻¹	No. of haulms plant ⁻¹	No. of tubers plant ⁻¹	Yield plant ⁻¹ (g)	Yield (t ha ⁻¹)	Harvest index (%)
V ₁ T ₀	57.33	25.33g	5.50	8.27g	389.0g	18.79	67.45e
V ₁ T ₁	66.67	28.53c-f	6.83	11.33bc	541.3de	28.19	68.23e
V ₁ T ₂	65.00	31.07c	6.67	11.33bc	581.0c-e	28.57	69.64de
V ₁ T ₃	69.00	35.20ab	6.33	11.87a-c	586.7b-d	29.63	67.69e
V ₁ T ₄	71.00	37.40a	7.33	12.93a	676.7a	31.93	68.69e
V ₁ T ₅	68.33	34.27b	6.83	12.33ab	636.3ab	30.99	69.71de
V ₂ T ₀	56.67	21.93h	5.33	6.73h	374.3g	18.33	71.91cd
V ₂ T ₁	59.33	27.20d-g	5.83	7.40gh	580.7c-e	27.06	73.71bc
V ₂ T ₂	59.67	28.33c-g	5.67	8.13g	552.7de	27.59	73.83bc
V ₂ T ₃	61.67	28.47c-f	5.83	8.33g	546.7de	27.72	72.26cd
V ₂ T ₄	64.67	29.67cd	5.83	8.53fg	605.7bc	31.25	72.10cd
V ₂ T ₅	62.67	28.93c-e	5.83	8.33g	574.7c-e	30.73	73.84bc
V ₃ T ₀	53.33	16.40i	5.00	8.27g	369.7g	18.35	72.29cd
V ₃ T ₁	58.00	20.33h	6.00	9.67ef	487.7f	26.51	75.43ab
V ₃ T ₂	57.00	21.27h	6.17	9.93de	533.0ef	27.28	75.75ab
V ₃ T ₃	60.67	21.53h	6.00	10.07de	548.3de	27.60	77.17a
V ₃ T ₄	60.67	26.47e-g	6.50	10.93cd	583.3c-e	29.18	76.83a
V ₃ T ₅	58.67	25.73fg	6.33	10.73c-e	554.7de	28.66	76.50a
Level of significance	NS	**	NS	**	**	NS	*
CV (%)	3.57	5.09	5.65	5.28	4.22	2.99	1.96

V₁=Diamant, V₂=Asterix, V₃=Granola

T₀=Control, T₁ = Vitapulus, T₂= Brassinosteroid, T₃=Wuxalsuper

T₄= Vitapulus + Wuxalsuper, T₅= Brassinosteroid+ Wuxalsuper,

In a column, the figures bearing same letter(s) or without letters are identical and those having dissimilar letters differed significantly as per DMRT

4.9 Benefit Cost Ratio (BCR)

In 2010-11 and 2011-12, results showed that all the parameters relating to benefit cost ratio (BCR) i.e Gross return (Tk per ha), Net return (Tk per ha) and Benefit cost ratio (BCR) except cost of production (Tk per ha) were significantly influenced by the growth regulators and micro-nutrient treatments.

4.9.1 Gross return (Tk ha⁻¹)

Gross return had a significant effect with the application of different plant growth regulators and micronutrient treatments in both the years of 2010-11 and 2011-12. The highest return (365.70 Tk ha⁻¹ in the first year and 370.80 in the second year) was obtained from the treatment T₄ (Vitaplus + Wuxalsuper) in both the years. In both the years, treatments T₄ (Vitaplus + Wuxalsuper) and T₅ (Brassinosteroid + Wuxalsuper) were found statistically identical. The lowest gross returns (248.70 Tk ha⁻¹ in first year and 221.88 Tk ha⁻¹ in second year) were obtained from the unsprayed T₀ (control) treatment (Tables 38a and 38b).

4.9.2 Cost of production (Tk ha⁻¹)

There was no significant difference among the treatments in respect of total cost in both the years of 2010-11 and 2011-12. The highest cost of production (226.17 Tk ha⁻¹ and 240.32 Tk ha⁻¹) was recorded for the treatment T₄ (Vitaplus + Wuxalsuper) and T₅ (Brassinosteroid + Wuxalsuper) in both the years of 2010-11 and 2011-12. The lowest cost was recorded for the treatment T₀ (control) for both the years (Tables 38a and 38b).

4.9.3 Net returns (Tk ha⁻¹)

The net return was significantly influenced owing to the effect of different treatments in both the years of 2010-11 and 2011-12. The highest net returns (139.50 Tk ha⁻¹ in first year and 130.40 in second years) was obtained from the treatment T₄ (Vitaplus + Wuxalsuper), while the lowest net returns (44.20 Tk ha⁻¹ in first year and 3.22 Tk ha⁻¹ in second year) were obtained from the treatment T₀ (control) (Tables 38a and 38b).

4.9.4 Benefit cost ratio (BCR)

Different treatments played significant roles in contributing benefit cost ratio in both the years. The highest BCR values (1.62 in the first year and 1.54 in the second years) were obtained from the treatment T₄ (Vitaplus + Wuxalsuper). The second highest BCR values (1.59 in the 1st year and 1.50 in the 2nd years) were found in the treatment T₅ (Brassinosteroid + Wuxalsuper). The lowest BCR values (1.22 and 1.01) were obtained from the treatment T₀ (control) in the experimentation years of 2010-11 and 2011-12 respectively (Tables 38a and 38b).

Table 38a. BCR of different treatments of table potato [1st year (2010-2011)]

Treatment	Gross return (Tk ha ⁻¹)	Cost of Production (Tk ha ⁻¹)	Net return (Tk ha ⁻¹)	BCR
T ₀	248.70c	204.49	44.20d	1.22c
T ₁	335.60b	215.94	120.90bc	1.56ab
T ₂	330.90b	215.94	115.00c	1.53b
T ₃	337.10b	214.71	121.10bc	1.56ab
T ₄	365.70a	226.17	139.50a	1.62a
T ₅	359.40a	226.17	133.20ab	1.59ab
Level of significance	**	NS	**	**
CV (%)	3.37	-	9.88	3.47

Table 38b. BCR of different treatments of table potato [2nd year (2011-2012)]

Treatment	Gross return (Tk ha ⁻¹)	Cost of Production (Tk ha ⁻¹)	Net return (Tk ha ⁻¹)	BCR
T ₀	221.90d	218.64	3.22e	1.01e
T ₁	327.10c	230.10	96.95d	1.42d
T ₂	333.80bc	230.10	103.70cd	1.45cd
T ₃	339.80b	228.87	110.90bc	1.48bc
T ₄	370.80a	240.32	130.40a	1.54a
T ₅	361.60a	240.32	121.20ab	1.50ab
Level of significance	**	NS	**	**
CV (%)	3.01	-	10.37	2.95

T₀=Control, T₁ = Vitaplus, T₂= Brassinosteroid, T₃=Wuxalsuper

T₄= Vitaplus + Wuxalsuper, T₅= Brassinosteroid+ Wuxalsuper,

In a column, the figures bearing same letter(s) or without letters are identical and those having dissimilar letters differed significantly as per DMRT

After releasing the tubers from cold storages morphological appearance were recorded during the period 2010-2011 as follows:-

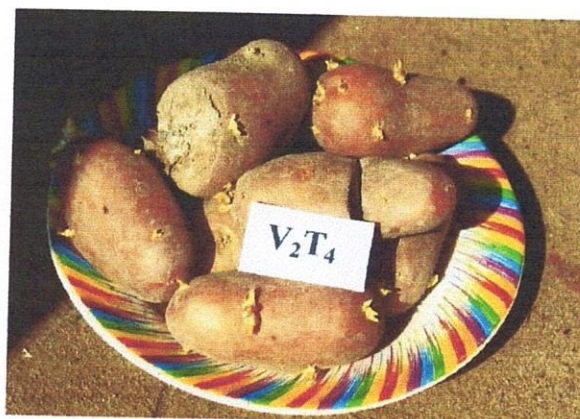
Table 39a. Morphological appearance of tubers of BADC Cold storage, Domer [1st year (2010-2011)]

Cultivar	Treatment	Observations
Diamant (V ₁)	T ₀	The condition of tubers was good; some small tubers were recorded shriveled.
	T ₁	2% ruptured tuber was recorded.
	T ₂	2% cracked tuber was recorded
	T ₃	The appearance of tuber was excellent. No damaged tuber was recorded.
	T ₄	Some 1% shriveled tubers were found. No distorted or damaged tubers were recorded.
	T ₅	Overall conditions of tubers were good.
Asterix (V ₂)	T ₀	No damaged or distorted tubers were found.
	T ₁	Around 2% ruptured tubers were recorded.
	T ₂	The condition of tubers were good
	T ₃	The appearance and colour of tubers were very good.
	T ₄	The conditions of tubers were good. No distorted or diseased tubers were found.
	T ₅	2% ruptured tuber but no damaged tuber was recorded.
Granola (V ₃)	T ₀	3% ruptured and some shriveled tubers in the bag were found.
	T ₁	Some 2% shriveled tubers were found but overall condition was excellent.
	T ₂	4% ruptured tubers were found.
	T ₃	The colour of tubers was excellent. No unhealthy tuber was recorded.
	T ₄	Tuber appearance was good and only 1% distorted tuber was recorded.
	T ₅	3% ruptured tubers were recorded.

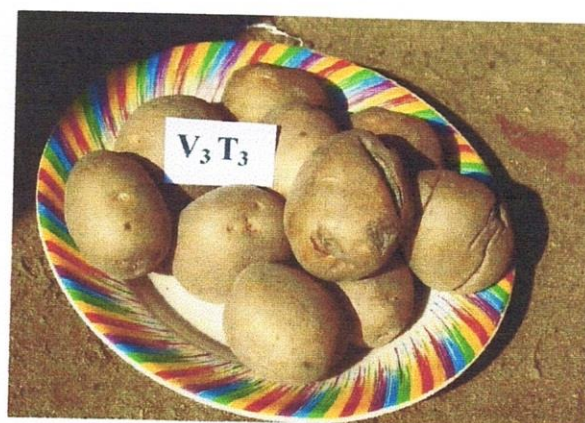
Plate 2



(A) Diamant



(B) Asterix



(C) Granola

Plate 2. A, B, C showing the morphological appearance of the tuber after releasing from BADC cold storage, Domar.

Table 39b. Morphological Appearance of tubers of BADC Cold Storage Domar [2nd year (2011-2012)]

Cultivar	Treatment	Observations
Diamant (V ₁)	T ₀	The condition of tuber was excellent
	T ₁	2% ruptured tuber was found
	T ₂	2% cracked tuber was recorded
	T ₃	The appearance of the tubers was excellent.
	T ₄	3% distorted tubers were found.
	T ₅	2% ruptured tubers was observed
Asterix (V ₂)	T ₀	No damaged distorted tuber was found.
	T ₁	5% ruptured tubers was found
	T ₂	2% damaged tuber was found
	T ₃	The appearance of the tuber was excellent
	T ₄	Over all condition was good.
	T ₅	2% ruptured tuber was recorded
Granola (V ₃)	T ₀	2% damaged tuber was found
	T ₁	2% shriveled tubers was found
	T ₂	3% ruptured tuber was found
	T ₃	The colour and appearance of the tuber was excellent
	T ₄	2% distorted tuber was recorded
	T ₅	3% ruptured tuber was found.

Table 40a. Morphological appearance of tubers of Saon Cold storage, Domer [1st year (2010-2011)]

Cultivar	Treatment	Observations
Diamant (V ₁)	T ₀	At least 2% shriveled, 2% ruptured and 2% rotting tubers was found.
	T ₁	Three percent ruptured and three percent rotting tubers was observed.
	T ₂	More than 4% early sprouted and 2% ruptured tubers have been reported.
	T ₃	At least 5% ruptured tubers, 2% early sprouted tubers and 2% rotting tubers have been recorded.
	T ₄	More than 4 percent early sprouted and 3% ruptured tuber have been recorded.
	T ₅	At least 3% spongy tuber, 2% rotting and more than 4% early sprouted tubers have been recorded in this treatment.
Asterix (V ₂)	T ₀	At least 2% early sprouted and 2% ruptured tubers have been recorded in this T ₀ treatment.
	T ₁	In this treatment 3% early sprouted and at least 4% rotting tubers were recorded.
	T ₂	More than 3% spongy tubers, 5% early sprouted tubers and 3% rotting tubers were recorded.
	T ₃	More than 4% spongy and 2% ruptured tubers have been recorded.
	T ₄	At least 3% ruptured 5% shriveled and 3% rotting tubers were recorded.
	T ₅	In this treatment, 3% ruptured and 3% shriveled tubers were found.
Granola (V ₃)	T ₀	More than 3% ruptured tubers were found. The colour of the tubers has been changed to some extent.
	T ₁	At least 4% early sprouted and 5% ruptured tubers have been recorded.
	T ₂	At least 8% ruptured tuber and 2% rotting tubers were observed in this treatment.
	T ₃	2% ruptured tubers and 2% rotting tubers were observed.
	T ₄	More than 3% ruptured and 5% rotting tubers were recorded in this treatment.
	T ₅	Only 4% ruptured tubers were recorded.

Plate 3



(A) Diamant



(B) Asterix



(C) Granola

Plate 3. A, B,C showing the morphological appearance of the tuber after releasing from Saon cold storage, Domar.

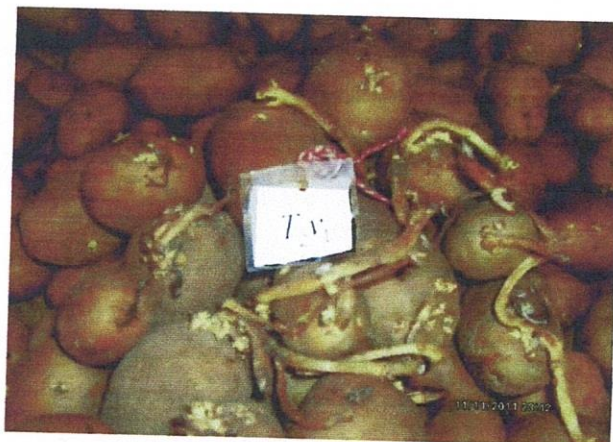
Table 40b. Morphological appearance of tubers Saon cold storage, Domar [2nd year (2011-12)]

Cultivar	Treatment	Observations
Diamant (V ₁)	T ₀	At least 2% early sprouted and 4% ruptured tubers were recorded.
	T ₁	3% to 5% percent ruptured tubers were found
	T ₂	At least 4% rotting and 7-8% ruptured tubers were reported
	T ₃	More than 4% ruptured, 2% early sprouted and 2% rotting tubers were observed
	T ₄	At least 3% early sprouted and 5% ruptured tubers were found
	T ₅	Around 3% early sprouted, 2% rotting and 3% spongy tubers were identified after releasing tubers from cold storage.
Asterix (V ₂)	T ₀	At least 2% early sprouted and 2% cracked tubers were reported.
	T ₁	More than 3% early sprouted and 3% rotting tubers were identified.
	T ₂	At least 3-4% early sprouted, 1-2% ruptured and 2-3% spongy tubers were found.
	T ₃	2-3% present spongy and 1-2% cracked tubers were recorded
	T ₄	More than 5-6% cracked, 2% early sprouted and 2% rotting tubers were found.
	T ₅	Around 2% ruptured and 2% rotting tubers were recorded.
Granola (V ₃)	T ₀	The colour of the tubers were changed to some extent and 3-4% cracked/distorted tubers were recorded
	T ₁	3% early sprouted and 3% cracked tubers were found.
	T ₂	More than 5% ruptured and 2% rotting tubers were recorded.
	T ₃	A very few of the rotting and cracked tubers were indentified.
	T ₄	More than 4% rotting and 2-3% cracked tubers were reported.
	T ₅	About 2-4% cracked and 3% spongy tubers have been reported.

Table 41a. Morphological appearance of tubers of Sajeda cold storage, Saidpur [1st (2010-11)]

Cultivar	Treatment	Observations
Diamant (V ₁)	T ₀	At least 5% shriveled to and 4% sprouted tubers were recorded. Sprout length was about 6" indicating high temperature and low relative humidity during storage period.
	T ₁	10% sprouted, 10% ruptured and 1% rotting tubers were recorded.
	T ₂	The colour of the tubers have been changed to some extent. At least 15% early sprouted and 20% shriveled tubers have been observed.
	T ₃	At least 10% shriveled and 10% sprouted tubers were recorded. Sprout length was about 1-3" clear indication poor preservation.
	T ₄	The colour of the tubers have been changed to some extent. At least 10% shriveled and 5% early sprouted (sprout length 1-3") tubers were observed.
	T ₅	More than 10% shriveled, 10% early sprouted (Sprout length up to 3") and 4% ruptured tubers have been observed.
Asterix (V ₂)	T ₀	At least 2% spongy, 10% shriveled 5% ruptured and very slow sprouted tubers were recorded.
	T ₁	At least 10% early sprouted, 3% ruptured and 35% shriveled tubers were observed.
	T ₂	Only 4% shriveled tubers and 4% rotted tubers were observed very slow sprouting were found.
	T ₃	Only 5% shriveled tubers were recorded.
	T ₄	Only 6% rotting tubers were found. At least 5% ruptured and 3% early sprouted tubers were recorded.
	T ₅	The colour of the tuber has been changed of some extent. At least 10% early sprouted and 10% shriveled tubers have been recorded.
Granola (V ₃)	T ₀	At least 3% shriveled and 2% ruptured tubers were found.
	T ₁	More than 5% ruptured and 5% early sprouted (sprout length 1-1.5") tubers were observed.
	T ₂	The colour of the tuber has been changed to some extent. More than 10% shriveled, 5% ruptured and 10% early sprouted tubers were recorded.
	T ₃	At least 7% ruptured 3% early sprouted, 6% shriveled tubers and 2% rotting tubers were recorded.
	T ₄	At least 4-5% early sprouted and 5% ruptured tubers were observed.
	T ₅	More than 6% shriveled, 4% ruptured and 4-5% early sprouted tubers were recorded.

Plate 4



(A) Diamant



(B) Asterix



(C) Granola

Plate 4. A, B, C showing the morphological appearance of the tuber after releasing from Sajeda cold storage, Saidpur.

Table 41b. Morphological appearance of tubers of Sajeda Cold Storage, Saidpur (2011-12)

Cultivar	Treatment	Observations
Diamant (V ₁)	T ₀	About 5-8% early sprouted tubers were found with sprout length 4-6 inches, some 8-10 spongy tubers were recorded.
	T ₁	More than 8-10% early sprouted, 8-10% ruptured and 1% rotting tubers were calculated.
	T ₂	At least 10-12% early sprouted and 10-15% shriveled tubers were found. The colour of the tubers have been changed to some extent.
	T ₃	At least 4-5% shriveled and 6-7% early sprouted tubers with sprout length 1-3% were found.
	T ₄	At least 18-20% shriveled and spongy and 5% early sprouted tubers were recorded. The colour of the tubers have been changed to some extent.
	T ₅	Around 12-15% shriveled, 3-4% ruptured and 6-8% early sprouted tubers were reported.
Asterix (V ₂)	T ₀	More than 4-5% shriveled, 3-4% ruptured and 2% spongy tubers have been detected.
	T ₁	At least 15-18% shriveled, 7-8% early sprouted and 2-3% ruptured tubers were recorded. Slow sprouted tendency was also observed.
	T ₂	Only 7-8% shriveled tubers were found, slow sprouting tendency was observed.
	T ₃	Only 6-7% shriveled tubers were found, slow sprouting tendency was observed even after 7 days of release from cold storage.
	T ₄	About 2% rotting, 3-4% ruptured and 2-3% early sprouted tubers were found.
	T ₅	Desirable colour of the seed potato has been changed to some extent. More than 6-8% early sprouted, 7-8% shriveled tubers were found.
Granola (V ₃)	T ₀	At least 1-2% ruptured, and 2-3% shriveled tubers have been observed.
	T ₁	About 2% early sprouted and 5-6% ruptured tubers were detected.
	T ₂	At least 10% shriveled, 3-4% ruptured and 7-8% early sprouted tubers have been recorded, sprouting tendency was very low.
	T ₃	At least 3-4 % ruptured, 2-3% early sprouted and 7-8% shriveled tubers have been found. The sprouting tendency was very slow.
	T ₄	Around 2-3% early sprouted and 2% ruptured tubers were noticed.
	T ₅	At least 7-8% shriveled, 6-7% ruptured and 3-4% early sprouted tubers were found.

