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A REVIEW ON THERAPEUTIC AND COMMERCIAL IMPORTANCE OF *GANODERMA LUCIDUM*

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Abstract

Ganoderma lucidum is an oriental traditional well known fungus and used globally for its therapeutic health promoting purposes from millions of years. It has been used as supplement in food and also as a therapeutic drug which invites in vivo and invitro studies of its bioactive compounds. Therefore, *Ganoderma* has made significant progress in Asian markets as a drug, supplement and cosmetic. This paper describes brief highlights of the *Ganoderma lucidum* products and bioactive elements significance for a common man.

Key words: *Ganoderma lucidum,* lingzhi, traditional medicine, Bioactive Elements

Introduction

The traditional herb *Ganoderma lucidum* also known as Lingzhi Mushroom is well as an immune booster with numerous scientific studies about active elements. The medicinal properties of red mushroom have been used for centuries in far eastern countries such as China, Japan and (Marek siwulski *et al*. 2015). It is used for the treatment of many diseases as a traditional medicine.

Taxonomical Classification
Kingdom: Fungi
Phylum: Basidiomycota
Class: Agaricomycetes
Order: Polyporales
Family: Ganodermataceae
Genus: Ganoderma
Species: G.lucidum

The Chinese term lingzhi is a representative of longevity and supreme capacity represents and so it is also known as ''Herb of spiritual potency''. These days, *Ganoderma* is commercialized and available in form of Gano-products such as dry powder, dietary capsules, supplements, tea and coffee. It is also available in fresh form of spores and mycelium. *Ganoderma lucidum* has wide range of health promoting benefits as a traditional and cultural medicine explained by (Sissi Wachtel-Galor et al). At present status of 270 species of fungus are used to for their therapeutic and immortality properties. (Marek siwulski *et al. 2015).* It is very rare thus it is called as "supernatural mushroom" (Chang ST *et al 2003).*

Common Name of Ganoderma in different countries-
United States: Reishi Mushroom,(Herbs of Commerce)
China: Lingzhi,lingzhicao
Japan: Reishi,Mannentake.
Korea: Young ji

Types of *Ganoderma lucidum* their flavor and use:

Table 1: Types of Ganoderma other than G.lucidum and their traditional names with their applications

Species Name (Traditional name)	Flavour	Application and references
Red Sekishi	Bitter	Inner strengthing of organs with aging, memory and vitality enhancer. (Szedlay 2002, Wasser 2005).
Black Kokushi	Salty	Savior drug for kidney malfunction. (Szedlay 2002, Wasser 2005).
White Hakushi	pungent	Internal strength, energy booster, mood enhancer (Szedlay 2002, Wasser 2005).
Blue Seishi	Sour	Improvement of functioning of liver, eyesight and neurological booster. (Szedlay 2002, Wasser 2005).
Yellow Oushi	Sweet	Regulates function of spleen (Szedlay 2002, Wasser 2005).

Background

Ganoderma lucidum is also called as king of herb because this red Mushroom has been recorded as a medicinal mushroom for over 2000 years with its superior powerful effect which has been recorded in an ancient time scripts (Wasser S. P et al 2005). Traditionally it was used in china, Japan and Korea as a source of art for art's men, craftsmen for the purpose of painting, women accessories carving and making furniture. (Walser 2005). It has superior quality of active elements and referred to as the "Mushroom of Immortality", "Mushroom of Spiritual potency" and "Divine plant" (Huang KC 1993and Liu B et al., 1994). *Ganoderma* was listed among the superior tonics in the Chinese medicine. [Matsumoto K. 1979 and Unschuld P. 1986) *Ganoderma* which is known as a s Superior Herbs is a king of Herbal Medicines since they were have contribution in prolonged and rejuvenating life which prevents sickness, and aging. It used as a therapeutic drug as it has major role in enhancing vital energy, boost cell production and in the strengthening of cardiac muscular function, in increasing memory, anti-aging effect and antioxidant effects (Yang SZ., 1997 and American Herbal Pharmacopoeia. 2006). The phytochemical and pharmacological investigations of *Ganoderma* for testing its anti-androgenic activity have been conducted in human cell lines by testing cytotoxicity assays (Nahata A. 2013). Previously, the occurrence of the nonvolatile components that containing 26–28% carbohydrate, 3–5% fat, 59% fiber, and 7–8% crude protein has been reported (Mau et al., 2001). Lectins were isolated from Ganoderma fruit body and mycelium of the mushroom (Kawagishi et al. 1997) and have important role in cellular processes and immune system (Wang et al., 1998).The gano products, their production industries and wide markets has been previously mentioned in details (Wen et al., 2018).