Fresh Air Intake

BADC cold storage, Domar does fresh air intake job appropriately and effectively 3 times in a week for about one hour in each time as told by the official in charge of cold storage. This is done to keep seed potato healthy and viable as the fresh air provides sufficient amount of oxygen.

Saon cold storage, Domar does this job 2 times in a week for about half an hour for the same purpose as revealed by the employee in charge of the storage. Fresh air intake was not sufficient in comparison to the need of potato. Because it is a storage for preserving of table potatoes. This was why; the management does not consider it essential as well.

The same scenario was noticed at Sajeda cold storage, Saidpur another private cold storage of this district. Fresh air intake is generally carried out early in the morning for about 30-40 minutes twice in a week, the employee in charge of management opined.

Cleanliness

BADC cold storage, Domar generally takes precautionary measures before storing potato. Cleanliness activities are done with detergent materials before storing of potato with a view to making it suitable for seed potato preservation in each season as revealed by the Deputy Director, BADC Foundation Seed Production Farm, Sonaroy, Domar and the Head of the institution.

In private cold storages, cleanliness measures are not done effectively like public seed potato storage. But normal washing and cleaning are done before storing of potato, the managers of the above mentioned two cold storages opined.

Weight loss (%) of potato tuber of cold storage

(i) BADC cold storage, Domar

It is revealed from the records of two years of 2010-11 and 2011-12 that this storage always maintained a congenial storage environment which are prerequisite to keep the seed tubers healthy and disease free. The optimum storage temperature was around 2.2° - 2.8° C and relative humidity 90% (Appendix-3) from starting to ending of storage life of tubers. No distorted, damaged and sprouted tubers were observed. Weight loss was slightly higher than normal. Normal weight loss of this storage was around 4-5% while the highest 7% weight loss was observed from the treatment T_2 (Brassinosteroid). Normal weight loss was observed from the treatment T_0 (unsprayed control) and T_3 (Wuxalsuper). Treatments treated with plant growth regulators showed the maximum weight loss up to 6.5-7% in both the years. It has been observed that weight loss was minimal in the treatment T_0 in comparison to the treatment T_3 (Wuxalsuper) (Table 42).

Table 42. Weight loss (%) of potato tuber at BADC cold storage, Domar (2010-2011 and 2011-2012)

Cultivars × Treatments	2010-2011			2011-2012			Av. Wt. loss (%)
	Initial wt.(kg)	Final wt.(kg)	Wt. loss (%)	Initial wt.(kg)	Final wt.(kg)	Wt. loss (%)	
V ₁ T ₀	17.82	16.84	5.50	15.57	14.49	5.00	5.25
V ₁ T ₁	15.27	14.20	7.00	18.35	17.18	6.50	6.75
V ₁ T ₂	17.66	16.42	7.00	18.15	17.08	7.00	7.00
V ₁ T ₃	16.97	16.03	5.50	20.26	19.15	6.00	5.75
V ₁ T ₄	17.02	15.91	6.50	18.67	17.46	6.50	6.50
V ₁ T ₅	16.79	15.70	6.50	18.88	17.52	7.00	6.75
V ₂ T ₀	18.01	17.11	5.00	14.38	13.67	5.00	5.00
V ₂ T ₁	18.62	17.41	6.50	18.04	16.77	7.00	6.75
V ₂ T ₂	18.93	17.70	6.50	18.75	17.53	6.50	6.50
V ₂ T ₃	20.96	19.81	6.50	19.64	18.36	6.50	6.50
V ₂ T ₄	20.10	18.90	6.00	19.02	17.68	7.00	6.50
V ₂ T ₅	20.38	19.16	6.00	18.76	17.45	7.00	6.50
V ₃ T ₀	17.38	16.68	5.60	14.32	13.53	5.50	5.55
V ₃ T ₁	18.39	17.10	7.00	16.93	15.74	7.00	7.00
V ₃ T ₂	19.03	16.70	7.00	17.94	16.78	6.50	6.75
V ₃ T ₃	19.04	17.99	5.50	19.49	18.41	5.50	5.50
V ₃ T ₄	17.62	16.47	6.50	18.70	17.58	6.00	6.25
V ₃ T ₅	19.74	18.36	7.00	18.25	17.15	6.00	6.50

V₁=Diamant, V₂=Asterix, V₃=Granola

T₀=Control, T₁ = Vitaplus, T₂= Brassinosteroid, T₃=Wuxalsuper

T₄= Vitaplus + Wuxalsuper, T₅= Brassinosteroid+ Wuxalsuper,

ii) Saon cold storage, Domar

It is revealed from the records of two years of 2010-11 and 2011-12 that the storage temperature was around 2.5°-4°C and relative humidity was around 80- 85% (Appendix-3). Though fresh air intake was done in a certain interval, it was not sufficient enough in comparison to the volume and number of bags stored in this storage. This has been observed while taking records of storage in both the years. Weight loss of tubers recorded maximum in the plant growth regulator treated treatments. Average maximum weight loss (10.70%) was observed in V_3T_2 (Granola+ Brassinosteroid) treatment combination while the minimum weight loss (6.25%) was observed in V_2T_0 (Asterix+control) treatment combination. Treatments (T_1 & T_2) treated with plant growth regulators alone caused 10.50-10.70%) weight loss for all three cultivars in both the years. On the other hand, growth regulators in combination with Wuxalsuper caused average (9.25-10.00%) weight loss indicating the positive influence of Wuxalsuper in reducing weight loss of potato tubers in both the years (Table 43).

Table 43. Weight loss (%) of potato tuber at Saon cold storage, Domar (2010-2011 and 2011-2012)

Cultivars × Treatments	2010-2011			2011-2012			Av. wt loss (%)
	Initial wt.(kg)	Final wt.(kg)	Wt. loss (%)	Initial wt(kg)	Final wt(kg)	Wt. loss (%)	
V ₁ T ₀	17.82	16.57	7.50	15.57	14.63	6.00	6.75
V ₁ T ₁	15.27	13.74	10.00	18.35	16.33	11.00	10.50
V ₁ T ₂	17.66	15.89	10.00	18.15	16.45	11.00	10.50
V ₁ T ₃	16.97	15.70	7.50	20.26	19.05	6.00	6.75
V ₁ T ₄	17.02	15.15	11.00	18.67	16.99	9.00	10.00
V ₁ T ₅	16.79	15.11	10.00	18.88	17.18	9.00	9.50
V ₂ T ₀	18.01	16.93	6.00	14.38	13.45	6.50	6.25
V ₂ T ₁	18.62	16.75	10.00	18.04	16.05	11.00	10.50
V ₂ T ₂	18.93	17.03	10.00	18.75	16.88	10.00	10.00
V ₂ T ₃	20.96	19.29	11.04	19.64	18.36	6.50	8.77
V ₂ T ₄	20.10	17.89	10.50	19.02	17.31	9.00	9.75
V ₂ T ₅	20.38	18.25	9.50	18.76	17.07	9.00	9.25
V ₃ T ₀	17.38	16.34	6.00	14.32	13.32	7.00	6.50
V ₃ T ₁	18.39	16.64	9.50	16.93	14.98	11.50	10.50
V ₃ T ₂	19.03	17.12	10.00	17.94	15.90	10.00	10.70
V ₃ T ₃	19.04	17.52	8.00	19.49	18.03	7.50	7.75
V ₃ T ₄	17.62	15.94	9.50	18.70	16.83	10.00	9.75
V ₃ T ₅	19.74	17.77	10.00	18.25	16.61	9.00	9.50

V₁=Diamant, V₂=Asterix, V₃=Granola

T₀=Control, T₁ = Vitapulus, T₂= Brassinosteroid, T₃=Wuxalsuper

T₄= Vitapulus + Wuxalsuper, T₅= Brassinosteroid+ Wuxalsuper,

iii) Sajeda cold storage, Saidpur

It is revealed from the records of Sajeda cold storage, Saidpur of the years of 2010-11 and 2011-12 that the storage temperature was around 2.5°-4° and there were no records of relative humidity of this storage (Appendix-3). Though fresh air intake was done at a certain interval, it was not sufficient enough in comparison to the volume and number of bags stored in the storage. This was observed while taking records of storage in both the years. Weight loss of tubers recorded maximum in the plant growth regulator treated treatments (T_1 & T_2). Average maximum weight loss (11.28%) was observed in V_3T_2 (Granola+ Brassinosteroid) treatment combination while the minimum weight loss (7.00%) was observed in V_1T_0 (Diamant+control) treatment combination. Treatments (T_1 & T_2) treated with plant growth regulators alone caused (9.77-11.28%) weight loss for all three cultivars in both the years. On the other hand, growth regulators in combination with Wuxalsuper caused average (9.25-10.00%) weight loss indicating the positive influence of Wuxalsuper in reducing weight loss of potato tubers in both the years (Table 44).

Table 44. Weight loss (%) of potato tubers at Sajeda cold storage, Saidpur (2010-2011 and 2011-2012)

Cultivars × Treatments	2010-2011			2011-2012			Av. Wt. loss (%)
	Initial wt.(kg)	Final wt.(kg)	Wt. loss (%)	Initial wt.(kg)	Final wt.(kg)	Wt. loss (%)	
V ₁ T ₀	17.82	16.66	6.50	15.57	14.40	7.50	7.00
V ₁ T ₁	15.27	13.82	9.50	18.35	16.05	12.50	11.00
V ₁ T ₂	17.66	15.89	10.00	18.15	15.87	12.50	11.25
V ₁ T ₃	16.97	15.78	7.00	20.26	18.95	6.50	6.75
V ₁ T ₄	17.02	15.48	9.00	18.67	16.52	11.50	9.75
V ₁ T ₅	16.79	15.28	9.00	18.88	16.81	11.00	9.25
V ₂ T ₀	18.01	16.57	8.00	14.38	13.38	7.00	7.50
V ₂ T ₁	18.62	16.47	9.50	18.04	15.85	12.11	10.81
V ₂ T ₂	18.93	16.94	7.50	18.75	16.50	12.03	9.77
V ₂ T ₃	20.96	19.39	7.50	19.64	18.07	8.00	7.75
V ₂ T ₄	20.10	17.99	10.50	19.02	17.31	9.00	9.75
V ₂ T ₅	20.38	15.58	11.00	18.76	17.07	9.00	10.00
V ₃ T ₀	17.38	16.16	7.00	14.32	13.17	8.00	7.50
V ₃ T ₁	18.39	16.46	10.50	16.93	14.96	11.60	11.05
V ₃ T ₂	19.03	17.12	10.00	17.94	15.69	12.55	11.28
V ₃ T ₃	19.04	17.71	7.00	19.49	17.93	8.00	7.50
V ₃ T ₄	17.62	15.86	10.00	18.70	16.74	10.00	10.00
V ₃ T ₅	19.74	17.86	9.50	18.25	116.43	10.00	9.75

V₁=Diamant, V₂=Asterix, V₃=Granola

T₀=Control, T₁ = Vitapulus, T₂= Brassinosteroid, T₃= Wuxalsuper

T₄= Vitapulus + Wuxalsuper, T₅= Brassinosteroid+ Wuxalsuper,

4.10 Benefit cost ratio (BCR) of seed potato

Sorting and grading were done as per Seed Certification Agency (SCA) manual after releasing potato from cold storages. Now, the seed potatoes are ready for sale in the local markets. Just before the commencement of seed potato quality test in the field, if we sale out the potatoes as a seed we can easily calculate the benefit cost ratio (BCR) which was very much important to ventilate the causes of rotting during preservation of potato treated with plant growth regulators. On the contrary, rotting percentage is comparatively low in the potato treated with liquid plant growth regulators like Wuxalsuper where high economic return is possible. This controversy has been explained through the following records and observations in three public and private cold storages of this district.

a) BADC cold storage, Domar

Gross return ha^{-1} : The highest (478488.89 Tk ha^{-1} in first year and 497388.89 Tk ha^{-1} in second year) gross return was found in the treatment T_3 (Wuxalsuper) and the lowest (431922.22 Tk ha^{-1} in first year and 340944.44 Tk ha^{-1} in second year) gross return was obtained from the treatment T_1 (Vitapulus) in the treatment T_0 in both the years (Table 45a and 45b).

Cost of production: The highest (308277.78 Tk ha^{-1} in first year and 330877.78 Tk ha^{-1} in second year) cost of production was found in the T_4 (Vitapulus + Wuxalsuper) and T_5 (Brassnosteroid+ Wuxalsuper) and the lowest (286588.89 Tk ha^{-1} in first year and 309200.00 Tk ha^{-1} in second year) in the treatment T_0 in both the years (Table 45a and 45b).

Net return ha^{-1} : The highest (181677.78 Tk ha^{-1} in first year and 177966.67 Tk ha^{-1} in second year) net returns were obtained in the treatment T_3 (Wuxalsuper) and the lowest (133877.78 Tk ha^{-1} in first year and 61744.44 Tk ha^{-1} in second year) net returns were obtained from in the treatment T_0 in both the years (Table 45a and 45b).

BCR: The highest (1.61 in first year and 1.56 in second year) BCR was obtained from the treatment T_3 (Wuxalsuper) and the lowest (1.45 in first year and 1.20 in second year) BCR were obtained from T_0 treatment in both the years (Table 45a and 45b).

Table 45a. Calculation of BCR as seed potato of BADC cold storage, Domar [1st year (2010-2011)]

Treatment	Gross return (Tk ha ⁻¹)	Cost of production (Tk ha ⁻¹)	Net return (Tk ha ⁻¹)	BCR
T ₀	450233.33	286588.89	163622.22	1.57
T ₁	431922.22	298044.44	133877.78	1.45
T ₂	451922.22	298044.44	153877.78	1.52
T ₃	478488.89	296811.11	181677.78	1.61
T ₄	456544.44	308277.78	148277.78	1.48
T ₅	472344.44	308277.78	164055.56	1.53

Table 45b. Calculation of BCR as seed potato of BADC cold storage, Domar [2nd year (2011-2012)]

Treatment	Gross return (Tk ha ⁻¹)	Cost of production (Tk ha ⁻¹)	Net return (Tk ha ⁻¹)	BCR
T ₀	370944.44	309200.00	61744.44	1.20
T ₁	442600.00	320655.56	121944.44	1.38
T ₂	457166.67	320655.56	136511.11	1.43
T ₃	497388.89	319422.22	177966.67	1.56
T ₄	468600.00	330877.78	137722.22	1.42
T ₅	463544.44	330877.78	132666.67	1.40

T₀=Control, T₁ = Vitaplus, T₂= Brassinosteroid, T₃=Wuxalsuper
T₄= Vitaplus + Wuxalsuper, T₅= Brassinosteroid+ Wuxalsuper,

b) Saon cold storage, Domar

Gross return ha^{-1} : The highest (466622.22 Tk ha^{-1} in first year and 493277.78 Tk ha^{-1} in second year) gross return was found in the treatment T_3 (Wuxalsuper) and the lowest (417922.22 Tk ha^{-1} in first year and 368533.33 Tk ha^{-1} in second year) gross return was obtained from the treatment T_1 (Vitapulus) in the treatment T_0 in both the years (Table 45a and 45b).

Cost of production: The highest (308277.78 Tk ha^{-1} in first year and 330877.78 Tk ha^{-1} in second year) cost of production was found in the T_4 (Vitapulus + Wuxalsuper) and T_5 (Brassnosteroid + Wuxalsuper) and the lowest (286588.89 Tk ha^{-1} in first year and 309200.00 Tk ha^{-1} in second year) in the treatment T_0 in both the years (Table 45a and 45b).

Net return ha^{-1} : The highest (169811.11 Tk ha^{-1} in first year and 173855.56 Tk ha^{-1} in second year) net returns were obtained in the treatment T_3 (Wuxalsuper) and the lowest (119877.78 Tk ha^{-1} in first year and 59333.33 Tk ha^{-1} in second year) net returns were obtained from in the treatment T_0 in both the years (Table 45a and 45b).

BCR: The highest (1.57 in first year and 1.54 in second year) BCR was obtained from the treatment T_3 (Wuxalsuper) and the lowest (1.40 in first year and 1.19 in second year) BCR were obtained from T_0 treatment in both the years (Table 45a and 45b).

Table 46a. Calculation of BCR as seed potato of Saon cold storage, Domar [1st year (2010-2011)]

Treatment	Gross return (Tk ha ⁻¹)	Cost of production (Tk ha ⁻¹)	Net return (Tk ha ⁻¹)	BCR
T ₀	443266.67	286588.89	156677.78	1.55
T ₁	417922.22	298044.44	119877.78	1.40
T ₂	442566.67	298044.44	144522.22	1.48
T ₃	466622.22	296811.11	169811.11	1.57
T ₄	435811.11	308277.78	127544.44	1.41
T ₅	453733.33	308277.78	145466.67	1.47

Table 46b. Calculation of BCR as seed potato of Saon cold storage, Domar [2nd year (2011-2012)]

Treatment	Gross return (Tk ha ⁻¹)	Cost of production (Tk ha ⁻¹)	Net return (Tk ha ⁻¹)	BCR
T ₀	368533.33	309200.00	59333.33	1.19
T ₁	421922.22	320655.56	101266.67	1.32
T ₂	438133.33	320655.56	117477.78	1.37
T ₃	493277.78	319422.22	173855.56	1.54
T ₄	455100.00	330877.78	124222.22	1.38
T ₅	452633.33	330877.78	121755.56	1.37

T₀=Control, T₁ = Vitapulus, T₂= Brassinosteroid, T₃=Wuxalsuper
T₄= Vitapulus + Wuxalsuper, T₅= Brassinosteroid+ Wuxalsuper

c) Sajeda cold storage, Saidpur

Gross return ha^{-1} : The highest (469944.44 Tk ha^{-1} in first year and 488811.11 Tk ha^{-1} in second year) gross return was found in the treatment T_3 (Wuxalsuper) and the lowest (414533.33 Tk ha^{-1} in first year and 364577.78 Tk ha^{-1} in second year) gross return was obtained from the treatment T_1 (Vitaplus) in the treatment T_0 in both the years (Table 45a and 45b).

Cost of production: The highest (308277.78 Tk ha^{-1} in first year and 330877.78 Tk ha^{-1} in second year) cost of production was found in the T_4 (Vitaplus + Wuxalsuper) and T_5 (Brassnosteroid + Wuxalsuper) and the lowest (286588.89 Tk ha^{-1} in first year and 309200.00 Tk ha^{-1} in second year) in the treatment T_0 in both the years (Table 45a and 45b).

Net return ha^{-1} : The highest (173133.33 Tk ha^{-1} in first year and 169388.89 Tk ha^{-1} in second year) net returns were obtained in the treatment T_3 (Wuxalsuper) and the lowest (111333.33 Tk ha^{-1} in first year and 52044.44 Tk ha^{-1} in second year) net returns were obtained from in the treatment T_5 and T_0 in both the years (Table 45a and 45b).

BCR: The highest (1.58 in first year and 1.53 in second year) BCR was obtained from the treatment T_3 (Wuxalsuper) and the lowest (1.36 in first year and 1.18 in second year) BCR were obtained from T_0 treatment in both the years (Table 45a and 45b).