Commercial application of *Ganoderma lucidum*

At present, approximately 270 species of fungi are used as therapeutic purposes. *Ganoderma luciderm* and its different members/species need different environmental /aseptic condition for their growth and many varieties are found in tropical and subtropical region. Artificial cultivation of *G.lucidum*, has been using substrates such as wheat grain, semi hard wood sawdust, wood logs, wood chips (Chang ST *et al 2004,* Wasser SP. 2005 and Boh B, et al., 2007). The different products could be prepared from various parts of mushroom such as body stem part, fruit part and spores. Gano products such as capsules, Cosmetic powder soap, Tonic can be used as a food supplement products too.

Medicinal application of *Ganoderma lucidum*

The medicinal and therapeutic action of Ganoderma has been summarized in Table 2:

Table 2: Medicinal use of *Ganoderma lucidum*

Bioactive compound	Therapeutic action
• Triterpenoids (Ganoderic acids, Lucidumol, Lucialdehyde, Lucidenic acids) • LZ-8 protein • Polysaccharides, GLP-2B • LZP-F3, • GLIS • GlPS	Anticancerous, Immunomodulatory, Cytotoxic)
• Polysaccharides, • proteoglycans, Proteins (LZ-8) and Triterpenoids	Anti-diabetic effects and blood glucose regulation.
• Ganoderic acids T-Q and • Lucideinic acids A, D2, E2,	Antiinflammatory
• Triterpenes, • Polysaccharides, • polysaccharide-peptide complex and phenolic component	Anti-oxidant activity and anti-ageing, Dementia control
• Polysaccharides • Triterpenoids (Ganoderic acids, Ganodermin, Ganoderic acid A, Ganodermadiol, Ganodermanondiol, • Lucidumol B, • Ganodermanontriol, Ganoderic acid B and Ganolucidic acid A	Anti- Microbial Activity, HIV, EBV, Influenza control, .Hepatoprotective and prevent hepatic tissue damage or chronic hepatitis B produces antihistamine to prevent allergies
• Polysaccharides (Ganopoly)	Cardiovascular problems, anti-platelet aggression, hyperlipidemia

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ASSESSMENT OF HERITABILITY, GENETIC ADVANCEMENT AND YIELD OF BITTER GOURD UNDER GARHWAL REGION

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Abstract

A fieldexperiment was conducted at Horticultural Research Centre, Department of Horticulture, H.N.B. Garhwal University, Srinagar Garhwal, Uttarakhand. The mean sum of squares due to treatments showed significant differences for all the traits except for number of nodes per vine, fruit length and seed diameter. Coefficients of variability, heritability and genetic advance were computed on 37 traits. In the present investigation, the PCV were higher than the GCV for almost all the traits under studied.The GCV and PCV were moderate to low for almost all the characters except fruit yield per vine. The highest heritability was observed in length of vine, number of nodes per vine, leaf area,days to first fruit harvest, length of fruit, weight of fruit, fruit yield per hectare, carbohydrate content and vitamin A. The estimates of high heritability accompanied with moderate genetic advance over mean were recorded for days taken to opening of first female flower, percent of fruit setting, seed length and percentage of seed germination, so there is an ample scope for direct selection for these traits and also can be improve through mass selection.Hence, provides better opportunities for selecting plant material for these traits inbitter gourd.

Key words: Bitter gourd, heritability, genetic advance and GCV.