Table 47a. Calculation of BCR as seed potato of Sajeda cold storage, Saidur [1st year (2010-2011)]

Treatment	Gross return (Tk ha ⁻¹)	Cost of production (Tk ha ⁻¹)	Net return (Tk ha ⁻¹)	BCR
T ₀	439344.44	286588.89	152755.56	1.53
T ₁	414533.33	298044.44	116522.22	1.39
T ₂	443522.22	298044.44	145477.78	1.49
T ₃	469944.44	296811.11	173133.33	1.58
T ₄	440133.33	308277.78	131866.67	1.43
T ₅	419566.67	308277.78	111333.33	1.36

Table 47b. Calculation of BCR as seed potato of Sajeda cold storage, Saidur [2nd year (2011-2012)]

Treatment	Gross return (Tk ha ⁻¹)	Cost of production (Tk ha ⁻¹)	Net return (Tk ha ⁻¹)	BCR
T ₀	364577.78	309200.00	52044.44	1.18
T ₁	417288.89	320655.56	96633.33	1.30
T ₂	427544.44	320655.56	106888.89	1.33
T ₃	488811.11	319422.22	169388.89	1.53
T ₄	449633.33	330877.78	118755.56	1.36
T ₅	445622.22	330877.78	114744.44	1.35

T₀=Control, T₁ = Vitaplus, T₂= Brassinosteroid, T₃=Wuxalsuper
 T₄= Vitaplus + Wuxalsuper, T₅= Brassinosteroid+ Wuxalsuper,

4.11 Seed quality test

(a) BADC Cold Storage, Domar

All the seed quality test parameters i.e number of total eyes, sprouted eyes(%), non-sprouted eyes(%), number of days to shoot emergence, number of haulms per tuber and seed vigour index excepts germination (%) of tubers sprouted were significant due to the cultivars. The parameters i.e number of total eyes, number of days to shoot emergence, number of haulms per tuber and seed vigour index were significantly influenced by the treatments while the rest parameters were non-significant. All the seed quality test parameters were non-significant by the interaction effect between cultivars and treatments in 2010-11.

In 2011-12, all the seed quality test parameters i.e total eyes, sprouted eyes(%), non-sprouted eyes(%), days to shoot emergence, number of haulms per tuber and seed vigour index were significant due to the cultivars but total eyes, sprouted and non-sprouted eyes, days to shoot emergence and number of haulms per tuber were significant. Only one parameter i.e germination(%) of tuber sprouted was non-significant due to the treatments while rest of the parameters were significant. All the seed quality test parameters except sprouted and non-sprouted eyes(%) were non-significant by the interaction of the cultivars and treatments.

4.11.1 Number of total eyes/ tuber

4.11.1.1 Effect of cultivars

The number of total eyes per tuber had significant effect on the cultivars in both the years. The highest number of eyes (3.96 in first year and 3.78 in second years) were found in Diamant (V_1) cultivar while the lowest number of eyes (3.34 in first year and 3.28 in second year) were found in Granola (V_3) cultivar. In the first year, the cultivar Diamant (V_1) and the

cultivar Asterix (V_2) were found statistically identical. Cultivar Asterix (V_2) and cultivar Granola (V_3) were found statistical identical in second year (Tables 48a and 48b).

4.11.1.2 Effect of treatments

The number of total eyes per tuber was significantly affected due to treatments in both the years. The highest number of total eyes (4.07 in first year and 3.71 in second year) per tuber was recorded in the treatment T_4 (Vitapplus + Wuxalsuper) in both the years. The treatment T_3 (Wuxalsuper) and T_5 (Brassinosteroid + Wuxalsuper) were found statistically identical in 2010-2011. Similarly, the treatments T_1 (Vitapplus) and T_2 (Brassinosteroid) were found statistically identical in the same year. In 2011-12, the treatments T_2 (Brassinosteroid) T_3 (Wuxalsuper) T_4 (Vitapplus + Wuxalsuper) and T_5 (Brassinosteroid + Wuxalsuper) were found statistically identical in 2011-2012. The lowest number of eyes per tuber (3.20 in first year and 3.11 in second year) was recorded in the treatment T_0 (control) in both the years (Tables 49a and 49b).

4.11.1.3 Interaction effect between cultivars and treatments

Total number of eyes per tuber had no significant effect due to the interaction between cultivars and treatments in both the years. Though the figures were statistically identical, the highest number of eyes per tuber 4.43 in first year were found in V_2T_2 (Asterix + Brassinosteroid) and 4.13 in second year in V_1T_5 (Diamant+Brassinosteroid+ Wuxalsuper) treatment combination, while the lowest number of eyes (2.73 in first year and 3.00 in second year) were found in V_2T_0 (Asterix+control) and V_3T_0 (Granola+control) treatment combination in both the years (Tables 50a and 50b).

4.11.2 Sprouted eyes (%)

4.1.2.1 Effect of cultivars

Sprouted eyes were influenced significantly by the cultivars in both the years. The highest sprouted eyes (56.99% in first year and 53.60% in second year) were found in Granola (V_3) cultivar while the lowest sprouted eyes (46.75% in first year and 50.33% in second year) were found in Asterix (V_2) cultivar (Tables 48a and 48b).

4.11.2.2 Effect of treatments

Sprouted eyes were not significantly affected due to treatments in the first year but it was significantly affected during the second year. The highest sprouted eyes (55.68% and 54.81%) was found in the treatment T_0 (control) in both the years. The treatment T_1 (Vitapplus), T_2 (Brassinosteroid), T_3 (Wuxalsuper), T_4 (Vitapplus + Wuxalsuper) and T_5 (Brassinosteroid+ Wuxalsuper) were found statistically identical in the second year (Tables 49a and 49b).

4.11.2.3 Interaction effect between cultivars and treatments

Interaction effect between cultivars and treatments were non- significant in 2010-11 but varied significantly in 2011-12. The highest sprouted eyes (66.74% in first year and 47.45% in second years) was found in V_3T_0 (Granola + control) treatment combination. In 2011-12, the treatment combinations V_1T_0 (Diamant+control), V_2T_1 (Asterix + Vitapplus), V_3T_3 (Granola + Wuxalsuper), V_3T_4 (Granola + Vitapplus + Wuxalsuper) and V_3T_5 (Granola+ Brassinosteroid + Wuxalsuper) were found statistically identical. Similarly, the treatment combinations V_2T_3 (Asterix+ Wuxalsuper), V_2T_4 (Asterix+ Vitapplus + Wuxalsuper) and V_3T_1 (Granola+ Vitapplus) were found statistically identical in the same year. Similarly, the treatment combinations V_1T_1 (Diamant + Vitapplus), V_1T_3 (Diamant+

Wuxalsuper) and V_2T_0 (Asterix+control) were found statistically identical in the same year. However, the lowest sprouted eyes (41.91% in first year and 46.97% in second years) was found in V_2T_2 (Asterix + Brassinosteroid) and V_2T_5 (Asterix + Brassinosteroid + Wuxalsuper) treatment combination in both the years (Table 50a and 50b).

4.11.3 Non-sprouted eyes (%)

4.11.3.1 Effect of cultivars

There was significant effect on non-sprouted eyes due to cultivars in both the years. The highest non-sprouted eyes (53.25% in first year and 49.67 % in second year) were found in Asterix (V_2) cultivar. The lowest non sprouted eyes (43.01 in first year and 46.40 in second years) were found in Granola (V_3) cultivar (Tables 48a and 48b).

4.11.3.2 Effect of treatments

The non sprouted eyes were not significantly influenced due to treatments in the first year but it was significantly affected in the second year. The highest non-sprouted eyes (51.94%) was found in the treatment T_2 (Brassinosteroid) and the lowest non-sprouted eyes (44.32%) was observed in the treatment T_0 (control) in 2010-11. In 2011-12, the highest non-sprouted eyes (48.38%) was found in the treatment T_5 (Brassinosteroid + Wuxalsuper) and the lowest non-sprouted eyes (45.19%) was observed in the treatment T_0 (control). The treatments T_1 (Vitapulus), T_3 (Wuxalsuper), T_4 (Vitapulus + Wuxalsuper) and T_5 (Brassinosteroid + Wuxalsuper) were found statistically identical in the second year (Tables 49a and 49b).

4.11.3.3 Interaction effect between cultivar and treatment

Interaction effect between cultivars and treatments did not vary significantly in 2010-11 but it varied significantly in the year 2011-12.

However, the highest non-sprouted eyes (58.09% and 53.03%) were found in V_2T_2 (Asterix+Brassinosteroid) and in V_2T_5 (Asterix+Brassinosteroid + Wuxalsuper) treatment combination respectively in 2010-11 and 2011-12. In 2011-12, the treatment combinations V_2T_3 (Asterix + Wuxalsuper), V_2T_4 (Asterix + Vitapulus + Wuxalsuper) and V_3T_1 (Granola + Vitapulus) were found statistically identical. Similarly, the non-sprouted eyes (47.68% and 49.17%) was found statistically identical as obtained from V_1T_1 (Diamant+ Vitapulus) and V_1T_4 (Diamant+ Vitapulus +Wuxalsuper) treatment combination. In the same way, the treatment combinations V_1T_3 (Diamant+Wuxalsuper), V_1T_5 (Diamant+Brassinosteroid Wuxalsuper), V_2T_0 (Asterix+control), and V_3T_2 (Granola+Brassinosteroid) were found statistically identical in the same. The lowest non-sprouted eyes (33.26%and 43.18%) were found in V_3T_4 (Granola + Vitapulus + Wuxalsuper) and in V_1T_2 (Diamant + Brassinosteroid) treatment combination respectively in 2010-11 and 2011-12 (Tables 50a and 50b).

4.11.4 Germination percentage of sprouted tuber

4.11.4.1 Effect of cultivars

Germination percentage of tuber sprouted was not influenced significantly by the cultivars in both the years. The highest germination percentage of tuber was recorded in Diamant (V_1) and in Granola (V_3) cultivar in first year and only in Diamant (V_1) cultivar in second year. The lowest germination percentage of tuber was recorded in Asterix (V_2) in first year. During the second year the lowest germination percentage was recorded both in both the cultivars of Asterix (V_2) and Granola (V_3) cultivar in 2011-12 (Tables 48a and 48b).

4.11.4.2 Effect of treatments

Treatments did not vary significantly in respect of germination percent in both the year of 2010-11 and 2011-12. The highest germination of 100% was found in the treatment T_0 (control) and in the treatment T_3 (Wuxalsuper), while the lowest germination of 91.11% was found in the treatment T_1 (Vitapulus) in both the years (Tables 49a and 49b).

4.11.4.3 Interaction effect between cultivars and treatments

In both the years, the interaction effect between cultivars and treatments was non-significant. With a few exceptions, the highest 100 percent germination was recorded in most of the treatment combinations consisted of the treatment T_0 and T_3 in both the years. The lowest 86.67% germination was found in T_1V_2 treatment combination in both the years (Tables 50a and 50b).

4.11.5 Number of days to shoot emergence

4.11.5.1 Effect of cultivars

The number of days required to emerge shoot was greatly influenced by the cultivars in both the years. The highest number of days (17.83 in first year and 17.00 in second year) were required to emerge shoot in cultivar Granola (V_3), while the lowest number of days (16.11 in first year and 15.50 in second year) were required to emerge shoot in cultivar Diamant (V_1) (Tables 48a and 48b).

4.11.5.2 Effect of treatments

The number of days required to emerge shoot was influenced significantly by the treatments in both the years. The highest number of days 19.33 in first year and 18.22 in second year were required to emerge shoot in the treatment T_0 (control). The lowest number of days of 16.22

and 15.11 were required to emerge shoot in the treatment T_1 (Vitaplus) and T_2 (Brassinosteroid) in the first year. The treatments T_0 (control) & T_3 (Wuxalsuper) and the treatments T_4 (Vitaplus + Wuxalsuper) & T_5 (Brassinosteroid + Wuxalsuper) and treatments T_1 (Vitaplus) & T_2 (Brassinosteroid) were found statistically identical in 2010-11. The treatments T_1 (Vitaplus), T_2 (Brassinosteroid) and T_3 (Wuxalsuper) were found statistically identical in 2011-12 (Tables 49a and 49b).

4.11.5.3 Interaction effect between cultivars and treatments

Interaction effect between cultivars and treatments had no significant effect on days to shoot emergence in 2010-11 and 2011-12. The highest number of days 19.67 in first year and 19.33 in second year were required to emerge shoot in V_2T_0 (Asterix+control) and in V_3T_0 (Granola+control) treatment combination respectively in both the years. The lowest number of days (15.67 and 14.33) were required to emerge shoot in V_1T_1 (Diamant + Vitaplus) and V_1T_2 (Biamant + Brassinosteroid) in 2010-11 and in 2011-12 (Tables 50a and 50b).

4.11.6 Number of haulms per tuber

4.11.6.1 Effect of cultivars

The number of haulms per tuber was significantly affected due to cultivars in both the years. The highest number of haulms (4.92 in first year and 4.73 in second years) per tuber was found in Diamant (V_1) cultivar, while the lowest number of haulms per tuber (4.46 in first year and 4.39 in second years) was found in Asterix (V_2) cultivar (Tables 48a and 48b).

4.11.6.2 Effect of treatments

The number of haulms per tuber varied significantly by treatments in both the years. The highest number of haulms (5.47 in first year and 5.24 in second year) was obtained from the treatment T_4 (Vitaplug + Wuxalsuper) in both the years. The treatment T_1 (Vitaplug), T_2 (Brassinosteroid) and T_3 (Wuxalsuper) were statistically identical in 2010-11. Similarly, the treatment T_1 (Vitaplug), T_2 (Brassinosteroid) and T_3 (Wuxalsuper) were statistically identical in 2011-12. However, the lowest number of haulms (3.86 in first year and 3.80 in second year) were found in the treatment T_0 (control) in 2010-11 and 2011-12 (Tables 49a and 49b).

4.11.6.3 Interaction effect between cultivars and treatments

Interaction effect between cultivars and treatments had no significant influence on the number of haulms tuber⁻¹ in both the years. In the first year, the highest number of haulms tuber⁻¹ (6.17) was produced in V_2T_4 (Asterix + Vitaplug + Wuxalsuper) treatment combination and in the second year the highest number of haulms tuber⁻¹ (5.27) was produced in V_1T_4 (Diamant + Vitaplug + Wuxalsuper) treatment combination. The lowest number of haulms (3.50 in first year and 3.60 in second year) tuber⁻¹ were produced in V_2T_0 (Asterix + control) treatment combination (Tables 50a and 50b).

4.11.7 Seed vigor index

4.11.7.1 Effect of cultivars

Seed vigor index was significantly influenced by cultivars in both the years. However, the highest index (8.01 in first year and 7.81 in second year) was found in Diamant (V_1) cultivar, while the lowest index (7.46 in

first year) and (7.51 in second year) was found in Granola (V_3) cultivar (Tables 48a and 48b).

4.11.7.2 Effect of treatments

Treatments had a significant effect on seed vigor index in both the years. The highest seed vigor index (8.04 in first year and 7.92 in second year) was found in the treatment T_1 (Vitaplus), while the lowest index (7.26 in first year and 7.28 in second years) were noticed in the treatment T_0 (control). Seed vigour index of 7.94, 7.83 and 7.81 were found statistically identical and were obtained from the treatment T_2 (Brassinosteroid), T_4 (Vitaplus + Wuxalsuper) and T_5 (Wuxasuper and Brassinosteroid) respectively in 2010-11. In 2011-12, the treatments T_1 (Vitaplus), T_2 (Brassinosteroid) and T_4 (Vitaplus + Wuxalsuper) were found statistically identical. Similarly, seed vigour index of 7.35 and 7.28 were found statistically identical and were obtained from the treatment T_1 (Vitaplus) and T_5 (Wuxasuper + Brassinosteroid) respectively in 2011-12 (Tables 49a and 49b).

4.11.7.3 Interaction effect between cultivars and treatments

Seed vigor index was not significantly influenced due to the interaction of cultivars and treatments in both the years. However, the highest index (8.33) was found in V_1T_1 (Diamant + Vitaplus) treatment combination in the first year. During the second year the highest seed vigour index was found in V_1T_2 (Diamant + Brassinosteroid) and V_1T_3 (Diamant + Wuxalsuper) treatment combination. The lowest index (6.83 and 6.85) were found in V_3T_1 (Granola + Vitaplus) and V_3T_5 (Granola + Brassinosteroid + Wuxalsuper) treatment combination in 2010-11 and 2011-12 respectively (Tables 50a and 50b).

Table 48a. Effect of cultivars on seed quality of potato [1st year (2010-2011)]

Cultivar	No. of total eyes	Sprouted eyes (%)	Non sprouted eyes (%)	Germination % of tubers sprouted	No. of days to shoot emergence	No. of haulm tuber ⁻¹	Seed vigour index
Diamant (V ₁)	3.96a	52.20b	47.80ab	97.78	16.11b	4.92a	8.01a
Asterix (V ₂)	3.93a	46.75c	53.25a	94.94	17.61ab	4.46b	7.78b
Granola (V ₃)	3.34b	56.99a	43.01b	97.78	17.83a	4.71ab	7.46c
Level of significance	**	**	**	NS	**	*	**
CV (%)	12.86	15.96	17.28	7.93	3.80	10.46	5.09

Table 48b. Effect of cultivars on seed quality of potato [2nd year (2011-2012)]

Cultivar	No. of total eyes	Sprouted eyes (%)	Non sprouted eyes (%)	Germination % of tubers sprouted	No. of days to shoot emergence	No. of haulm tuber ⁻¹	Seed vigour index
Diamant (V ₁)	3.78a	53.30a	46.70ab	97.78	15.50c	4.73a	7.81a
Asterix (V ₂)	3.46b	50.33b	49.67a	96.67	16.17b	4.39b	7.63ab
Granola (V ₃)	3.28b	53.60a	46.40b	96.67	17.00a	4.59ab	7.51b
Level of significance	**	**	**	NS	**	*	**
CV (%)	8.95	4.32	5.64	7.51	2.80	7.81	3.64

In a column, the figures bearing same letter(s) or without letters are identical and those having dissimilar letters differed significantly as per DMRT

Table 49a. Effect of plant growth regulators and micronutrients on seed quality of potato [1st year (2010-2011)]

Treatment	No. of total eyes	Sprouted eyes (%)	Non sprouted eyes (%)	Germination % of tubers sprouted	No. of days to shoot emergence	No. of haulm tuber ⁻¹	Seed vigour index
T ₀	3.20c	55.68	44.32	100.00	19.33a	3.86c	7.26c
T ₁	3.61b	51.48	48.52	91.11	16.22c	4.53b	8.04a
T ₂	3.63b	48.06	51.94	93.33	16.22c	4.64b	7.94ab
T ₃	3.72ab	49.95	50.05	100.00	18.78a	4.62b	7.62b
T ₄	4.07a	54.26	45.74	97.78	17.22b	5.47a	7.83ab
T ₅	3.93ab	52.45	47.55	97.78	17.33b	5.06ab	7.81ab
Level of significance	0.01	NS	NS	NS	0.01	0.01	0.01
CV(%)	8.35	15.96	17.28	7.93	3.80	10.46	5.09

Table 49b. Effect of plant growth regulators and micronutrients on seed quality of potato [2nd year (2011-2012)]

Treatment	No. of total eyes	Sprouted eyes (%)	Non sprouted eyes (%)	Germination % of tubers sprouted	No. of days to shoot emergence	No. of haulm tuber ⁻¹	Seed vigour index
T ₀	3.11b	54.81a	45.19b	100.00	18.22a	3.80c	7.28b
T ₁	3.34ab	52.34b	47.66a	91.11	15.22d	4.42b	7.92a
T ₂	3.56a	52.22b	47.78ab	95.56	15.11d	4.49b	7.88a
T ₃	3.60a	51.75b	48.25a	100.00	17.22b	4.40b	7.35b
T ₄	3.71a	51.74b	48.26a	97.78	15.67cd	5.24a	7.86a
T ₅	3.71a	51.62b	48.38a	97.78	15.89c	5.07a	7.61ab
Level of significance	0.01	0.05	0.05	NS	0.01	0.01	0.01
CV(%)	8.95	4.32	5.64	7.51	2.80	7.81	3.64