Introduction

In vegetables, cucurbits are one of the most diversified families with wide range of variation in crops that supplied edible products and useful fibers to mankind. The cucurbitaceae family consists of about 30 genera and 750 species almost equally divided between the new world and old world tropics. In India alone, 117 genera and 100 species of cucurbits have been reported (Singh & Bhatia, 2009). In the family cucurbitaceae, bitter gourd (*Momordicacharantia*L.) is one of the most important commercial crops in the point of economic and medicinal value. The bitter gourd (*Moinordicacharantia*L.) is known as various names *viz.,*bitter gourd, balsam pear, bitter melon, bitter cucumber and African cucumber (Heiser, 1979). It is a large genus comprising nearly 23 species (Jeffrey, 1967) in Africa alone. The bitter gourd is particularly originated to Tropical Asia in the region of East India and South China (Laxuman, 2005). The bitterness of bitter gourd is due to the cucurbitacin-like alkaloid *momordicine* and *triterpene glycosides* (*momordicoside* K and L) (Jeffrey, 1980 and Okabe *et. al.,* 1982). The presence of genetic variability is very lethal for genetic improvement, higher yield, and wider adaptability in thestrains. The selection of traits is

very effective when there is availability of genetic variability among the plant populations. For the starting of a successful breeding programme, magnitude of genetic variability is very crucial. The advancement by selection totally depends onthe knowledge of heritability and genetic advance. Genetic advance along with heritability played a vital role in predicting the gain under selection then heritability estimates alone (Johnson *et al.,* 1955). Hence, this research work was undertaken at Garhwal region which comes under subtropical climate to find out the various genetic components for quantitative, qualitative and seed traitsin bitter gourd.

Materials and Methods

The field experiment was conducted at Horticultural Research Centre, Chauras Campus, Department of Horticulture, H.N.B. Garhwal University, Srinagar, Garhwal, Uttarakhand (India) during 2015 summer season in Randomized Block Design with 20 genotypes. These genotypes were collected from all over India *viz.,* Himachal Pradesh, Madhya Pradesh, Maharastra, Rajesthan, Uttarakhand and Uttar Pradesh. The seedling was transplanted at 4 leaf stage in the experimental plot with the spacing of 1.50 x 0.50 m. The standard horticultural practices and plant protection measures recommended for health crop were adopted for better growth, yield and quality. Five plants were randomly selected from each plot per replication for collecting the data. The observation were recorded *viz.,* length of vine (cm), number of primary branches per vine (cm), days to opening of first male and female flower, number of nodes bearing first male and female flower, number of fruit per vine, fruit length (cm), fruit diameter (cm), fruit weight (g) and fruit yield per vine (kg). Analysis of varianceestimated byPanse and Sukhatme (1961) andgenotypic and phenotypic coefficients by Burton & De Vane (1953). The heritability and genetic advanceby Burton (1952), Johnson *et. al.* (1955) respectively. ThePCV and GCV > 30%- High, 15-30%- Moderate and < 15%- Low, heritability >80%- High, 50-80%- Moderate, >50%- Low by Sharma (1994) and genetic advance in percent of mean (GAM) by >20- high, 10-20- Moderateand<10- Low Johnson *et. al.* (1955).

Result and Discussion

The success of crop improvement lies in the selection of suitable strains. While evaluating the strain, high mean value is considered as the acceptable procedure for a long time among the breeders. In this context, the 20 strains assembled from different geographical locations were evaluated for 37 traits and were given scores based on their significance over general mean. Genetic variability plays key role in crop breeding programme. The selection of traits is very effective when there is availability of genetic variability among the plant populations. The mean sum of squares due to treatments showed significant differences at 1 and 5% level for all the traits except for number of nodes per vine, fruit length and seed diameter (Table1). The results of present study indicate the availability of wide range of genetic variability among the strains. Similar results were also reported by Singh *et. al.* (2008) in ridge gourd; Arunkumar*et. al.* (2011) &Veena*et. al.* (2012) in cucumberandJat*et. al.* (2014) in kakri. The success of any breeding programme is totally depends on the presence of broad range of genetic variability in the strains.

The mean performance of bitter gourd strains is presented in (Table 2 to 4).The minimum days to first seed germination was found in PDM, VRBTG-6 and VRBTG-9 respectively, while maximum days for first seed germination were recorded in RAJ-2.The days to 50% seed germination were recorded minimum in PDM, while maximum in RAJ-2. The maximum germination rate was observed in PDM, while minimum in GP-1. Vine length is an important trait that's indirectly influence the yield, as maximum vine length provide the opportunity to produce the highest number of primary branches, number of nodes, number of male and female flower, which eventually increases the yield. The length of vine was recorded maximum in RAJ-2 and minimum in PDM. The diameter of vine was recorded in GP-1 which was found maximum among the genotypes, while minimum in VRBTG-3. The maximum number of primary branches per vine was observed in JP-1, while minimum in VRBTG-2. The strain RAJ-2 had the maximum number of nodes per vine, whereas minimum in PDM. The results of present studies are in line with Mohan (2005), Islam *et. al.* (2014) & Singh *et. al.* (2016) in bitter

gourd. Leaf is the primary source of photosynthesis activity in plant, so the plant with maximum leaf area captures maximum sunlight that's ultimately produces more photosynthate that eventually used for better growth, development and yield. The leaf area was recorded maximum in RAJ-2 and minimum in VRBTG-2.

The lowest number of nodes bearing first male and female flower is one of the key traits, that's directly correlated to yield, because nodes is the main site of flower emergence. If the nodes are appeared at lowest nodes, then there is chance to produces high number of flower and fruits per plant. The lowest number of nodes bearing first male flower was recorded in PDM and highest in VRBTG-8.The minimum number of nodes bearing first female flower was observed in KVS-7, while maximum in VRBTG-9. These finding are in corroboration with work of Laxuman (2005), Mohan (2005), Islam *et. al.* (2014) & Singh *et. al.* (2016) in bitter gourd. Early flowering is one of the most important traits, which decides who early the fruits reach to market, so for, earliness is concern this characters is very necessary. The minimumdays taken to opening of first male flower were noticed in VRBTG-6, while maximum in RAJ-1.The minimum days taken to opening of first female flower was noticed in VRBTG-2, while maximum in RAJ-1. The above results are found in conformity with the findings of Mohan (2006), Islam *et. al.* (2014) & Singh *et. al.* (2016) in bitter gourd. High percent of fruit setting directly related to high number of fruits per plant, while minimum days to first fruit harvest provide opportunity to enhance the harvesting duration of crop that directly influenced the crop yield in bitter gourd. The maximum percent of fruit setting was recorded in VRBTG-8 and minimum in VRBTG-1. The minimum days to first fruit harvest were recorded in VRBTG-6 and maximum in RAJ-2. The maximum number of fruits per vine was reported in VRBTG-6, while minimum fruit was recorded in VRBTG-1.The genotype HP-2 had maximum total fruit yield per vine and VRBTG-1 exhibited minimum. The results of present studies are in line with Shah *et. al.* (2016) in cucumber and Singh *et. al.* (2016) in bitter gourd.

Yield is a collective efforts of fruit length, fruit diameter and fruit weight, hence these the traits directly manipulate the total yield of a crop. The maximum fruit length was recorded in KVS-7, while minimum was recorded in VRBTG-1. The maximum weight of fruit was recorded in PSPB-14 and minimum in VRBTG-1. The genotype JP-1 recorded maximum fruit diameter and the genotypes VRBTG-3 and KVS-7 recorded minimum fruit diameter. Similar results were recorded by Mohan (2006), Islam *et. al.* (2014) & Singh *et. al.* (2016) in bitter gourd. The rind thickness of fruit is directly associated with the shelf life of fruit. The thickness of rind was recorded minimum in VRBTG-9 and the maximum in VRBTG-6. The minimum number of locules per fruit was exhibited in VRBTG-6 and MN-1 respectively and maximum in KVS-7. The genotype KVS-7 exhibited maximum fruit yield per plot, while VRBTG-1 recorded minimum. The maximum fruit yield per hectare was recorded by KVS-7 and minimum by VRBTG-1. Singh *et. al.* (2016) also obtained similar results in bitter gourd. The maximum duration of harvesting was recorded in VRBTG-6 and minimum in RAJ-2.The maximum carbohydrate content was recorded in VRBTG-8 and minimum in RAJ-2. The genotype RAJ-2 produces highest protein content, while HP-1 produces lowest. The maximum T.S.S was recorded in VRBTG-2 and minimum in GP-1.The genotype JP-1 had highest calcium content and VRBTG-2 recorded lowest. The vitamin C was found maximum in RAJ-2 and minimum in KVS-7. The phosphorus content was found maximum in JP-1 and minimum in PDM. Similar findings were also reported by Shah *et. al.* (2016) cucumber and Singh *et. al.* (2016) in bitter gourd. The maximum vitamin A was recorded in MN-1 and minimum in PDM. Yields are directly or indirectly influence by number of seeds per fruit, seed length and seed diameter. The maximum number of seeds per fruit was exhibited by MN-1, while minimum by VRBTG-1. The results are in similarly with Mohan (2006)& Singh *et. al.* (2016) in bitter gourd. The maximum seed length was recorded in VRBTG-1 and RAJ-1 respectively, while minimum in KVS-7. The maximum seed diameter was recorded in PDM and KVS-7 respectively, while minimum in PSPB-14. Test weight is directly or indirectly influences the seed viability and germination percentage, high test weight is the indicator of boldness of seed and healthy embryo. The maximum test weight of seed was recorded in VRBTG-8 and minimum in JP-1. The maximum seed viability was recorded in KVS-7, while minimum in PDM. The maximum germination