T₀= Control, T₁= Vitaplus, T₂= Brassinosteroid, T₃= Wuxalsuper

T₄= Vitaplus + Wuxalsuper, T₅=Brassinosteroid+ Wuxalsuper,

In a column, the figures bearing same letter(s) or without letters are identical and those having dissimilar letters differed significantly as per DMRT

Table 50a. Effect of interaction between cultivars and plant growth regulators & micronutrients on seed quality contributing characters of potato [1st year (2010-2011)]

Cultivars × Treatments	No. of total eyes	Sprouted eyes (%)	Non sprouted eyes (%)	Germination % of tubers sprouted	No. of days to shoot emergence	No. of haulm tuber ⁻¹	Seed vigour index
V ₁ T ₀	3.73	58.22	41.78	100.00	19.33	4.40	7.53
V ₁ T ₁	4.17	51.64	48.36	93.33	15.67	4.97	8.33
V ₁ T ₂	3.97	48.13	51.87	93.33	15.67	4.83	8.25
V ₁ T ₃	3.77	50.24	49.76	100.00	18.67	5.07	7.87
V ₁ T ₄	3.90	49.64	50.36	100.00	16.67	5.27	7.87
V ₁ T ₅	4.03	55.33	44.67	100.00	16.67	4.97	8.21
V ₂ T ₀	3.63	52.35	47.65	100.00	19.67	3.50	7.96
V ₂ T ₁	4.07	44.11	55.89	86.67	16.67	4.17	7.08
V ₂ T ₂	4.43	41.91	58.09	93.33	16.67	4.60	8.14
V ₂ T ₃	3.63	43.72	56.28	100.00	18.67	4.43	8.03
V ₂ T ₄	3.80	46.39	53.61	93.33	17.67	6.17	7.98
V ₂ T ₅	4.20	52.02	47.98	93.33	17.67	5.40	7.45
V ₃ T ₀	2.73	66.74	43.53	100.00	19.00	3.67	7.95
V ₃ T ₁	3.30	58.68	41.33	93.33	16.33	4.47	6.83
V ₃ T ₂	3.57	52.34	47.66	93.33	16.33	4.50	7.43
V ₃ T ₃	3.47	57.70	42.30	100.00	19.00	4.37	7.74
V ₃ T ₄	3.50	56.47	33.26	100.00	17.33	4.97	7.63
V ₃ T ₅	3.47	50.00	50.00	100.00	17.67	4.80	7.20
Level of significance	NS	NS	NS	NS	NS	NS	NS
CV (%)	12.86	15.96	17.28	7.93	3.80	10.46	5.09

V₁=Diamant, V₂=Asterix, V₃=Granola

T₀=Control, T₁= Vitapulus, T₂= Brassinosteroid, T₃=Wuxalsuper

T₄= Vitapulus + Wuxalsuper, T₅= Brassinosteroid+ Wuxalsuper,

In a column, the figures bearing same letter(s) or without letters are identical and those having dissimilar letters differed significantly as per DMRT

Table 50b. Effect of interaction between cultivars and plant growth regulators & micronutrients on seed quality contributing characters of potato [2nd year (2011-2012)]

Cultivars × Treatments	No. of total eyes	Sprouted eyes (%)	Non sprouted eyes (%)	Germination % of tubers sprouted	No. of days to shoot emergence	No. of haulm tuber ⁻¹	Seed vigour index
V ₁ T ₀	3.27	54.93a-c	45.07c-e	100.00	17.33	4.07	7.63
V ₁ T ₁	3.67	52.32b-d	47.68a-d	93.33	14.33	4.60	7.35
V ₁ T ₂	3.80	56.82ab	43.18de	100.00	14.33	4.60	8.23
V ₁ T ₃	3.93	52.06b-d	47.94a-e	100.00	16.33	4.67	8.23
V ₁ T ₄	3.87	50.83c-e	49.17a-d	93.33	15.33	5.27	7.98
V ₁ T ₅	4.13	52.87a-d	47.13a-e	100.00	15.33	5.20	7.45
V ₂ T ₀	3.00	52.03b-d	47.97a-e	100.00	18.00	3.60	7.63
V ₂ T ₁	3.17	54.30a-c	45.70b-e	86.67	15.33	4.20	7.39
V ₂ T ₂	3.47	48.42de	51.58ab	93.33	15.00	4.20	7.47
V ₂ T ₃	3.60	50.18c-e	49.82a-c	100.00	17.00	4.27	7.77
V ₂ T ₄	3.87	50.08c-e	49.92a-c	100.00	15.67	5.13	7.97
V ₂ T ₅	3.67	46.97e	53.03a	100.00	16.00	4.93	7.55
V ₃ T ₀	3.07	57.45a	47.45e	100.00	19.33	3.73	7.58
V ₃ T ₁	3.20	50.40c-e	49.60a-c	93.33	16.00	4.47	7.30
V ₃ T ₂	3.40	51.43c-e	48.57a-e	93.33	16.00	4.67	7.93
V ₃ T ₃	3.27	53.00a-c	47.00b-e	100.00	18.33	4.27	7.77
V ₃ T ₄	3.40	54.32a-c	45.68b-e	100.00	16.00	5.33	7.62
V ₃ T ₅	3.33	55.02a-c	44.98b-e	93.33	16.33	5.07	6.85
Level of significance	NS	**	**	NS	NS	NS	NS
CV (%)	8.95	4.32	5.64	7.51	2.80	7.81	3.64

V₁=Diamant, V₂=Asterix, V₃=Granola

T₀=Control, T₁ = Vitaplus, T₂= Brassinosteroid, T₃=Wuxalsuper

T₄= Vitaplus + Wuxalsuper, T₅=Brassinosteroid+ Wuxalsuper,

In a column, the figures bearing same letter(s) or without letters are identical and those having dissimilar letters differed significantly as per DMRT

b) Saon cold storage, Domar

In 2010-11, seed quality test parameters i.e number of total eyes, sprouted and non-sprouted eyes, number of days to shoot emergence, number of haulms per tuber and seed vigour index were significant due to the cultivars and the rest of the parameters like germination(%) of tubers were non-significant. The seed quality test parameters like number of total eyes per tuber, number of days to shoot emergence and number of haulms per tuber were significant and the rest of the parameters like number of sprouted and non-sprouted eyes (%), germination(%) and seed vigour index were non-significant due to the different treatments. All the seed quality test parameters were non-significant by the interaction effect between cultivars and treatments.

In 2011-12, five seed quality parameters i.e number of total eyes, non-sprouted eyes (%), number of days to shoot emergence, number of haulms per plant and seed vigour index were significant due to the cultivars while the rest of the parameters like sprouted eyes(%) and germination (%) of tuber sprouted were non-significant. All the seed quality parameters were significant due to the different treatments. Seed quality test parameters like sprouted eyes(%), non-sprouted eyes(%) and number of haulms per tuber were significant by the interaction effect between cultivars and treatments while the rest four parameters were non-significant.

4.12.1 Number of total eyes per tuber

4.12.1.1 Effect of cultivar

The number of total eyes per tuber had significant effect on the cultivars in 2010-11 and 2011-12. The highest number of eyes (3.92 in first year and 3.83 in second years) per tuber was recorded in cultivar Diamant (V₁)

in both the years. The number of eyes (3.92) in cultivar Diamant (V_1) was found statistically identical to the number of eyes (3.87) of cultivar Asterix (V_2) in 2010-11. The number of eyes (3.83 and 3.62) of the cultivar Diamant (V_1) and cultivar Asterix (V_2) were found statistically identical in 2011-12. The lowest number of eyes (3.26 in first year and 3.28 in second year) per tuber were recorded in the cultivar Granola (V_3) (Tables 51a and 51b).

4.12.1.2 Effect of treatments

Different growth regulators and micronutrient treatments had significant influence on the number of total eyes per tuber in both the years. The highest number of eyes per tuber (3.89 in first year and 4.12 in second year) were observed in the treatment T_5 (Brassinosteroid + Wuxalsuper) in 2010-11 and in the treatment T_4 (Vitapplus + Wuxalsuper) in 2011-12. The treatments T_1 (Vitapplus), T_2 (Brassinosteroid), T_3 (Wuxalsuper), T_4 (Vitapplus + Wuxalsuper) and T_5 (Wuxalsuper + Brassinosteroid) were found statistically identical in 2010-11. In 2011-12, the treatments T_4 (Vitapplus + Wuxalsuper) and T_5 (Wuxalsuper + Brassinosteroid) were found statistically identical. Similarly, the treatments T_1 (Vitapplus), T_2 (Brassinosteroid) and T_3 (Wuxalsuper) were found statistically identical in the same year. The lowest number of eyes per tuber (3.10 in first year and 2.99 in second year) were recorded in the treatment T_0 (control) in 2010-11 and 2011-12 (Tables 52a and 52b).

4.12.1.3 Interaction effect between cultivars and treatments

The number of total eyes per tuber was non-significant due to the interaction effect between cultivars and treatments in 2010-11 and 2011-12. However, the highest number of eyes (4.13 and 4.57) per tuber were found in V_1T_3 (Diamant+Wuxalsuper), V_1T_4 (Diamant+ Vitapplus

+Wuxalsuper) and in V_1T_5 (Diamant+Wuxalsuper + Brassinosteroid) treatment combination in first year and in V_1T_4 (Diamant+ Vitapulus +Wuxalsuper) in second year. The lowest number of eyes (2.80 in first year and 2.77 in second years) were found in V_3T_0 (Granola+control) treatment combination in 2010-11 and in 2011-12 (Tables 53a and 53b).

4.12.2 Sprouted eyes (%)

4.12.2.1 Effect of cultivar

Sprouted eyes were influenced significantly by the cultivars in 2010-11 but did not respond significantly in 2011-12. The highest number of sprouted eyes (56.62% in first year and 51.11% in second years) of total eyes was observed in the cultivar Granola (V_3) in both the years. In 2010-11, the sprouted eyes (53.80% and 56.62%) were found statistically identical and were obtained from the cultivar Diamant (V_1) and Granola (V_3). The lowest number of sprouted eyes (48.00% and 48.82%) eyes were recorded in the cultivar Asterix (V_2) in 2010-11 and 2011-12 (Tables 51a and 41b).

4.12.2.2 Effect of treatments

Sprouted eyes were not significantly affected due to the treatments in 2010-11 but responded significantly in 2011-12. The highest sprouted eyes (54.53% and 53.27%) were observed in the treatment T_0 (control) in both the years. In 2011-12, the treatments T_2 (Brassinosteroid), T_3 (Wuxalsuper), T_4 (Vitapulus + Wuxalsuper) and T_5 (Brassinosteroid + Wuxalsuper) were found statistically identical. On the contrary, the lowest (51.25% and 47.31%) sprouted eyes were found in the treatment T_2 (Brassinosteroid) and in the treatment T_3 (Wuxalsuper) respectively in 2010-11 and 2011-12 (Tables 52a and 52b).

4.12.2.3 Interaction effect between cultivars and treatments

Interaction effect between cultivars and treatments were non-significant in 2010-11 but found significant in 2011-12. The highest sprouted eyes (58.95% in first year and 59.48% in second year) were found in T_5V_3 (Granola + Brassinosteroid + Wuxalsuper) and in V_3T_0 (Granola+control) treatment combination. In 2011-12, the treatment combinations V_1T_4 (Diamant+ Vitapulus + Wuxalsuper), V_2T_1 (Asterix + Vitapulus), V_2T_2 (Asterix + Brassinosteroid), V_2T_4 (Asterix+ Vitapulus +Wuxalsuper), V_2T_5 (Asterix + Brassinosteroid + Wuxalsuper), V_3T_2 (Granola + Brassinosteroid), V_3T_3 (Granola+Wuxalsuper) and V_3T_4 (Granola+ Vitapulus +Wuxalsuper) respectively were found statistically identical. The lowest sprouted eyes (45.05% and 45.00%) of total eyes were recorded in V_2T_3 (Asterix + Wuxalsuper) treatment combination in 2010-11 and in V_2T_0 (Asterix+control) treatment combination in 2011-12 (Tables 53a and 53b).

4.12.3 Non-sprouted eyes (%)

4.12.3.1 Effect of cultivar

There was significant effect on non-sprouted eyes due to cultivars in both the years. However, the highest non-sprouted eyes (52.00% in first year and 51.18% in second year) of total eyes were recorded in Asterix (V_2) cultivar and the lowest non-sprouted eyes (43.38% in first year and 48.89% in second years) were obtained from Granola (V_3) cultivar (Tables 51a and 51b).

4.12.3.2 Effect of treatments

The non-sprouted eyes were not influenced significantly by the different treatments in first year but responded significantly in second year. The

highest non-sprouted eyes (48.75% and 52.79%) of total eyes were observed from the treatment T_2 (Brassinosteroid) in 2010-11 and in 2011-12 while the lowest non-sprouted eyes (45.47% in first year and 46.73% in second year) were recorded from the treatment T_0 (control). The treatments T_1 (Vitapulus), T_2 (Brassinosteroid), T_3 (Wuxalsuper), T_4 (Vitapulus + Wuxalsuper) and T_5 (Brassinosteroid + Wuxalsuper) were found statistically identical in 2011-12 (Tables 52a and 52b).

4.12.3.3 Interaction effect between cultivars and treatments

Interaction effect between cultivars and treatments did not vary significantly in 2010-11 but influenced significantly 2011-12. However, the highest non-sprouted eyes (54.95% in first year and 55.92% in second year) were observed in V_2T_3 (Asterix + Wuxalsuper) and in V_3T_5 (Granola + Brassinosteroid + Wuxalsuper) treatment combination. In 2011-12, the treatment combinations V_1T_1 (Diamant + Vitapulus), V_1T_2 (Diamant + Brassinosteroid), V_1T_3 (Diamant + Wuxalsuper) and V_2T_0 (Asterix + control) were found statistically identical. Similarly, the treatment combinations V_2T_1 (Asterix + Vitapulus) V_2T_2 (Asterix + Brassinosteroid) and V_3T_3 (Granola + Wuxalsuper) were found statistically identical. The lowest non-sprouted eyes (43.23% in first year and 40.52% in second year) were obtained from V_3T_0 (Granola+control) treatment combination in 2010-11 and 2011-12 (Tables 53a and 53b).

4.12.4 Germination percentage of sprouted tuber

4.12.4.1 Effect of cultivars

Germination percentage of tubers sprouted was not significantly influenced by the cultivars in both the years. The highest (96.67% and 95.56%) germination were obtained only in Diamant (V_1) cultivar in first year and both in Diamant (V_1) and Granola (V_3) cultivar in second year.

The lowest 94.44% germination were obtained both in Asterix (V_2) and Granola (V_3) cultivar in 2010-11 and Asterix (V_2) cultivar in 2011-12 (Tables 51a and 51b).

4.12.4.2 Effect of treatments

Treatments did not vary significantly in respect of germination percent in 2010-11, while it was statistically significant in 2011-12. The highest germination percentage of tubers were 100 in T_0 (control) and the lowest (91.11% and 86.67%) germination was observed in the treatment T_2 (Brassinosteroid) in both the years. In 2011-12, the germination percentage 97.78 and 100 was found statistically identical and were obtained from the treatment T_0 (control), T_3 (Wuxalsuper) and T_1 (Vitaplus) in 2011-12 (Tables 52a and 52b).

4.12.4.3 Interaction effect between cultivars and treatments

Interaction effect between cultivars and treatments was non-significant in respect of germination in both the years. The highest 100% germination have been recorded in the treatment combinations constituted with T_0 (control) and T_3 (Wuxalsuper) treatment in both the years. The lowest 86.67% germination was found in V_1T_2 (Diamant + Brassinosteroid) treatment combination in 2010-11 and 2011-12 (Tables 53a and 53b).

4.12.5 Number of days to shoot emergence

4.12.5.1 Effect of cultivar

The number of days required to emerge shoot was greatly influenced by the cultivars in both the years. The highest number of days (18.00 in first year and 17.56 in second years) were required for shoot emergence in Granola (V_3) cultivar. In 2010-11, the number of days (18.00 and 17.61) of cultivar Granola (V_3) and Asterix (V_2) were found statistically

identical. The lowest number of days (16.61 and 17.00) were required for shoot emergence in Diamant (V_1) cultivar in both the years (Tables 51a and 51b).

4.12.5.2 Effect of treatments

The number of days required to emerge shoot was influenced significantly by the treatments in both the years. The highest number of days (19.56 in first year and 19.33 in second years) were required for shoot emergence from the treatment T_0 (control). The number of days (16.44 and 16.78) were found statistically identical and were obtained from the treatment T_1 (Vitaplus), T_2 (Brassinosteroid), T_4 (Vitaplus + Wuxalsuper) and T_5 (Brassinosteroid + Wuxalsuper) in 2010-11. The lowest number of days (16.44 and 16.00) were required for shoot emergence from the treatment T_1 (Vitaplus) and T_2 (Brassinosteroid) in 2010-11 and from the treatment T_2 (Brassinosteroid) in 2011-12 (Tables 52a and 52b)

4.12.5.3 Interaction effect between cultivars and treatments

In 2010-11 and 2011-12, days to shoot emergence were not influenced significantly by the interaction effect between cultivars and treatments. The highest number of days (20.00 and 19.67) were required for shoot emergence from both the treatment combinations V_2T_0 (Asterix + control) and V_3T_0 (Granola + control) in 2010-11 and only in V_3T_0 (Granola + control) in 2010-12. The lowest number of days (15.33 and 16.00) were required for shoot emergence from V_1T_1 (Diamant+ Vitaplus) and V_1T_2 (Diamant + Brassinosteroid) treatment combinations in both the years (Tables 53a and 53b).

4.12.6 Number of haulms per tuber

4.12.6.1 Effect of cultivar

The number of haulms per tuber was significantly influenced by the cultivars in both the years. The highest number of haulms (5.17 in first year and 4.51 in second years) per tuber was found in Diamant (V_1) cultivar. In 2011-12, the number of haulms (3.60 and 3.92) was found statistically identical and was obtained from Granola (V_3) and Asterix (V_2) cultivar. The lowest number of haulms (4.56 in first year and 3.60 second year) per tuber was recorded in Asterix (V_2) cultivar in both the years (Tables 51a and 51b).

4.12.6.2 Effect of treatments

The number of haulms per tuber varied significantly by treatments in both the years. However, the highest number of haulms (5.27 in first year and 4.51 in second years) per tuber were obtained from the treatment T_4 (Vitaplus + Wuxalsuper) in consecutive two years of 2010-11 and 2011-12. On the other hand, the lowest number of haulms (4.24 in first year and 3.72 in second years) per tuber were obtained from the treatment T_0 (control) (Tables 52a and 52b).