percentage was observed in MN-1 and minimum in JP-1.

The extent of variability in 37traits of different strains is given in (Table 5, 6 and 8).In the present research work, the phenotypic coefficient of variation and genotypic coefficient of variation were moderate to low for almost all the characters except total fruit yield per vine. Similar results were also confirmed by Singh *et. al.* (2009) sponge gourd; Hanchinamani*et. al.* (2011) in cucumber andJat*et. al.* (2014) in kakari.The fruit yield per vine showed high phenotypic coefficient of variation and genotypic coefficient of variation. Similar result was also noted by Singh *et. al.* (2014) in bitter gourd. The phenotypic coefficient of variation (PCV) were reported to be higher most of the traits than the corresponding values of genotypic coefficient of variation (GCV) but they were close to one another implying that the influence of environment on the expression of these traits were negligible, hence selection based on phenotypic values would be feasible. These findings are also confirmed by Singh &Lal (2005) in musk melon; Kumar *et. al.* (2008) in cucumber;Jat*et. al.* (2014) in kakri and Singh *et. al.* (2014) in bitter gourd.Comparatively there were wide differences between estimates of PCV and GCV for germination rate, number of locules per fruit, T.S.S and seed diameter which indicated higher environmental effect on the expression of these characters. Similar result was also reported by Rabbani*et. al.* (2012) in ridge gourd.

Heritability are useful in selection, on the basis of phenotypic performance of the different traits and the characters with high heritability value could be improved to a great extent through selection since they are least affected by environment factors and are controlled by additive gene effect. In the present investigation, high heritability was reported for almost all the traits. Similar results were also reported by Arunkumar*et. al.* (2011) in cucumber and Jat*et. al.* (2014) in kakri for vine length, days taken to opening of first male and female flower, number of nodes bearing first male and female flower, number of fruit per vine, fruit yield per vine, rind thickness, fruit length and fruit diameter; Hanchinamani*et. al.* (2011) in cucumber for days to first fruit harvest, number of nodes per vine, average fruit weight, yield per plot and yield per hectare; Rabbani*et. al.* (2012) in ridge gourd for seed length and test weight and Kumar *et. al.* (2013) in cucumber reported high heritability for germination percentage. Three traits recorded moderate heritability (above 50%) like, days to first seed germination, germination rate and number of locules per fruit, whereas two traits *viz.,* T.S.S and seed diameter showed low heritability (below 50%) which indicates that these characters were highly influenced by environmental causes, so it need to be tested under diverse environmental conditions for effective selection. Similar result was also reported earlier by Kumar *et. al.* (2013) in cucumber. High heritability does not guarantee large gain from selection unless sufficient genetic advance attributable to additive gene action is present (Srivastava& Jain, 1994). The high heritability value along with high value of genetic advance as percent of mean is most effective condition for selection (Gandhi *et. al.,* 1964).

According to Rajput *et. al.* (1996) the joint consideration of genetic advance and heritability suggested that all the characters were controlled by additive gene effect. Heritability coupled with genetic advance as percentage of mean were more useful than H^2 alone in predicting the resultant effect for selecting the best individual as explained by Johson*et. al.* (1955). In the present research work, the resemblance in the magnitude of heritability and genetic advance over mean in almost all the traits. Similar results were also obtained by Singh *et. al.* (2002) in ridge gourd; Hanchinamani*et. al.* (2011) in cucumber and Mandal*et. al.* (2015) in bottle gourd for number of primary branch per vine, number of nodes per vine, number of nodes bearing first male and female flower, days to first fruit harvest, fruit length, fruit diameter, average fruit weight, number of fruit per vine and total fruit yield per vine indicating that simple selection based on phenotypic performance of these traits may be effective to improve. Similar results were also reported by Sanwal*et. al.* (2007) in sweet gourd for days to first fruit harvest and ascorbic acid content.

However, the estimates of high heritability accompanied with moderate genetic advance over mean were recorded for days taken to opening of first female flower, percent of fruit setting, harvesting duration, seed length and percentage of seed germination which signify that the existing variability among the strains is mainly due to additive type of gene action, so there is an

ample scope for direct selection for these traits and also can be improve through mass selection. The results are in line with the findings of Arunkumar*et. al.* (2011) and Kumar *et. al.* (2011a) in cucumber. High heritability accompanied with low genetic advance over mean were revealed by test weight and seed viability which showed predominance of non-additive gene action, therefore selection in early for these traits may not be effective due to linkage and could be exploited through heterosis breeding. The moderate heritability accompanied with high genetic advance over mean were observed for first seed germination, germination rate and number of locules per fruit which is influence by the additive gene effects coupled with high environmental impact on these traits, so selection wound not be effective. The low heritability with low expected genetic advance as percent of mean was reported for total soluble solids and seed diameter, which is highly influenced by environmental factors and controlled by non-additive gene, thus limits the chances of improvement of this trait through direct selection. Hence, heterosis breeding would be rewarding.

Table 1: Analysis of variance of bitter gourd genotypes for quantitative, qualitative and seed parameters

Source of variance	**Mean sum of square**		
	Replication	**Treatment**	**Error**
Degree of freedom	**2**	**19**	**38**
Days to first seed germination	4.116	9.757*	1.555
Days to 50 percent seed germination	0.600	10.851*	0.670
Germination rate	0.005	0.555*	0.103
Length of vine (cm)	1.597	7269.234*	1.211
Diameter of vine (mm)	0.006	0.012*	0.003
Number of primary branches per vine	0.064	5.821**	0.097
Number of nodes per vine	0.653	369.388	0.224
Leaf area (cm^2)	0.029	479.812*	0.056
Days taken to opening of first male flower	1.248	111.142*	0.401
Number of nodes bearing first male flower	0.076	3.366**	0.227
Days taken to opening of first female flower	1.009	124.822**	0.400
Number of nodes bearing first female flower	0.047	7.194*	0.206
Percent of fruit setting	0.028	73.911**	0.488
Days to first fruit harvest	0.320	235.924*	0.266
Number of fruits per vine	0.048	67.143**	0.018
Fruit yield per vine (kg)	0.003	2.295**	0.002
Length of fruit (cm)	0.009	59.852	0.029
Weight of fruit (g)	0.075	1163.461*	0.092
Diameter of fruit (cm)	0.016	2.880**	0.005
Rind thickness (cm)	0.001	0.021*	0.001
Number of locules per fruit	0.054	1.399*	0.260
Fruit yield per plot (kg)	7.332	171.756**	6.687
Fruit yield per hectare (tonnes)	0.014	155.401*	0.005
Harvesting duration	5.049	202.522**	1.751
Carbohydrate (g/100g)	0.003	9.140*	0.005

Protein (g/100g)	0.003	0.120**	0.003
Vitamin A (I.U.)	0.990	1974.402**	1.908
Vitamin C (mg/100g)	3.097	253.695*	1.982
T.S.S. (^{0} Brix)	0.025	0.421**	0.136
Calcium (mg/100g)	0.520	28.186**	0.920
Phosphorus (mg/100g)	0.140	347.153*	0.609
Number of seeds per fruit	0.152	29.372*	0.279
Seed length (mm)	0.001	0.036*	0.004
Seed diameter (mm)	0.294	0.604	0.592
Test weight (g)	0.420	217.705**	2.170
Seed viability (%)	0.020	16.473**	0.390
Germination percentage	0.013	135.813**	0.322