4.12.6.3 Interaction effect between cultivars and treatments

The number of haulms per tuber was statistically significant due to interaction effect between cultivars and treatments in both the years. Treatment combination V_1T_4 (Diamant+ Vitaplus + Wuxalsuper) produced highest number of haulms (5.70 in first year and 5.20 in second year) per tuber. In 2010-11, the number of haulms (5.27 and 5.20) were found statistically identical and were obtained from V_2T_1 (Asterix + Vitaplus), V_2T_3 (Asterix + Wuxalsuper) and V_3T_2 (Granola +

Brassinosteroid) treatment combination. Similarly, the number of haulms (5.03 and 5.10) were found statistically identical and were obtained from V_1T_1 (Diamant + Vitapulus), V_1T_2 (Diamant + Brassinosteroid) V_1T_3 (Diamant + Wuxalsuper) and V_3T_4 (Granola + Vitapulus + Wuxalsuper) treatment combination. In the similar way, the number of haulms (4.63, 4.60 and 4.67) were found statistically identical as they were bearing the same letters and were obtained from V_1T_0 (Diamant+control), V_2T_2 (Asterix + Brassinosteroid), V_2T_5 (Asterix + Brassinosteroid + Wuxalsuper) and V_3T_5 (Granola + Brassinosteroid + Wuxalsuper) treatment combination. In 2011-12, the number of haulms (5.07 and 5.00) were found statistically identical and were obtained from V_1T_3 (Diamant + Wuxalsuper) and V_1T_5 (Diamant + Brassinosteroid +Wuxalsuper) treatment combination. Treatment combinations V_3T_0 (Granola + control) and V_2T_0 (Asterix + control) produced lowest number of haulms (3.67 in first year and 3.13 in second year) per tuber. (Tables 53a and 53b)

4.12.7 Seed vigour index

4.12.7.1 Effect of cultivar

In both the years, seed vigour index was influenced significantly by the cultivars. However, the highest seed vigour index (7.14 in first year and 7.16 in second years) were calculated in Diamant (V_1) cultivar. The vigour index (6.56 and 6.72) was found statistically identical and was obtained from Granola (V_3) and Asterix (V_2) cultivar in 2010-11. In the similar way, the vigour index (6.64 and 6.45) was found statistically identical and was recorded in Asterix (V_2) and Granola (V_3) cultivar in 2011-12. The lowest index (6.56 in first year and 6.45 in second years) were observed in Granola (V_3) cultivar (Tables 51a and 51b).

4.12.7.2 Effect of treatments

In 2010-11, treatments had no significant contribution on seed vigour index, while they played a great contribution on seed vigour index in 2011-12. The highest seed vigour index (7.04 in first year and 7.25 in second years) were recorded in the treatment T_1 (Vitaplus) in 2010-11 and 2011-12. The treatment T_3 (Wuxalsuper), T_4 (Vitaplus + Wuxalsuper) and T_5 (Brassinosteroid + Wuxalsuper) were found statistically identical in 2011-12. The lowest vigour index (6.61 in first year and 6.00 in second years) were found in the treatment T_0 (control) (Tables 52a and 52b).

4.12.7.3 Interaction effect between cultivars and treatments

Seed vigour index was not significantly influenced due to the interaction effect between cultivars and treatments in both the years. Though they were numerically different, the highest number of index (7.43 in first year and 7.75 in second years) were recorded in V_1T_1 (Diamant+ Vitaplus) treatment combination. The lowest number of index (6.38 and 5.) were recorded in V_3T_2 (Granola + Brassinosteroid) treatment combination in 2010-11 and in V_2T_2 (Asterix + Brassinosteroid) treatment combination in 2011-12 (Tables 53a and 53b).

Table 51a. Effect of cultivars on seed quality of potato [1st year (2010-2011)]

Variety	No. of total eyes	Sprouted eyes (%)	Non sprouted eyes (%)	Germination % of tubers sprouted	No. of days to shoot emergence	No. of haulm tuber ⁻¹	Seed vigour index
Diamant (V ₁)	3.92a	53.80a	46.19b	96.67	16.61b	5.17a	7.14a
Asterix (V ₂)	3.87a	48.00b	52.00a	94.44	17.61a	4.56b	6.72b
Granola (V ₃)	3.26b	56.62a	43.38b	94.44	18.00a	4.86ab	6.56b
Level of significance	**	**	**	NS	**	**	**
CV (%)	5.79	10.70	10.70	9.73	3.18	8.37	4.98

Table 51b. Effect of cultivars on seed quality of potato [2nd year (2011-2012)]

Variety	No. of total eyes	Sprouted eyes (%)	Non sprouted eyes (%)	Germination % of tubers sprouted	No. of days to shoot emergence	No. of haulm tuber ⁻¹	Seed vigour index
Diamant (V ₁)	3.83a	49.74	50.26ab	95.56	17.00b	4.51a	7.16a
Asterix (V ₂)	3.62a	48.82	51.18a	94.44	17.22ab	3.60b	6.64b
Granola (V ₃)	3.28b	51.11	48.89c	95.56	17.56a	3.92b	6.45b
Level of significance	**	NS	*	NS	*	**	**
CV (%)	6.54	6.88	6.18	7.94	3.68	8.85	5.52

In a column, the figures bearing same letter(s) or without letters are identical and those having dissimilar letters differed significantly as per DMRT

Table 52a. Effect of plant growth regulators and micronutrients on seed quality of potato [1st year (2010-2011)]

Treatments	No. of total eyes	Sprouted eyes (%)	Non sprouted eyes (%)	Germination % of tubers sprouted	No. of days to shoot emergence	No. of haulm tuber ⁻¹	Seed vigour index
T ₀	3.10b	54.53	45.47	100.00	19.56a	4.24b	6.61
T ₁	3.72a	52.00	48.00	93.33	16.44c	4.87a	7.04
T ₂	3.73a	51.25	48.75	91.11	16.44c	4.94a	6.92
T ₃	3.82a	51.38	48.62	97.78	18.44b	4.89a	6.69
T ₄	3.81a	53.71	46.29	93.33	16.78c	5.27a	6.77
T ₅	3.89a	53.97	46.03	95.56	16.78c	4.98a	6.82
Level of significance	**	NS	NS	NS	**	**	NS
CV (%)	5.79	10.70	12.10	9.73	3.18	8.37	4.98

Table 52b. Effect of plant growth regulators and micronutrients on seed quality of potato [2nd year (2011-2012)]

Treatments	No. of total eyes	Sprouted eyes (%)	Non sprouted eyes (%)	Germination % of tubers sprouted	No. of days to shoot emergence	No. of haulm tuber ⁻¹	Seed vigour index
T ₀	2.99c	53.27a	46.73b	100.00a	19.33a	3.72d	6.00c
T ₁	3.38b	50.15ab	52.79a	97.78a	16.00e	3.80c	7.25a
T ₂	3.41b	48.93b	51.07a	86.67b	16.11de	4.02bc	7.06ab
T ₃	3.58b	47.31b	49.85a	100.00a	18.22b	4.20a-c	6.65b
T ₄	4.12a	49.83b	50.17a	93.33ab	16.89cd	4.51a	6.76b
T ₅	3.99a	49.86b	50.14a	93.33ab	17.00c	4.31ab	6.77b
Level of significance	**	*	*	**	**	**	**
CV(%)	6.54	6.88	6.18	7.94	3.68	8.85	5.52

T₀=Control, T₁ = Vitaplus, T₂= Brassinosteroid, T₃=Wuxalsuper

T₄= Vitaplus + Wuxalsuper, T₅= Brassinosteroid+ Wuxalsuper,

In a column, the figures bearing same letter(s) or without letters are identical and those having dissimilar letters differed significantly as per DMRT

Table 53a. Effect of interaction between cultivars and plant growth regulators & micronutrients on seed quality of potato [1st year (2010-2011)]

Cultivars × Treatments	No. of total eyes	Sprouted eyes (%)	Non sprouted eyes (%)	Germination % of tubers sprouted	No. of days to shoot emergence	No. of haulm tuber ⁻¹	Seed vigour index
V ₁ T ₀	3.20	56.34	43.67	100.00	18.67	4.63c-e	6.81
V ₁ T ₁	3.93	52.61	47.39	93.33	15.33	5.03a-d	7.43
V ₁ T ₂	3.97	53.81	46.19	86.67	15.33	5.03a-d	7.33
V ₁ T ₃	4.13	50.95	49.05	100.00	17.67	5.03a-d	6.87
V ₁ T ₄	4.13	54.08	45.92	100.00	16.33	5.70a	7.17
V ₁ T ₅	4.13	55.08	44.92	100.00	16.33	5.60ab	7.25
V ₂ T ₀	3.30	50.48	49.52	100.00	20.00	4.43de	6.70
V ₂ T ₁	3.97	48.33	51.67	93.33	17.00	5.27a-c	6.79
V ₂ T ₂	4.00	46.88	53.12	93.33	17.00	4.60c-e	6.81
V ₂ T ₃	4.00	45.05	54.95	93.33	18.67	5.20a-c	7.03
V ₂ T ₄	3.93	49.56	50.44	93.33	16.33	5.00b-d	6.40
V ₂ T ₅	4.00	47.87	52.13	93.33	16.67	4.67c-e	6.58
V ₃ T ₀	2.80	56.77	43.23	100.00	20.00	3.67f	6.82
V ₃ T ₁	3.27	57.28	44.72	93.33	17.00	4.30ef	6.71
V ₃ T ₂	3.23	53.06	46.94	93.33	17.00	5.20a-c	6.38
V ₃ T ₃	3.33	58.15	41.85	100.00	19.00	4.43de	6.65
V ₃ T ₄	3.67	57.50	42.50	86.67	17.67	5.10a-d	6.68
V ₃ T ₅	3.53	58.95	43.05	93.33	17.33	4.67c-e	6.55
Level of significance	NS	NS	NS	NS	NS	0.05	NS
CV (%)	5.79	10.70	12.10	9.73	3.18	8.37	4.98

V₁=Diamant, V₂=Asterix, V₃=Granola

T₀=Control, T₁ = Vitapulus, T₂= Brassinosteroid, T₃=Wuxalsuper

T₄= Vitapulus + Wuxalsuper, T₅=Brassinosteroid+ Wuxalsuper,

In a column, the figures bearing same letter(s) or without letters are identical and those having dissimilar letters differed significantly as per DMRT

Table 53b. Interaction effect between cultivars and plant growth regulators & micronutrients on seed quality contributing characters of potato [2nd year (2011-2012)]

Cultivars × Treatments	No. of total eyes	Sprouted eyes (%)	Non sprouted eyes (%)	Germination % of tubers sprouted	No. of days to shoot emergence	No. of haulm tuber ⁻¹	Seed vigour index
V ₁ T ₀	3.07	55.33ab	44.67ef	100.00	19.00	3.20g	6.46
V ₁ T ₁	3.67	46.58de	53.42ab	100.00	16.00	4.00c-e	7.75
V ₁ T ₂	3.50	46.80de	53.20ab	86.67	16.00	4.60a-c	7.31
V ₁ T ₃	3.87	45.42e	54.58ab	100.00	17.67	5.07ab	7.11
V ₁ T ₄	4.57	50.15b-e	49.85a-e	93.33	16.67	5.20a	7.13
V ₁ T ₅	4.30	54.15a-d	45.85c-f	93.33	16.67	5.00ab	7.18
V ₂ T ₀	3.13	45.00e	55.00ab	100.00	19.33	3.13g	7.47
V ₂ T ₁	3.27	49.07b-e	50.93a-e	100.00	16.00	3.80d-g	6.59
V ₂ T ₂	3.40	48.90b-e	51.10a-e	80.00	16.33	3.80d-g	5.41
V ₂ T ₃	3.67	47.50c-e	52.50a-c	100.00	18.00	3.87c-g	7.19
V ₂ T ₄	4.20	51.12b-e	48.88b-e	93.33	16.67	4.53a-d	6.62
V ₂ T ₅	4.07	51.33b-e	48.67b-e	93.33	17.00	4.40b-e	6.54
V ₃ T ₀	2.77	59.48a	40.52f	100.00	19.67	3.33fg	6.60
V ₃ T ₁	3.20	54.80a-c	45.20d-f	93.33	16.00	3.60fg	6.40
V ₃ T ₂	3.33	51.08b-e	45.58d-f	93.33	16.00	3.67e-g	6.15
V ₃ T ₃	3.20	49.00b-e	51.00a-e	100.00	19.00	3.67e-g	6.81
V ₃ T ₄	3.60	48.22b-e	51.78a-d	93.33	17.33	3.80d-g	6.52
V ₃ T ₅	3.60	44.08e	55.92a	93.33	17.33	3.53f-g	6.22
Level of significance	NS	**	**	NS	NS	**	NS
CV (%)	6.54	6.88	6.18	7.94	3.68	8.85	5.52

V₁=Diamant, V₂=Asterix, V₃=Granola,

T₀=Control, T₁ = Vitapulus, T₂= Brassinosteroid, T₃=Wuxalsuper

T₄= Vitapulus + Wuxalsuper, T₅=Brassinosteroid+ Wuxalsuper,

In a column, the figures bearing same letter(s) or without letters are identical and those having dissimilar letters differed significantly as per DMRT

c) Sajeda cold storage, Saidpur

In 2010-11, all the seed quality test parameters, i.e number of total eyes per tuber, sprouted and non-sprouted eyes(%), number of days to shoot emergence, number of haulms per tuber and seed vigour index excepts germination(%) of tuber sprouted were significant due to the cultivars. Seed quality test parameters like number of days to shoot emergence and seed vigour index were significant due to the different treatments and the rest parameters were non-significant. All the seed quality test parameters except sprouted eyes(%) were non-significant due to the interaction effect between cultivars and treatments.

In 2011-12, all the seed quality parameters excepts germination (%) of the tuber sprouted were significant by the cultivars. Only 2 parameters i.e sprouted and non-sprouted eyes (%) were non-significant by the different treatments while the rest of the parameters were significant. All the seed quality contributing parameters excepts number of total eyes per tuber and number of haulms per tuber were non-significant by the interaction of the cultivars and treatments.

4.13.1 Number of total eyes per tuber

4.13.1.1 Effect of cultivar

The number of total eyes per tuber had significant effect on the cultivars in both the years. The highest number of eyes (4.41 in first year and 4.13 in second years) were observed in Diamant (V_1) cultivar. In 2011-12, the number of eyes per tuber (4.13 and 4.00) was found statistically identical and was obtained from Diamant (V_1) and Asterix (V_2) cultivar. The lowest number of eyes (3.93 in first year and 3.66 in second years) per tuber was recorded in Granola (V_3) cultivar (Tables 54a and 54b).

4.13.1.2 Effect of treatments

The number of total eyes per tuber was non-significant due to the treatments in 2010-11 but had a significant effect in 2011-12. However, the highest number of eyes (4.41 in first year and 4.69 in second years) per tuber was observed in the treatment T_4 (Vitaplus + Wuxalsuper). In 2011-12, the number of eyes (4.69 and 4.44) were found statistically identical as they were bearing the same letters and were obtained from the treatment T_4 (Vitaplus + Wuxalsuper) and T_5 (Brassinosteroid + Wuxalsuper). Similarly, the number of eyes (3.91 and 4.01) were found statistically identical and were observed in the treatment T_2 (Brassinosteroid) and T_3 (Wuxalsuper) in the same year. The lowest number of eyes per tuber (3.97 in first year and 3.56 in second years) were recorded in the treatment T_0 (control) (Tables 55a and 55b).

4.13.1.3 Interaction effect between cultivars and treatments

The number of total eyes per tuber had no significant effect due to the interaction between cultivars and treatments in 2010-2011 but played a significant role in 2011-12. The highest number of eyes (5.47 and 4.93) were obtained from V_1T_4 (Diamant + Vitaplus + Wuxalsuper) treatment combination in both the years. In 2011-12, the number of eyes (4.67 and 4.87) were found statistically identical and were obtained from V_1T_5 (Diamant+Brassinosteroid + Wuxalsuper) and V_2T_4 (Asterix+ Vitaplus + Wuxalsuper) treatment combination. The lowest number of eyes (3.30 and 3.31) per tuber were recorded from V_2T_0 (Asterix+control) treatment combination in 2010-11 and from V_1T_0 (Diamant+control) treatment combination in 2011-12 (Tables 56a and 56b).

4.13.2 Sprouted eyes (%)

4.13.2.1 Effect of cultivars

Sprouted eyes were significantly influenced by the cultivars in both the years. The highest sprouted eyes (56.00% in first year and 56.60% in second years) were recorded in Granola (V_3) cultivar in both the years, while the lowest sprouted eyes (48.63% and 48.71%) were observed in Asterix (V_2) cultivar in both the years of 2010-11 and 2011-12 (Tables 54a and 54b).

4.13.2.2 Effect of treatments.

Sprouted eyes were not significantly affected due to treatments in both the years. The highest sprouted eyes (54.20% in first year and 56.47% in second years) of total eyes were recorded in the treatment T_2 (Brassinosteroid) and in the treatment T_0 (control) respectively. The lowest sprouted eyes (49.95% and 50.30%) were observed in the treatment T_4 (Vitapulus + Wuxalsuper) in 2010-11 and in the treatment T_1 (Vitapulus) in 2011-12 (Tables 55a and 55b).

4.13.2.3 Interaction effect between cultivars and treatments.

Interaction effect between cultivars and treatments were significant in 2010-2011 but not significant in 2011-2012. However, the highest sprouted eyes (58.85% in first year and 60.20% in second years) were observed in V_3T_5 (Granola + Brassinosteroid + Wuxalsuper) and in V_3T_4 (Granola + Vitapulus + Wuxalsuper) treatment combination, while the lowest sprouted eyes (42.06% in first year and 42.78% in second years) were observed in V_2T_4 (Asterix + Vitapulus + Wuxalsuper) and in V_2T_1 (Asterix + Vitapulus) treatment combination respectively. In 2010-11, the sprouted eyes (57.77% and 57.32%) were found statistically identical and

were obtained from V_3T_4 (Granola+ Vitaplus +Wuxalsuper) and V_3T_0 (Granola +control) treatment combination. Similarly, the treatment combinations V_1T_0 (Diamant+ control), V_1T_3 (Diamant+Wuxalsuper), V_2T_2 (Asterix+Brassinosteroid) and V_3T_1 (Granola+ Vitaplus) were found statistically identical in the same year. In the same way, the treatment combinations V_1T_2 (Asterix+ Brassinosteroid), V_2T_3 (Asterix +Wuxalsuper), V_3T_2 (Granola+Brassinosteroid) and V_3T_3 (Granola+Wuxalsuper) were found statistically identical in 2010-11 (Tables 56a and 56b).

4.13.3 Non -sprouted eyes (%)

4.13.3.1 Effect of cultivars

There was significant effect on non-sprouted eyes due to cultivars in both the years. The highest non-sprouted eyes (51.37% in first year and 51.29% in second years) were recorded in Asterix (V_2) cultivar. In 2011-12, the non-sprouted eyes (59.25% and 51.29%) were found statistically identical and were obtained from Diamant (V_1) and Asterix (V_2) cultivar. The lowest non-sprouted eyes (44.00% and 43.40%) were recorded only in Granola (V_3) cultivar in 2010-11 and 2011-12 (Tables 54a and 54b)

4.13.3.2 Effect of treatments

The non-sprouted eyes were not significantly influenced due to the treatments in both the years. The highest non-sprouted eyes (50.05% in first year and 49.70% in second years) were observed in the treatment T_4 (Vitaplus + Wuxalsuper) and in the treatment T_1 (Vitaplus) in both the years. The lowest non-sprouted eyes (45.80% in first year and 43.53% in second years) were observed in the treatment T_2 (Brassinosteroid) and in T_0 (control) (Tables 55a and 55b).

4.13.3 Interaction effect between cultivars and treatments

Interaction effect between cultivars and treatments did not vary significantly in both the years. The highest non-sprouted eyes (57.94% in first year and 59.58% in second years) were observed in V_2T_4 (Asterix+ Vitapulus + Wuxalsuper) and in V_2T_3 (Asterix +Wuxalsuper) treatment combination in both the years. On the contrary, the lowest non-sprouted eyes (41.15% in first year and 39.81% in second years) were recorded in V_3T_5 (Asterix+Brassinosteroid+Wuxalsuper) and in T_4V_3 (Granola+ Vitapulus + Wuxalsuper) treatment combination respectively (Tables 56a and 56b).

4.13.4 Germination percentage of sprouted tuber.

4.13.4.1 Effect of cultivars

Germination percentage of sprouted tuber was not influenced significantly by the cultivars in both the years. However, the highest germination (95.56% in first year and 96.67% in second years) was recorded in Diamant (V_1) cultivar. The lowest germination (93.33% in first year and 90.00% in second years) was recorded in Granola (V_3) cultivar and in Asterix (V_2) cultivar (Tables 54a and 54b).