** Significant at 5% level, ** Significant at1% level*

Table 2: Mean performance of bitter gourd genotypes for growth parameters

Genotypes	Days to first seed germination	Days to 50% seed germination	Germination rate	Length of vine (cm)	Diameter of vine (mm)	Number of primary branches per vine	Number of nodes per vine	Leaf area (cm^2)	Days taken to opening of first male flower	Number of nodes bearing first male flower	Days taken to opening of first female flower	Number of nodes bearing first female flower
GP-1	11.33	16.00	2.12	322.18	5.20	9.90	54.59	112.76	58.76	8.61	63.21	13.53
HP-1	14.00	17.00	2.65	320.44	4.50	8.16	63.84	104.04	60.23	10.35	65.74	14.48
HP-2	11.66	17.00	2.83	319.47	4.90	10.44	58.43	111.54	62.70	10.01	66.02	15.74
JP-1	13.33	18.00	2.91	220.78	4.90	11.33	31.66	114.79	70.72	10.26	73.42	12.84
KVS-7	10.66	13.66	3.46	296.32	4.10	8.78	61.55	98.64	59.71	7.82	62.80	10.77
MN-1	14.33	14.00	3.16	312.52	5.10	8.56	51.29	108.54	71.41	9.52	77.28	12.37
MP-1	12.66	16.00	3.33	339.20	3.30	7.55	48.55	104.50	60.18	8.09	64.67	13.46
PDM	9.00	11.00	3.52	163.44	4.20	6.79	27.71	110.26	63.83	6.65	70.52	10.95
PSPB-14	14.33	17.33	2.41	260.47	4.80	9.53	39.75	125.63	59.10	8.27	63.89	12.36
RAJ-1	11.00	14.66	3.19	307.17	3.80	9.53	59.18	126.53	72.90	8.77	77.33	13.98
RAJ-2	15.00	18.33	2.14	351.50	3.80	8.66	71.43	128.50	72.54	7.70	76.65	14.85
VRBTG-1	12.00	12.00	2.36	260.50	4.30	6.02	42.34	109.32	66.88	7.87	72.57	13.19
VRBTG-2	10.66	14.33	2.42	227.88	3.20	7.55	40.67	79.67	55.38	8.44	58.01	12.49
VRBTG-3	12.00	15.00	2.80	211.30	3.10	8.67	41.92	91.64	61.39	7.32	66.09	11.15
VRBTG-4	12.66	15.00	2.28	310.60	4.0	9.54	44.41	97.61	56.98	8.79	61.81	15.25
VRBTG-5	10.33	16.66	2.35	274.81	4.60	8.50	40.79	120.30	58.22	8.72	60.13	14.55
VRBTG-6	9.00	14.33	2.50	261.65	4.70	10.43	52.06	115.16	54.83	8.56	58.64	13.20
VRBTG-7	11.00	16.66	2.84	283.44	4.40	9.63	38.65	125.23	67.91	8.30	74.07	14.51
VRBTG-8	11.33	16.66	2.60	301.31	5.0	7.43	53.66	96.81	55.66	10.49	60.55	14.13
VRBTG-9	9.00	15.33	3.26	340.82	3.70	6.68	46.84	111.31	55.51	9.78	61.09	16.38
Range Max.	15.00	18.33	3.52	351.50	5.20	11.33	71.43	128.50	72.90	10.49	77.33	16.38
Min.	9.00	11.00	2.12	163.44	3.10	6.02	27.71	79.67	54.83	6.65	58.01	10.77
Mean	**11.76**	**15.45**	**2.76**	**284.29**	**4.30**	**8.68**	**48.46**	**109.64**	**62.24**	**8.71**	**66.72**	**13.51**
S.Em±	0.72	0.47	0.18	0.61	0.01	0.17	0.27	0.13	0.36	0.27	0.36	0.26
C.D @5%	2.06	1.35	0.53	1.75	0.02	0.51	0.78	0.39	1.04	0.78	1.04	0.75