4.13.4.2 Effect of treatments

Treatments did not vary significantly in respect of germination percent in 2010-11, while it influenced significantly in 2011-12. Though the germination percent was statistically identical in 2010-11, the highest 100 percent germination was recorded in the treatment T_3 (Wuxalsuper) and the lowest germination (91.11% in first year and 84.44% in second years) were recorded in the treatment T_1 (Vitapulus) and T_2 (Brassinosteroid) respectively in 2010-11 and 2011-12. Germination percentage 100.00,

97.78 and 95.56 of the treatment T_0 (control), T_3 (Wuxalsuper) and T_5 (Brassinosteroid + Wuxalsuper) was found statistically identical in 2011-12. Treatments T_1 (Vitapulus) and T_2 (Brassinosteroid) were found statistically identical in the same year (Tables 55a and 55b).

4.13.4.3 Interaction effect between cultivars and treatments

Interaction effect between cultivars and treatments was non-significant in both the years. With a few exceptions, the highest 100 percent germinations were observed in most of the treatment combinations consisted of T_0 (control) and T_3 (Wuxalsuper) in both the years. The lowest 86.67% germination were observed in V_1T_2 (Diamant + Brassinosteroid), V_2T_1 (Asterix + Vitapulus) V_3T_2 (Granola + Brassinosteroid)) and V_3T_4 (Granola + Vitapulus + Wuxalsuper) treatment combinations in 2010-11 and 80% germination were observed in V_2T_2 (Asterix + Brassinosteroid) treatment combination in 2011-12 (Tables 56a and 56b).

4.13.5 Number of days to shoot emergence

4.13.5.1 Effect of cultivars

The number of days required to emerge shoot was significantly influenced by the cultivars in both the years. The highest number of days (17.39 in first year and 17.78 in second years) was needed to emerge shoot in Granola (V_3) cultivar. Cultivars Asterix (V_2) and cultivar Granola (V_3) was found statistically identical in 2010-11 and cultivar Diamant (V_1) and Asterix (V_2) was also found statistically identical in 2011-12. The lowest number of days (16.44 in first year and 17.00 in second year) were needed to emerge shoot in Diamant (V_1) cultivar. (Tables 54a and 54b).

4.13.5.2 Effect of treatments

The number of days required to emerge shoot was influenced significantly by the treatments in both the years. The highest number of days (18.89 in first year and 19.33 in second years) were required to emerge shoot in the treatment T_0 (control). In 2010-11, the treatment T_1 (Vitapulus) and T_2 (Brassinosteroid) and the treatment T_4 (Vitapulus + Wuxalsuper) and T_5 (Brassinosteroid + Wuxalsuper) were found statistically identical. The lowest number of days (15.78 in first year and 16.00 in second years) were required to emerge shoot in the treatment T_1 (Vitapulus) (Tables 55a and 55b).

4.13.5.3 Interaction effect between cultivars and treatments

Interaction effect between cultivars and treatments had no significant effect on the number of days to shoot emergence in 2010-11 and 2011-12. However, the highest number of days (19.33 in first year and 20.00 in second years) were needed for shoot emergence in treatment combination the V_2T_0 (Asterix + control). The lowest number of days (15.00 and 16.00) were needed for shoot emergence in the treatment combination V_1T_1 (Diamant + Vitapulus) in 2010-11 and in the treatment combinations V_1T_1 (Diamant + Vitapulus) and V_1T_2 (Diamant + Brassinosteroid) in 2011-12 (Tables 56a and 56b).

4.13.6 Number of haulms per tuber

4.13.6.1 Effect of cultivars

The number of haulms per tuber was significantly influenced due to cultivars in both the years. The highest number of haulms (4.96 in first year and 4.27 in second years) haulms per tuber was observed in Diamant (V_1) cultivar. In 2011-12, the number of haulms (3.76 and (3.67)

were found statistically identical and were observed in cultivar Granola (V_3) and in Asterix (V_2). The lowest number of haulms (4.03 in first year and 3.67 in second years) per plant was observed in the cultivar Asterix (V_2) (Tables 54a and 54b).

4.13.6.2 Effect of treatments

The number of haulms per tuber did not vary significantly in 2010-11 but had a significant contribution in 2011-12. However, the highest number of haulms (4.67 in first year and 4.44 in second years) per tuber were observed in the treatment T_3 (Wuxalsuper) and in T_4 (Vitaplus + Wuxalsuper). In 2011-12, the number of haulms (4.44 and 4.36) were found statistically identical as they were bearing the same letters and were observed in the treatment T_4 (Vitaplus + Wuxalsuper) and in T_5 (Brassinosteroid + Wuxalsuper). Similarly, the number of haulms (3.67 and 3.69) were found statistically identical and were obtained from the treatment T_1 (Vitaplus) and treatment T_2 (Brassinosteroid) in the same year. The lowest number of haulms (4.29 in first year and 3.58 in second years) per tuber was observed in the treatment T_0 (control) (Tables 55a and 55b).

4.13.6.3 Interaction effect between cultivars and treatments

Interaction effect of cultivars and treatments had no significant influence on the number of haulms per tuber in 2010-11 but played a significant role in 2011-12. However, the highest number of haulms (5.20 in first year and 4.67 in second years) were observed in V_1T_4 (Diamant + Vitaplus + Wuxalsuper) treatment combination. In 2011-12, the number of haulms (4.67 and 4.60) were found statistically identical and were obtained from V_1T_4 (Diamant + Vitaplus + Wuxalsuper) and V_1T_5 (Diamant + Brassinosteroid + Wuxalsuper) treatment combination. The treatment combinations V_1T_3 (Diamant + Wuxalsuper) and V_2T_4 (Asterix + Vitaplus

+Wuxalsuper) were found statistically identical. Similarly, the treatment combinations V_1T_1 (Diamant + Vitapulus), V_1T_2 (Diamant + Brassinosteroid), V_2T_3 (Asterix + Wuxalsuper), V_2T_5 (Asterix + Brassinosteroid + Wuxalsuper), V_3T_4 (Granola + Vitapulus + Wuxalsuper) and V_3T_5 (Granola + Brassinosteroid + Wuxalsuper) were found statistically identical in the same year. In the similar way, the treatment combinations V_1T_0 (Diamant + control), V_2T_1 (Asterix + Vitapulus), V_3T_1 (Granola + Vitapulus), V_3T_2 (Granola + Brassinosteroid) and V_3T_3 (Granola+Wuxalsuper) were found statistically identical in 2011-12. The lowest number of haulms (3.60 and 3.07) haulms per tuber were observed in V_3T_0 (Granola+control) treatment combination in 2010-11 and 2011-12 (Tables 56a and 56b).

4.13.7 Seed vigour index

4.13.7.1 Effect of cultivars

Seed vigour index was influenced significantly by the cultivars in 2010-11 and 2011-12. The highest seed vigour index (7.15 in first year and 6.87 in second years) was observed in Diamant (V_1) cultivar. In 2010-11, the seed vigour index (6.77 and 6.61) was found statistically identical and was obtained from Asterix (V_2) and Granola (V_3) cultivar. The lowest seed vigour index (6.61 and 6.40) was assessed in Granola (V_3) cultivar in both the years (Tables 54a and 54b).

4.13.7.2 Effect of treatments

Treatments had a significant effect on seed vigour index in both the years. The highest seed vigour index (7.33 in first year and 7.03 in second years) was observed in the treatment T_1 (Vitapulus) in both the years. In 2010-11, the treatment T_3 (Wuxalsuper), T_4 (Vitapulus +Wuxalsuper) and T_5 (Brassinosteroid +Wuxalsuper) were found statistically identical. In

2011-12, the treatment T_1 (Vitapulus) and T_2 (Brassinostroid) were found statistically identical. Similarly, the seed vigour index (6.63 and 6.75) were found statistically identical and were observed in the treatment T_4 (Vitapulus + Wuxalsuper) and T_5 (Brassinosteroid and Wuxalsuper) respectively. In the similar way, the seed vigour index (6.34 and 6.21) were found statistically identical and were obtained in the treatment T_3 (Wuxalsuper) and T_0 (control) in the same year. The lowest seed vigour index (6.45 and 6.21) were obtained in the treatment T_0 (control) in both the years (Tables 55a and 55b).

4.13.7.3 Interaction effect between cultivars and treatments

Interaction effect between cultivars and treatments did not play significant role on seed vigour in 2010-11 and 2011-12. However, the highest potato seed vigour (7.84 and 7.43) were observed in V_1T_3 (Diamant+Wuxalsuper) treatment combination in 2010-11 and 2011-12. The lowest seed vigour index (6.24 in first year and 5.78 in second years) were recorded in V_3T_2 (Granola+Brassinosteroid) treatment combination in both the years (Tables 56a and 56b).

Table 54a. Effect of cultivars on seed quality of potato [1st year (2010-2011)]

Cultivars	No. of total eyes	Sprouted eyes (%)	Non sprouted eyes (%)	Germination % of tubers sprouted	No. of days to shoot emergence	No. of haulms tuber ⁻¹	Seed vigour index
Diamant (V ₁)	4.41a	51.23ab	48.76ab	95.56	16.44b	4.96a	7.15a
Asterix (V ₂)	4.28ab	48.63b	51.37a	94.44	17.28a	4.03b	6.77b
Granola (V ₃)	3.93b	56.00a	44.00b	93.33	17.39a	4.29ab	6.61b
Level of significance	*	**	**	NS	**	**	**
CV (%)	13.03	10.59	11.32	9.83	3.07	19.50	5.00

Table 54b. Effect of cultivars on seed quality of potato [2nd year (2011-2012)]

Cultivars	No. of total eyes	Sprouted eyes (%)	Non sprouted eyes (%)	Germination % of tubers sprouted	No. of days to shoot emergence	No. of haulms tuber ⁻¹	Seed vigour index
Diamant (V ₁)	4.13a	50.75b	49.25a	96.67	17.00b	4.27a	6.87a
Asterix (V ₂)	4.00a	48.71b	51.29a	90.00	17.00b	3.67b	6.68ab
Granola (V ₃)	3.66b	56.60a	43.40b	93.33	17.78a	3.76b	6.40b
Level of significance	**	**	**	NS	*	**	*
CV (%)	5.04	9.80	10.63	8.92	5.36	4.78	6.78

In a column, the figures bearing same letter(s) or without letters are identical and those having dissimilar letters differed significantly as per DMRT

Table 55a. Effect of plant growth regulators and micronutrients on seed quality of potato [1st year (2010-2011)]

Treatments	No. of total eyes	Sprouted eyes (%)	Non sprouted eyes (%)	Germination % of tubers sprouted	No. of days to shoot emergence	No. of haulms tuber ⁻¹	Seed vigour index
T ₀	3.97	52.64	47.36	97.78	18.89a	4.29	6.45c
T ₁	4.36	50.20	49.80	91.11	15.78d	4.34	7.33a
T ₂	4.02	54.20	45.80	91.11	16.00d	4.38	7.06ab
T ₃	3.97	53.89	46.11	100.00	18.00b	4.67	6.64bc
T ₄	4.41	49.95	50.05	93.33	16.78c	4.43	6.77bc
T ₅	4.29	50.61	49.39	93.33	16.78c	4.44	6.80bc
Level of significance	NS	NS	NS	NS	**	NS	**
CV (%)	13.03	10.59	11.32	9.83	3.07	19.50	5.00

Table 55b. Effect of plant growth regulators and micronutrients on seed quality of potato [2nd year (2011-2012)]

Treatments	No. of total eyes	Sprouted eyes (%)	Non sprouted eyes (%)	Germination % of tubers sprouted	Days to shoot emergence	No. of haulms tuber ⁻¹	Seed vigour index
T ₀	3.56d	56.47	43.53	100.00a	19.33a	3.58d	6.21b
T ₁	3.69c	50.30	49.70	91.11ab	16.00e	3.67c	7.03a
T ₂	3.91b	50.85	49.15	84.44b	16.11de	3.69c	6.94a
T ₃	4.09b	53.14	46.86	97.78a	18.22b	4.04b	6.34b
T ₄	4.69a	50.37	49.63	91.11ab	16.89cd	4.44a	6.63ab
T ₅	4.44a	51.01	48.99	95.56a	17.00c	4.36a	6.75ab
Level of significance	**	NS	NS	**	**	**	**
CV (%)	5.04	9.80	10.63	8.92	5.36	4.78	6.78

T₀= Control, T₁ = Vitaplu, T₂= Brassinosteroid, T₃=Wuxalsuper

T₄= Vitaplu + Wuxalsuper, T₅=Brassinosteroid+ Wuxalsuper,

In a column, the figures bearing same letter(s) or without letters are identical and those having dissimilar letters differed significantly as per DMRT

Table 56a. Effect of interaction between cultivars and plant growth regulators & micronutrients on seed quality of potato [1st year (2010-2011)]

Cultivars × Treatments	No. of total eyes	Sprouted eyes (%)	Non sprouted eyes (%)	Germination % of tubers sprouted	No. of days to shoot emergence	No. of haulms tuber ⁻¹	Seed vigour index
V ₁ T ₀	3.5	55.37a-c	44.63	100	18.33	5.13	7.36
V ₁ T ₁	4.47	44.67de	55.33	93.33	15.00	4.77	7.14
V ₁ T ₂	4.5	53.37a-d	46.63	86.67	15.33	5.13	6.57
V ₁ T ₃	4.2	55.90a-c	44.09	100	17.67	5.07	7.84
V ₁ T ₄	5.47	50.03a-e	49.97	93.33	16.33	5.2	6.89
V ₁ T ₅	4.3	48.05c-e	51.95	93.33	16.00	4.47	7.07
V ₂ T ₀	3.3	42.80e	52.86	93.33	19.33	4.13	6.95
V ₂ T ₁	4.4	49.28b-e	50.72	86.67	16.33	3.9	6.29
V ₂ T ₂	3.83	55.76a-c	44.24	100	16.33	4.17	6.54
V ₂ T ₃	3.53	52.63a-d	47.37	100	18.00	4.43	7.17
V ₂ T ₄	5.13	42.06e	57.94	100	16.67	4.53	7.12
V ₂ T ₅	4.47	44.92de	55.08	93.33	17.00	4.83	6.57
V ₃ T ₀	3.43	57.32ab	42.68	100	19.00	3.6	6.88
V ₃ T ₁	4.2	56.67a-c	43.33	93.33	16.00	4.37	6.49
V ₃ T ₂	3.73	53.49a-d	46.51	86.67	16.33	3.83	6.24
V ₃ T ₃	4.13	53.15a-d	46.85	100	18.33	4.77	6.99
V ₃ T ₄	4.97	57.77ab	42.23	86.67	17.33	3.57	6.30
V ₃ T ₅	4.1	58.85a	41.15	93.33	17.33	4.03	6.76
Level of significance	NS	*	NS	NS	NS	NS	NS
CV (%)	13.03	10.59	11.32	9.83	3.07	19.5	5.00

V₁=Diamant, V₂=Asterix, V₃=Granola T₀=control,

T₁ = Vitaplust, T₂= Brassinosteroid, T₃=Wuxalsuper T₄= Vitaplust + Wuxalsuper,

T₅= Brassinosteroid+ Wuxalsuper

In a column, the figures bearing same letter(s) or without letters are identical and those having dissimilar letters differed significantly as per DMRT

Table 56b. Effect of interaction between cultivars and plant growth regulators & micronutrients on seed quality of potato [2nd year (2011-2012)]

Cultivars × Treatments	No. of total eyes	Sprouted eyes (%)	Non sprouted eyes (%)	Germination % of tubers sprouted	No. of days to shoot emergence	No. of haulms tuber ⁻¹	Seed vigour index
V ₁ T ₀	3.3lk	56.54	43.46	100.00	19.67	3.53c	6.90
V ₁ T ₁	3.57h-j	54.06	45.94	93.33	16.00	4.13b	6.13
V ₁ T ₂	4.20d-f	50.06	49.94	93.33	16.00	4.27b	6.91
V ₁ T ₃	4.33cd	52.75	47.25	100.00	17.00	4.40ab	7.43
V ₁ T ₄	4.93a	45.08	54.92	93.33	16.67	4.67a	6.84
V ₁ T ₅	4.67ab	46.00	54.00	100.00	16.67	4.60a	7.02
V ₂ T ₀	3.27k	53.19	46.80	100.00	20.00	2.93e	7.00
V ₂ T ₁	3.47jk	42.78	57.22	86.67	16.00	3.47c	6.52
V ₂ T ₂	3.87g-i	46.41	53.59	80.00	16.00	3.33cd	5.94
V ₂ T ₃	3.93f-i	50.42	59.58	93.33	18.00	4.13b	6.96
V ₂ T ₄	4.87ab	45.83	54.17	86.67	16.00	4.40ab	6.57
V ₂ T ₅	4.60bc	53.64	46.36	93.33	16.00	4.27b	7.09
V ₃ T ₀	3.37l	59.67	40.33	100.00	19.33	3.07de	6.91
V ₃ T ₁	3.27k	54.05	45.95	93.33	16.67	3.40c	6.39
V ₃ T ₂	3.67ij	56.07	43.93	80.00	16.33	3.47c	5.78
V ₃ T ₃	4.00e-h	56.25	43.75	100.00	19.00	3.60c	6.69
V ₃ T ₄	4.27de	60.19	39.81	93.33	17.67	4.27b	6.48
V ₃ T ₅	4.07d-g	53.38	46.62	93.33	17.67	4.20b	6.15
Level of significance	*	NS	NS	NS	NS	*	NS
CV (%)	5.04	9.80	10.63	8.92	5.36	4.78	6.78

V₁= Diamant, V₂=Asterix, V₃=Granola

T₀= Control, T₁ = Vitapulus, T₂= Brassinosteroid, T₃=Wuxalsuper

T₄= Vitapulus + Wuxalsuper, T₅= Brassinosteroid+ Wuxalsuper,

In a column, the figures bearing same letter(s) or without letters are identical and those having dissimilar letters differed significantly as per DMRT

CHAPTER 5

DISCUSSION

The result of the present investigation revealed that the total dry matter (TDM) per plant increased with the increase of plant age but decreased gradually at later stages of plant growth. The TDM values were always relatively high in the treatments with growth regulators and micronutrients over the control in both the years. This result was supported by Samui *et al.* (2007), Barche *et al.* (2000), Anjanappa *et al.* (2000), Kumar *et al.* (2011) and Delinchenko *et al.* (2005). The treatment T₄ (Vitapulus+Wuxalsuper) produced the highest TDM in both the years. The second highest TDM was obtained from the treatment T₅ (Brassinosteroid+ Wuxalsuper) in both the years. This might be due to the highest vegetative growth. The number of leaf, haulms and tuber resulted higher TDM per plant in both the years. With a few exceptions, the highest TDM values per plant were obtained from the treatment combination V₁T₄ (Diamant+ Vitapulus +Wuxalsuper) in both the years.

In the present investigation starting from lower value, LAI increased with increase of plant age but decreased at later stages of plant growth. The LAI value was higher in all the treatments over the control in both the years. This result was supported by Samui *et al.* (2007), Barche *et al.* (2007) and Kumar *et al.* (2011) in potato. Prakash *et al.* (2001) got the similar findings in potato. The highest LAI value was observed in V₁T₄ (Diamant + Vitapulus + Wuxalsuper) treatment combination. With the application of plant growth regulators and micronutrients, leaf expansion process taken place by absorbing more moisture from soil resulted turgor

pressure in the cells and turgor forces played a part in the process of leaf expansion leads to increased leaf area. The second highest LAI value was observed in V_1T_5 (Diamant + Brassinosteroid + Wuxalsuper) treatment combination. With a few exceptions, the highest LAI value was found in the treatment combination V_1T_4 (Diamant + Vitapulus + Wuxalsuper) in both the years.

Crop growth rate (CGR) increased slowly at early stages of plant growth and reached the peak at 65-75 DAP and thereafter it declined to negative value. This was possibly due to maximum production of dry matter at initial stages of growth. CGR increased with the application of plant growth regulators and liquid micronutrients like Wuxalsuper on the foliage of potato plants which initiated vigorous vegetative growth. All the treatments showed the significant results over the control in both the years. The similar result was reported by Prakash *et al.* (2001), Samui *et al.* (2007) and Kumar *et al.* (2011) in potato.

Maximum relative growth rate (RGR) values were observed at 35-45 DAP in both the years. The reasons for higher RGR values at early stages of plant growth were possibly due to the juvenility of plants and less interplant competition. RGR decreased gradually with the increase of plant age in both the years. This result is in agreement with the findings of Prakash *et al.* (2001), Anjanappa *et al.* (2000) and Samui *et al.* (2007) in potato. RGR decreased gradually with the increase of plant age in both the years.

Net assimilation rate (NAR) measured the amount of dry matter production per unit area of leaf surface and it is an indicator of photosynthetic efficiency. It is established that NAR became higher

during vegetative phase and declined rapidly as the growth of the potato plant progressed. This might be due to mutual leaf shading and increased the number of old leaves which ultimately lost photosynthetic efficiency. Prakash *et al.* (2001) and Tsegaw (2006) got the similar finding in potato. With a few exceptions, unsprayed control treatment showed the higher NAR value in both the years. In both the years NAR values fluctuated throughout the growing period. In all the treatments and cultivars NAR showed negative values at 75-85 DAP.

In the present study, the relative leaf growth rate (RLGR) showed maximum at 35-45 DAP and then decreased gradually with increasing plant age in all three cultivars and for all the treatments in both the years. The cause of decrease of RLGR values at the later stages due to the abscission of older leaves. However, the RLGR values showed negative values at the later stages of growth in all three cultivars and for all the treatments in both the years.

Leaf area ratio (LAR) values showed highest at the early stages of growth and then declined slowly with the increase of plant age. The treatment T₁ (Vitaplus) showed the highest LAR values at 45 DAP in both the years. The second highest LAR values were found in the treatment T₂ (Brassinosteroid) in both the years. On the contrary, the treatment T₀ (control) showed the highest LAR value at only 35 DAP only in both the years. Interaction effect between cultivars and treatments was observed significant only at 75-85 DAP in both the years.

In the present study, specific leaf area (SLA) gradually decreased at the early growth stages declined at middle and again it increased at the later stages of growth of both the years. SLA was higher at early stages of

growth for all the treatments and cultivars in both the years. It might be due to the higher amount of food material preparation on the leaves and its use efficiency. Significantly the highest SLA value was found in the treatment T_1 (Vitapulus) and T_2 (Brassinosteroid) in most of the harvests in both the years. On the contrary, the treatment T_0 showed the highest SLA values at only 35 and 55 DAP in 2010-11 and at 35 DAP in 2011-12. Interaction effect between cultivars and treatments had a significant effect on SLA at 65, 75 and 85 DAP in 2010-11 and 75 and 85 DAP in 2011-12.

Leaf weight ratio (LWR) showed the maximum values at the beginning of the plant growth and gradually declined with the increasing of plant age. All the treatments showed the significant LWR over the control in both the years. Interaction effect between cultivars and treatments were recorded significant at 45 and 85 DAP in 2010-11 and at 85 DAP in 2011-12.

Plant height was low at early stages of growth but it increased linearly up to 75 DAP and then slightly decreased in all three cultivars and all the treatments in both the years. The highest plant height was observed in the treatment T_4 (Vitapulus+Wuxalsuper) at 75 DAP followed by the treatment T_5 (Brassinosteroid + Wuxalsuper). Birbal *et al.* (2003), Thakare *et al.* (2007) and Yangi *et al.* (2005) reported the similar results regarding plant height.

In both the years, number of haulms per plant was significantly influenced by the plant growth regulators and micronutrient treatments. The highest number of haulms was observed at 75 DAP and then it decreased very slowly in the years 2010-11 and 2011-12. The treatment

T₄ (Vitaplus+ Wuxalsuper) produced highest number of haulms per plant followed by the treatment T₅ (Brassinosteroid+Wuxalsuper) in both the years. The lowest number of haulms per plant were recorded in unsprayed control treatment in both the years. Gauhar *et al.* (2007) and Pruski *et al.* (2003) are in agreement with this finding.

In both the years, plant height varied significantly due to different treatments. The highest plant height was obtained from the treatment T₄ (Vitaplus+Wuxalsuper). These plants received growth regulators and micro-nutrients that possibly enhanced meristematic elongation of plants as a result good plant height was obtained. The lowest plant height was recorded in unsprayed control treatment in 2010-11 and 2011-12. Birbal *et al.* (2003) reported that plant growth regulators (GA and NAA) increased plant growth in terms of height and highest tuber yield. Thakare *et al.* (2007), Yangi *et al.* (2005) and Gauhar *et al.* (2007) reported similar results.

Number of leaves per plant was significantly influenced by different growth regulators and micronutrient treatments. The highest number of leaves were recorded with the treatment T₄ (Vitaplus+Wuxalsuper) followed by the treatment T₅ (Brassinosteroid + Wuxalsuper) in 2010-11 and 2011-12. The rest of the treatments of growth regulators and micronutrients also contributed to produce significant number of leaves in comparison to control treatments in both the years. Number of leaves per plant showed significant effect among the cultivars. The cultivar V₁ (Diamant) recorded the highest number of leaves while the cultivar V₃ (Granola) showed the lowest number of leaves per plant in both the years. Interaction between cultivars and treatments was significant on the above parameters. It was possibly that application of growth regulators and

micronutrients might have helped supply available nutrients to the root zone of potato plants and that have helped plants for production of more leaves. Treatment combinations of ($V_1 \times T_1$), ($V_1 \times T_2$), ($V_1 \times T_4$), ($V_1 \times T_5$), ($V_2 \times T_4$) and ($V_2 \times T_5$) in 2010-11 and treatment combination of ($V_1 \times T_4$) and ($V_1 \times T_3$) in 2011-12 gave the highest values. Treatment combination of ($V_3 \times T_0$) resulted in the lowest values in both the years. With few exceptions, treatment combination of ($V_1 \times T_4$) and ($V_2 \times T_4$) produced the highest values in 2010-11 and 2011-12. Birbal *et al.* (2003) and Barche *et al.* (2000) reported the similar results. Gauhar *et al.* (2007) reported that N and P application produced maximum number of leaf/hill.

Number of haulms per plant was significantly influenced by the plant growth regulators and micronutrient treatments in the years 2010-11 and 2011-12. The treatment T_4 (Vitaplus+ Wuxalsuper) produced highest number of haulms per plant followed by the treatment T_5 (Brassinosteroid+Wuxalsuper) in both the years. Control treatment produced the lowest number of haulms per plant obtained from 2010-11 and 2011-12. The treatments of Vitaplus, Brassinosteroid and Wuxalsuper also produced significant number of haulms per plant in comparison to control treatments in both the years. Cultivar V_1 (Diamant) showed the highest number of haulms per plant. The second highest number of haulms per plant was recorded in the cultivar V_2 (Asterix) while the cultivar V_3 (Granola) recorded the lowest number of haulms per plant in both the years. Gauhar *et al.* (2007) reported that N and P fertilizer increased the haulm number/hill. Pruski *et al.* (2003) reported similar results. Maier *et al.* (2002) reported that P fertilizer increased total leaf, stem and haulm number per plant.

Three cultivars responded significantly in respect of number of tuber per plant in both the years. The highest number of tubers were recorded in the cultivar V_1 (Diamant) while the lowest number of tubers were observed in the cultivar V_3 (Granola) in both the years. The treatment T_4 (Vitapulus+Wuxalsuper) produced the highest number of tuber per plant. The second highest number of tuber per plant was recorded in the treatment T_5 (Brassinosteroid+Wuxalsuper). Treatments of Vitapulus, Brassinosteroid and Wuxalsuper also influenced significantly in comparison to control treatment in both the years. Needless to say that control treatment produced the lowest value. Interaction effect between cultivars and treatments were non-significant in 2010-11 but significant in 2011-12. In 2011-12, the highest number of tubers was recorded in ($V_1 \times T_4$) treatment combination followed by the treatment combination ($V_1 \times T_5$). The lowest value was recorded from the treatment combination ($V_3 \times T_0$) in both the years. Knowles *et al.* (2005), Alexopoulos *et al.* (2007) and Markys *et al.* (2007) reported that plant growth regulators increase the number of yield per plant. Kumar *et al.* (2011), Mousavi *et al.* (2007), Thakare *et al.* (2007) and El-Haddad *et al.* (2007) reported that the foliar application of micronutrients increased the number of tuber per plant.

Yield per plant is the ultimate goal of potato cultivation. With a few exceptions, the treatment T_4 (Vitapulus+ Wuxalsuper) produced the highest yield per plant in both the years. The application of growth regulators and micronutrients increased the opportunity to better utilization of nutrients which might be the cause of higher potato yield per plant. Yield per plant is associated with plant height, number of leaves per plant, number of haulms per plant and number of tuber per plant. Number of tuber per plant is associated with number of leaves per plant and number of haulms

per plant. The second highest yield per plant was recorded in the treatment T_5 (Brassinosteroid+Wuxalsuper) while the lowest yield per plant was recorded in unsprayed T_0 (control) treatment in both the years. It is revealed that three cultivars responded significantly in both the years. Cultivar V_1 (Diamant) ranked first with the highest yield per plant while the cultivar V_3 (Granola) produced the lowest yield per plant in 2010-11 and 2011-12. Interaction effect between cultivar and treatment was significant in 2010-11 and 2011-12. Treatment combination ($V_1 \times T_4$) produced highest yield (646.7 and 676.7 g) per plant in both the years. The second highest yield (601.7 and 636.3 g) per plant was recorded in the treatment combination ($V_1 T_5$) in both the years. On the other hand, the lowest yield was obtained from the unsprayed control treatment in both the years. This result is also confirm the result of Puzina (2004) who stated that boric acid treatment increased cell diameter in the tuber perimedullary zone, an increase in tuber weight per plant was related to tuber growth. Alekseev (2002), Sawicka (2002), Alexopoulos *et al.* (2007) and Kumar *et al.* (2011) reported the similar results.

Ton per hectare yield varied significantly in both the years. The highest (30.47 and 30.79) yield per hectare were obtained from the treatment T_4 (Vitaplus+Wuxalsuper) in both the years. The second highest yield (29.95 and 30.13) ton per hectare were obtained from the treatment T_5 (Brassinosteroid) in 2010-11 and 2011-12. The lowest yield (20.72 and 18.49) per hectare were obtained from the treatment T_0 (control) in both the years. The highest yield of above two treatments might be due to the combined effect of plant growth regulators and liquid micronutrients leading to maximum vegetative growth. This result is also confirming the result of Kumar *et al.* (2011) who stated that the foliar spray of 100 ppm

GA₃ and 125 ppm cycocel produced maximum tuber yield 9.16 kg/plot, GA₃ alone produced 8.04 kg/plot (plot size=3m sq.) which were significantly higher than unsprayed control (6.89 kg/plot). Puzina (2001), Liu-Hua *et al.* (2002), Prakash *et al.* (2001), Barche *et al.* (2000) and Khalila *et al.* (2003) reported similar results. It was suggested that the increase in potato yield per plant due to application of growth regulators and micronutrients was suggested.

Harvest index was influenced significantly in both the years. It is revealed that the treatment T₅ (Brassinosteroid+Wuxalsuper) produced highest (72.85 and 73.35) harvest index in 2010-11 and 2011-12. Unsprayed control treatment produced the lowest (69.91 and 70.96) crop harvest index in both the years. Cultivar responded significantly to crop harvest index in both the years. Cultivar V₃ (Granola) produced the highest (74.60 and 75.66) while the cultivar V₁ (Diamant) produced the lowest (68.33 and 68.75) crop harvest index respectively in 2010-11 and 2011-12. Interaction effects between cultivar and treatment were non-significant in 2010-11 but significant in 2011-12. In 2010-11, the results were statistically similar. In 2011-12, the highest (76.83) value was obtained from the treatment combination (V₃×T₄) and the lowest (68.23) value was obtained from the treatment combination (V₁×T₁).

In the present investigation, the highest total yield (30.47 and 30.90 t/ha), Gross return (365.7 and 370.80 Tk ha⁻¹), Net return (139.50 and 130.40 Tk ha⁻¹), was obtained from the treatment T₄ (Vitaplus + Wuxalsuper). The second highest total yield 29.95 and 30.13 t/ha, Gross return (359.4 and 361.6 Tk ha⁻¹), and Net return (133.2 and 121.2 Tk ha⁻¹) was obtained from the treatment T₅ (Brassinosteroid + Wuxalsuper). The rest three

treatments- T_1 (Vitaplus), T_2 (Brassinosteroid) and T_3 (Wuxalsuper) contributed significant yield and return in comparison to unsprayed control treatment in both the years. The lowest yield (20.72 and 18.49 t ha^{-1}), Gross return (248.7 and 221.9 Tk ha^{-1}) and Net return (44.2 and 3.223 Tk ha^{-1}) were obtained from the control treatment in 2010-11 and 2011-12. Accordingly, the highest cost benefit ratio (BCR) was obtained from the treatment T_4 (Vitaplus + Wuxalsuper) followed by the treatment T_5 (Brassinosteroid + Wuxalsuper). On the contrary, the lowest BCR values were found in control treatment in both the years. Total cost was more or less same in all the treatments.

Morphological appearance of seed potatoes after releasing from cold storages represents the management system of that particular cold storage. It is also indicated the early warning of potato crop of that year because good seed health was directly related to good crop production largely depended on proper management system. Three cold storages (one public and two private) of Nilphamari district were selected for preservation of tubers collected from the experimental plots for preservation period of the years 2010-11 and 2011-12. It is evident that ruptured, rotted, shriveled, early sprouted, spongy and tuber damaged by using hooks were observed and recorded treatment wise in each and every cold storages during this period. Morphological appearance of the tubers of BADC cold storage, Domar was very good in respect of weight loss, distorted, shriveled, early sprouted and colour in comparison to other two private cold storages. With a very few exception, tubers of all the treatments were excellent and healthy. No distorted, shriveled, early sprouted, rotted, ruptured and spongy tubers were observed. On the other hand, a good number of ruptured, shriveled, early sprouted, spongy,

rotted and tuber damaged by the hooks were observed and recorded both at Saon cold storage, Domar and Sajeda cold storage, Saidpur. In some cases sprout length was about 4-6 inches long and tuber colour changed to some extent indicating the poor management system.

A considerable amount of weight loss of tuber during is a great concern for all. In the present study, it has been observed that average weight loss (10-11.28%) was recorded in the treatment T_1 (Vitaplus) and T_2 (Brassinosteroid) of Saon cold storage, Domar and Sajeda cold storage, Saidpur. On the other hand, the average weight loss of BADC cold storage, Domar was around (5.00-7.00%) for all the treatments. The treatments of plant growth regulators in combination with micronutrients caused comparatively lower weight loss (9.25-10.00%) were observed in the treatment T_4 (Vitaplus + Wuxalsuper) and T_5 (Brassinosteroid + Wuxalsuper) in both the years in the two private cold storages. The lowest average weight loss (5.00%) was recorded at unsprayed control treatment combination V_2T_0 (Asterix+control) in BADC cold storage, Domar. In Saon cold storage, Domar the highest weight loss (10.70%) was recorded in the treatment combination V_3T_2 (Granola + Brassinosteroid) and the lowest weight loss (6.25%) was observed in the treatment combination V_2T_0 (Asterix + control). On the other hand, the highest average weight loss (10.70%) was observed in the treatment combination V_3T_2 (Granola + Brassinosteroid) and the lowest average weight loss (6.75%) was observed in the treatment combination V_1T_3 (Diamant + Wuxalsuper) in Sajeda cold storage, Saidpur. T_3 (Wuxalsuper) treatment showed minimum weight loss among the sprayed treatments for all three cold storages in both the years. It might be due to the application of plant growth regulators on the crop during vegetative

period increases vegetative growth and yield, decreases tuber quality including weight loss during storage.

Internal management system of the cold storages including relative humidity, storage temperature, fresh air intake and cleanliness was satisfactory at BADC cold storage, Domar in comparison with Saon cold storage, Domar and Sajeda cold storage, Saidpur. Relative humidity was around 90% and storage temperature was 2.2-2.8°C at BADC cold storage, Domar, while two private cold storages maintained 80-85% relative humidity and varied temperature during entire preservation period in 2010-11 and 2011-12. In this regard, Eltawil *et al.* (2006) said that the quality of potato and its storage life is reduced by the loss of moisture, decay and physiological breakdown. The deteriorations are directly related to storage temperature, relative humidity, air circulation and gas composition. Potatoes being living organisms require an effective management for storage. Chourasia *et al.* (2004) got average storage weight loss (5.3%) after 8 months of storage. Czerk (2004) and Marwaha *et al.* (2005) reported similar results.

Calculation of BCR as a seed potato of BADC cold storage, Domar Saon cold storage, Domar and Sajeda cold storage, Saidpur was done after releasing tubers from cold storages following Seed Certification Agency (SCA) standard. In the present investigation, the highest BCR value was obtained from the treatment T₃ (Wuxalsuper) and lowest BCR value was obtained from the treatment T₁ (Vitapulus) followed by the treatment T₂ (Brassinodteroid) in all three cold storages in both the years. The highest BCR value of all the treatments was obtained from BADC cold storage, Domar in comparison to Saon cold storage, Domar and Sajeda cold storage, Saidpur because of improved storage management practices.

Number of total eyes per tuber was significantly influenced by the different treatments in 3 cold storages in both the years except Sajeda cold storage, Saidpur in 2010-11. The treatment T_4 (Vitaplug + Wuxalsuper) produced the higher number of eyes (3.72 and 3.71) in BADC cold storage, Domar in 2010-11 and 2011-12, (4.12) in Saon cold storage, Domar in 2011-12 and (4.49) in Sajeda cold storage, Saidpur in 2011-12 while treatment T_5 (Brassinosteroid + Wuxalsuper) produced the higher number of eyes (3.89) in Saon cold storage in 2010-11 and (4.29) in Sajeda cold storage in 2010-11. On the other hand, the lowest number of eyes was obtained from the control treatment from above three cold storages in both the years. Plant growth regulators and micronutrients may have some residual impact in increasing the number of eyes per tuber. Number of total eyes per tuber was significantly influenced by the cultivars in three cold storages in both the years. Cultivar V_1 (Diamant) produced the highest number of eyes per tuber while the cultivar V_3 (Granola) produced the lowest number of eyes per tuber. Significant variation of eyes among the cultivars can be considered as varietal characteristics.

Sprouted eyes (%) were non-significant for all the treatments in 2010-11 in all the three cold storages, but it was found marginally significant in BADC and Saon cold storage, Domar. Sprouted eyes were also found non-significant in Sajeda cold storage, Saidpur in 2011-12. In both the cases of significant and non-significant values, the treatment unsprayed control expressed highest percent sprouted eyes in all 3 cold storages in both the years. Cultivars were significantly influenced by the sprouted eyes (%) in all 3 cold storages in both the years. Cultivar V_3 (Granola) showed the highest percent of sprouted eyes with a few exceptions in 3

cold storages in both the years. Interaction effect between cultivars and treatments were non-significant in both the years except BADC and Saon cold storage, Domar in 2011-12. In 2011-12, treatment combination ($V_3 \times T_0$) showed the highest percent of sprouted eyes. Unsprayed treatment and treatment combination produced highest percent of sprouted eyes.

Non-sprouted eyes (%) were non-significant due to the treatments in three cold storages in 2010-11 but were found significant in BADC and Saon cold storage in 2011-12. It was non-significant in Sajeda cold storage, Saidpur in 2011-12. Treatments treated with growth regulators produced highest percent of non-sprouted eyes in BADC and Saon cold storages in 2011-12. Non-sprouted eyes (%) were significantly influenced by the cultivars. Cultivar V_2 (Asterix) showed the highest non-sprouted eyes in 2010-11 and 2011-12 in all three cold storages of Nilphamari district. Interaction effect between cultivars and treatments were found significant in BADC and Saon cold storage, Domar and Sajeda cold storage, Saidpur in 2011-12. Treatment combination ($V_2 \times T_5$) in BADC cold storage, Domar and treatment combination ($V_3 \times T_5$) in Saon cold storage, Domar produced the highest non-sprouted eyes in 2011-12. The residual effect of growth regulators may influence in non-sprouting of tubers in the next growing season, it is apprehended.

Germination (%) of sprouted tubers was non-significant by the treatments but it responded significantly in Saon cold storage, Domar and Sajeda cold storage, Saidpur in 2011-12. In 2011-12, treatment T_0 (control) and treatment T_3 (Wuxalsuper) showed highest (100% and 100%) and (100% and 97.78%) germination in 2011-12. With a very few exceptions, germination of all the treatments were around 95% for both significant.

Germination percent of tuber sprouted were more or less same for all the cultivars. It is revealed that none of the treatment combination responded significantly in all 3 cold storages in 2010-11 and 2011-12. Pang-WengJing (2004) got the similar observation while working with plant growth regulators on potato and stated that Gibberellic acid had no effect i.e no significant difference on germination of potato.

The number of days needed for shoot emergence was significantly influenced by the different growth regulators and micronutrient treatments. The highest (18.89-19.59) days were required to emerge shoot in the treatment T_0 (control) for two private cold storages followed by the treatment T_3 (Wuxalsuper) needed the highest (18.22) days. The treatment T_1 (Vitapulus) and T_2 (Brassinosteroid) needed lowest (15.78-16.44) days followed by the treatment T_4 (Vitapulus+Wuxalsuper) and T_5 (Brassinosteroid +Wuxalsuper) needed (16.78-17.00) days for two private cold storages. Tubers stored in the BADC cold storage needed at least one day less for all the treatments in both the years in comparison to two private cold storages of this district. It is apprehended that pre-application of plant growth regulators during vegetative period shortened 2-3 days emergence time in comparison unsprayed control. Growth regulators alone needed 1-2 more days when treated with liquid micronutrients like Wuxalsuper for all three cold storages in both the years. This observation is supported by Pruski *et al.* (2003) stated that average time to emergence (ATE) for all the cultivars were 2-3 days shorter in plants from the ethylene treatments than from control.

Number of haulms per tuber was influenced significantly in all 3 cold storages in both the years except Sajeda cold storage Saidpur in 2010-11. Treatment T_4 (Vitapulus+ Wuxalsuper) produced the highest number of

haulms for tuber while the treatment T_0 (control) produced the lowest number of haulms per tuber in 2010-11 and 2011-12. Treatment T_5 (Brassinosteroid+Wuxalsuper) produced the second highest number of haulms per tuber in both the years. Number of haulms per tuber was influenced significantly by the cultivars in all 3 cold storages in 2010-11 and 2011-12. Cultivar V_1 (Diamant) produced the highest number of haulms per tubers in both the years while cultivar V_3 (Granola) produced the lowest number of haulms in both the years. Interaction effect between cultivars and treatments was non-significant in case of BADC cold storage, Domar in 2010-11 and 2011-12 while it was found significant for Saon cold storage, Domar and Sajeda cold storage, Saidpur in 2011-12. Treatment combination ($V_1 \times T_4$) produced highest number of (5.7, 5.2 and 4.67) haulms respectively in Saon cold storage, Domar and Sajeda cold storage, Saidpur in 2011-12. Treatment combinations ($V_3 \times T_0$), ($V_2 \times T_0$) and ($V_2 \times T_0$) produced the lowest number (3.67, 3.13 and 2.93) of haulms in Saon cold storage, Domar and Sajeda cold storage, Saidpur in 2010-11 and 2011-12. Maier *et al* (2002) and Knowles *et al* (2005) stated that application of plant growth regulators increases the stem and haulm number.

Seed vigour index was influenced significantly by the treatments in all 3 cold storages except Saon cold storage, Domar in 2010-11. Treatment T_3 (Wuxalsuper) produced the highest seed vigour index values in all the cold storages in 2010-11 and 2011-12. Seed vigour index was influenced significantly by the cultivars in all 3 cold storages in both the years. Cultivar V_1 (Diamant) showed the highest seed vigour index in both the years while the cultivar V_2 (Asterix) showed the second highest values in all 3 cold storages in 2010-11 and 2011-12. Pu-YuLin *et al.* (2008) reported that potato mini tuber could maintain higher vigour under cold storage condition below 4-6°C temperature.

CHAPTER 6

CONCLUSION

For future improvement and sustainability of potato production and storage with plant growth regulators and micronutrients, some agronomic practices like time and doses of foliar application of plant growth regulators and balanced use of fertilizers for table potato production and judicious use of balanced fertilizers, micro-nutrients and storage management (maintaining optimum temperature, relative humidity, light, fresh air intake cleanliness etc.) for quality seed production. From the results of the present study the following conclusions can be drawn.

Plant growth regulators alone or in combination with micronutrients produced higher yield which is profitable for farmers and can be used as a table potato. Vitaplus+Wuxalsuper (Vitaplus @ of 500 ml ha⁻¹ and Wuxalsuper @ of 1500ml ha⁻¹) can be recommended.

Micronutrients also produced higher yield which is profitable for farmers and can be used as a seed potato Wuxalsuper @ of 4000ml ha⁻¹ can be recommended. Cultivar Diamant was the best performance for all treatment and the best yield potato variety. In case of cold storage, maximum seed quality test parameter was obtained from BADC cold storage with highly sophisticated storage condition. Micro-nutrients wuxalsuper (T₃) and cultivar Diamant gave the highest values of growth, yield contributing characters and seed quality test of potato in BADC cold storage.

Private level cold storage management practices (maintaining optimum temperature, relative humidity, light, fresh air intake cleanliness etc.)

should be improved with a view to reducing weight loss (weight loss due to early sprouting, low relative humidity and using no hooks during shifting of potato bags etc.) both for table and seed potato during storage.

So, judicious and timely use of balanced fertilizers, plant growth regulators and micro-nutrients in potato production is better for maximizing growth and yield of tubers for both purpose in one hand and cold storage management practices at private level should be improved with a view to reducing weight loss and enhancing tuber quality during storage on the other.

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APPENDICES

Appendix II. Soil chemical properties

Elements analysed	Results	Fertility status
Nitrogen(%)	0.09	very low
Phosphorus(ppm)	85.4	very high
PotassiumCMol/kg	0.10	low
Sulphur(ppm)	2.3	low
Zinc(ppm)	0.88	low
Boron (ppm)	0.21	low
Magnesium (ppm)	4.28	low
pH	5.8	moderately acidic
Organic Matter(%)	1.12	low

Source: The soil samples of farmers plot, BADC farm, Domar, Nilphamari-2010 was collected and analysed by Regional station, Soil Resources Development Institute (SRDI), Shyampur, Rajshahi

Appendix I. Soil chemical properties

Elements analysed	Results	Fertility status
Nitrogen(%)	0.03	very low
Phosphorus(ppm)	20.2	standard
PotassiumCMol/kg	0.08	very low
Sulphur(ppm)	7.8	low
Zinc(ppm)	0.96	Medium
Boron (ppm)	0.31	Mesium
Magnesium (ppm)	4.2	low
pH	4.9	very acidic
Organic Matter(%)	0.48	very low

Source: The soil samples of farmers plot, Debiganj, Panchaghar-2011 was collected and analysed by Regional station, Soil Resources Development Institute (SRDI), Shyampur, Rajshahi

Appendix III. Monthly average maximum and minimum temperature (0 C), average relative humidity (%) and total rainfall (mm) received from Meteorological office (Saidpur Air Port Office) Saidpur, Nilphamari, during the period from October 2010 to March 2011.

Month	Year	** Air temperature(0C)			**Relative Humidity (%)	*Rainfall (mm)	Remarks
		Maximum	Minimum	Average			
October	2010	35.2	19.5	27.0	82	163	
November	2010	31.8	13.4	23.1	78	2	
December	2010	27.8	8.2	18.0	76	1	
January	2011	26.4	5.7	14.7	82	0	
February	2011	30.6	11.2	20.4	72	19	
March	2011	35.2	13.2	24.1	69	28	

*=Monthly total

**= Monthly average

Appendix IV. Monthly average maximum and minimum temperature (0 C), average relative humidity (%) and total rainfall (mm) received from Meteorological office (Saidpur Air Port Office) Saidpur, Nilphamari, during the period from October 2011 to March 2012

Month	Year	**Air temperature(0C)			**Relative Humidity (%)	*Rainfall (mm)
		Maximum	Minimum	Average		
October	2011	35.5	17.4	27.6	80	0
November	2011	31.2	14.4	22.2	77	1
December	2011	30.4	7.2	17.4	82	0
January	2012	26.8	6.0	16.2	78	6
February	2012	30.6	8.2	19.7	68	6
March	2012	35.5	12.16	24.1	61	3

*=Monthly total

**= Monthly average

Appendix V. Mean squares from analysis of variation for yield and yield component of potato [1st year (2010-2011)]

Source of variance	df	Plant height	No. of leaves	No. of haulms	No. of tuber	Yield/ plant	Yield ton/ha	Harvest index (%)
Replicaton	2	0.465	1.536	0.027	1.816	1179.630	1.979	2.669
Factor A	2	2537.56**	34.887**	10.219**	56.060**	14258.796**	81.015**	178.099**
Factor B	5	70.123**	48.620**	1.249**	9.283**	53585.185**	121.779**	7.472*
AB	10	6.996NS	11.367**	0.049NS	0.435NS	1579.352**	1.902NS	3.483NS
Error	34	4.843	1.178	0.046	0.256	323.474	1.153	2.651

Appendix VI. Mean squares from analysis of variance for yield and yield component of potato [2nd year (2011-2012)]

Source of variance	df	Plant height	No. of leaves	No. of haulms	No. of tuber	Yield/ plant	Yield ton/ha	Harvest index (%)
Replicaton	2	44.103	3.476	0.027	0.414	676.963	0.770	36.977
Factor A	2	764.172**	452.276**	5.765**	53.605**	13986.352**	13.802**	230.465**
Factor B	5	263.636**	112.369**	1.339**	10.420**	64965.263**	178.048**	6.290*
AB	10	23.298NS	6.832**	0.111NS	0.849**	1740.307**	0.970NS	4.298*
Error	34	15.574	1.905	0.083	0.264	519.120	0.659	2.023

**Appendix VII. Mean squares from analysis of variance for BCR of potato
[1st year (2010-2011)]**

Source of variance	df	Total yield	Gross return	Net return	BCR
Replication	2	1.975	284.421	283.642	6775.946
Factor A	2	81.009**	11665.339**	11154.236**	298210.765**
Factor B	5	121.750**	17531.552**	11986.051**	273765.340**
AB	10	1.908NS	274.794NS	248.897NS	6456.783NS
Error	34	1.147	165.124	154.814	4312.105

**Appendix VII. Mean squares from analysis of variance for BCR of potato
[2nd year (2011-2012)]**

Source of variance	df	Total yield	Gross return	Net return	BCR
Replicaton	2	0.554	79.917	80.029	1728.420
Factor A	2	12.953**	1864.276**	1865.210**	41913.399**
Factor B	5	179.494**	25850.160**	19257.481**	427595.358**
AB	10	0.841NS	121.357NS	121.406NS	2503.436NS
Error	34	0.667	95.976	95.930	2106.003

Appendix VIII. Data on BADC cold storage, Sonaroy, Domar, Nilphamari (2011)

Month	Cold storage temperature (°C)		Relative Humidity (%)	Remarks
	Dry	Wet		
March	8.4	7.5	86	Fresh air intake is done twice in a week. Potato bags are placed vertically, congenial for seed health of potato. Cold storage is designed for seed potato preservation.
April	2.5	2.0	91	
May	2.8	2.2	90	
June	2.6	2.1	91	
July	2.5	2.0	91	
August	2.5	1.9	91	
September	2.4	1.9	91	
October	2.6	2.1	91	
November	2.6	2.1	91	

Appendix IX. Data on BADC cold storage, Sonaroy, Domar, Nilphamari (2012)

Month	Cold storage temperature (°C)		Relative Humidity (%)	Remarks
	Dry	Wet		
March	13.7	11.9	77	Fresh air intake is done twice in a week. Potato bags are placed vertically, congenial for seed health of potato. Cold storage is designed for seed potato preservation.
April	2.7	2.1	90	
May	2.7	2.1	90	
June	2.6	2.0	90	
July	2.6	2.0	90	
August	2.5	2.0	91	
September	2.3	1.8	91	
October	2.5	2.0	91	
November	2.8	2.2	90	

Appendix X. Data on Saon cold storage, Chhoto Rawta , Domar, Nilphamari (2011)

Month	Cold storage temperature (°C)		Relative Humidity (%)	Remarks
	Dry	Wet		
March	9.32	7.88	80	This cold storage is not designed for seed potato preservation rather designed for storing table potato. So fresh air intake is done. This is not sufficient enough for congenial seed health of potato. Potato bags are kept horizontally
April	2.36	1.94	80	
May	2.28	1.75	85	
June	2.43	1.92	85	
July	2.40	1.88	85	
August	2.47	1.94	85	
September	2.53	2.0	85	
October	2.57	2.04	85	
November	2.63	2.11	85	

Appendix XI. Data on Saon cold storage, Chotto Rawta , Domar, Nilphamari (2012)

Month	Cold storage temperature (°C)		Relative Humidity (%)	Remarks
	Dry	Wet		
March	10.27	8.98	80	This cold storage is not designed for seed potato preservation rather designed for storing table potato. So fresh air intake is done. This is not sufficient enough for congenial seed health of potato. Potato bags are kept horizontally
April	5.76	4.88	80	
May	3.35	2.68	85	
June	2.69	2.11	85	
July	2.66	1.98	85	
August	2.67	2.00	85	
September	2.66	1.99	85	
October	2.71	2.09	85	
November	3.04	2.27	85	

Appendix XII. Data on Sajeda cold storage, Kamarpukur, Saidpur , Nilphamari (2011)

Month	Cold storage temperature (°C)		Relative Humidity (%)	Remarks
	Dry	Wet		
March	6.34	5.77	There is no system to keep the record of relative humidity.	This cold storage is not designed for seed potato preservation rather designed for storing table potato. So fresh air intake is done. This is not sufficient enough for congenial seed health of potato. Potato bags are kept horizontally
April	2.32	1.82		
May	1.81	1.31		
June	1.68	1.15		
July	1.75	1.01		
August	1.77	1.23		
September	1.72	1.19		
October	1.71	1.18		
November	1.72	1.17		

Appendix XIII. Data on Sajeda cold storage, Kamarpukur, Saidpur, Nilphamari (2011)

Month	Cold storage temperature (°C)		Relative Humidity (%)	Remarks
	Dry	Wet		
March	6.86	6.3	There is no system to keep the record of relative humidity.	This cold storage is not designed for seed potato preservation rather designed for storing table potato. So fresh air intake is done. This is not sufficient enough for congenial seed health of potato. Potato bags are kept horizontally
April	3.29	2.8		
May	2.43	1.87		
June	2.50	1.94		
July	2.62	1.94		
August	2.64	2.08		
September	2.55	1.99		
October	2.89	2.33		
November	3.37	2.81		

Appendix XIV. Mean squares from analysis of variance for BADC cold storage, Domar [1st year (2010-2011)]

Source of variance	df	Total eyes	Sprouted eyes	Non-sprouted eyes	Germination (%)	Days to shoot emergence	No.of haulm	Seed vigour index
Replication	2	1.534	71.789	71.753	66.667	1.352	0.151	0.078
Factor A	2	2.205*	472.112**	472.166**	66.667NS	13.907**	0.937*	1.356**
Factor B	5	0.351NS	69.823NS	69.823NS	120.000NS	7.407**	2.635**	0.690**
AB	10	0.168NS	67.432NS	67.438NS	13.333NS	1.374NS	0.447NS	0.297NS
Error	34	0.232	68.824	68.819	58.824	1.528	0.241	0.156
Total	53							

Appendix XV. Mean squares from analysis of variance for BADC cold storage, Domar [2nd year (2011-2012)]

Source of variance	df	Total eyes	Sprouted eyes	Non-sprouted eyes	Germination (%)	Days to shoot emergence	No. of haulm	Seed vigour index
Replicaton	2	0.117	11.440	35.013	29.630	0.796	0.072	0.212
Factor A	2	1.152**	58.921**	40.311**	7.407NS	17.130**	0.539*	0.417**
Factor B	5	0.499**	13.122*	19.405*	100.741NS	9.796**	2.433**	0.718**
AB	10	0.063NS	20.489**	21.681*	34.074NS	5.730**	0.039NS	0.160NS
Error	34	0.098	5.120	7.305	53.159	1.816	0.128	0.078

Appendix XVI. Mean squares from analysis of variance for Saon cold storage, Domar [1st year (2010-2011)]

Source of variance	df	Total eyes	Sprouted eyes	Non-sprouted eyes	Germination (%)	Days to shoot emergence	No. of haulm	Seed vigour index
Replicaton	2	0.575	14.034	12.133	7.407	1.463	0.023	0.025
Factor A	2	2.439**	364.199**	352.856**	29.630NS	5.630*	1.681**	1.627**
Factor B	5	0.760**	18.204NS	19.208NS	96.296NS	2.430NS	1.019**	0.214NS
AB	10	0.025NS	10.548NS	8.445NS	47.407NS	1.274NS	0.388*	0.121NS
Error	34	0.045	31.953	32.613	85.839	1.188	0.166	0.115

Appendix XVII. Mean squares from analysis of variance for Saon cold storage, Domar [2nd year (2011-2012)]

Source of variance	df	Total eyes	Sprouted eyes	Non-sprouted eyes	Germination (%)	Days to shoot emergence	No. of haulm	Seed vigour index
Replicaton	2	0.094	44.485	27.477	229.630	0.685	0.282	0.185
Factor A	2	1.361**	23.940NS	36.400*	7.407NS	18.352**	3.842**	2.414**
Factor B	5	1.584**	34.411*	33.427*	238.519**	15.585**	1.877**	1.648**
AB	10	0.083NS	61.431**	65.120**	34.074NS	1.352NS	0.379**	0.284NS
Error	34	0.055	11.783	9.525	57.081	1.019	0.126	0.139

Appendix XVIII. Mean squares from analysis of variance for Sajeda cold storage, Domar [1st year (2010-2011)]

Source of variance	df	Total eyes	Sprouted eyes	Non-sprouted eyes	Germination (%)	Days to shoot emergence	No. of haulm	Seed vigour index
Replication	2	0.504	32.293	40.641	0.000	0.296	0.037	0.150
Factor A	2	1.101*	314.111**	243.380**	22.222NS	17.019**	4.174**	1.366**
Factor B	5	0.303NS	31.580NS	32.843NS	120.000NS	2.107*	0.155NS	0.887**
AB	10	0.562NS	68.431*	59.029NS	75.551NS	1.441*	0.542NS	0.175NS
Error	34	0.300	30.058	29.632	86.275	0.630	0.745	0.117

Appendix XVIV. Mean squares from analysis of variance for Sajeda cold storage, Domar [1st year (2010-2011)]

Source of variance	df	Total eyes	Sprouted eyes	Non-sprouted eyes	Germination (%)	Days to shoot emergence	No. of haulm	Seed vigour index
Replicaton	2	0.014	0.422	0.421	155.556*	0.667	0.000	0.016
Factor A	2	1.094**	301.992**	301.926**	200.000NS	8.722**	1.887**	1.016*
Factor B	5	3.619**	52.390NS	52.425NS	284.444**	6.089**	2.062**	0.942**
AB	10	0.085*	45.553NS	45.553NS	31.111NS	1.544NS	0.086*	0.319NS
Error	34	0.039	26.009	26.008	69.281	0.804	0.035	0.203

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