Table 3: Mean performance of bitter gourd genotypes for yield parameters

Genotypes	Percent of fruit setting	Days to first fruit harvest	Number of fruits per vine	Fruit yield per vine (kg)	Fruit length (cm)	Fruit weight (g)	Fruit diameter (cm)	Rind thickness (cm)	Number of locules per fruit	Fruit yield per plot (kg)	Fruit yield per hectare (tonnes)	Harvesting duration
GP-1	90.46	75.23	42.45	1.24	21.60	52.74	5.27	0.46	3.37	14.89	16.45	92.01
HP-1	89.24	79.45	35.31	3.37	18.75	95.82	3.05	0.36	3.67	30.84	34.26	88.34
HP-2	86.40	80.76	39.23	3.64	18.20	92.65	4.27	0.54	4.00	28.71	31.78	84.59
JP-1	91.42	86.60	44.81	2.23	21.75	49.81	5.33	0.48	4.00	26.78	29.75	80.15
KVS-7	83.41	74.66	42.36	3.36	23.55	79.54	5.53	0.38	4.36	37.68	41.86	93.65
MN-1	89.24	93.07	41.63	2.70	20.55	89.20	3.01	0.37	2.33	32.51	36.06	73.75
MP-1	79.48	78.50	34.61	3.11	19.66	90.25	4.87	0.34	2.66	31.02	34.46	87.23
PDM	80.95	85.22	35.63	1.45	10.51	40.22	3.42	0.37	3.66	17.24	19.15	80.96
PSPB-14	84.95	76.51	43.40	3.34	22.86	100.28	5.23	0.36	3.00	30.51	33.44	90.51
RAJ-1	86.37	92.52	40.33	2.63	19.84	89.89	4.15	0.55	3.66	31.45	34.94	75.39
RAJ-2	80.45	95.91	46.26	3.17	12.64	90.68	3.96	0.51	2.66	31.04	34.42	72.70
VRBTG-1	76.48	88.56	29.60	1.15	7.53	38.74	4.36	0.43	4.33	13.80	15.28	79.50
VRBTG-2	82.63	73.12	39.34	2.08	12.57	52.82	4.36	0.44	3.00	24.90	27.61	91.66
VRBTG-3	83.33	83.61	42.62	3.46	11.65	80.46	2.25	0.50	3.65	36.75	40.83	82.60
VRBTG-4	77.33	74.19	45.54	1.63	15.66	79.97	4.64	0.41	3.00	19.61	21.71	91.66
VRBTG-5	85.40	73.47	40.54	2.65	16.54	66.04	4.07	0.50	4.33	32.06	35.51	92.66
VRBTG-6	89.82	61.71	49.61	3.58	20.66	72.35	3.50	0.62	2.33	26.46	29.39	103.01
VRBTG-7	90.51	92.43	39.41	2.09	19.79	53.17	5.32	0.56	3.35	25.13	27.91	75.36
VRBTG-8	92.28	72.08	35.23	1.19	16.74	62.86	2.76	0.48	4.33	14.31	15.89	94.26
VRBTG-9	78.61	75.24	37.55	3.34	14.74	89.29	3.03	0.32	2.66	37.05	41.16	91.15
Range Max.	92.28	95.91	49.61	3.64	23.55	100.28	5.53	0.62	4.36	37.68	41.86	103.01
Min.	76.48	61.71	29.60	1.15	7.53	38.74	2.25	0.32	2.33	13.80	15.28	72.70
Mean	**84.94**	**80.64**	**40.27**	**2.57**	**17.29**	**73.34**	**4.12**	**0.45**	**3.41**	**27.14**	**30.09**	**86.06**
S.Em±	0.40	0.29	0.07	0.01	0.09	0.17	0.04	0.01	0.29	1.49	0.05	0.76
C.D @5%	1.15	0.85	0.22	0.02	0.28	0.50	0.12	0.02	0.84	4.27	0.13	2.18

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Table 4: Mean performance of bitter gourd genotypes for quality and seed parameters

Genotypes	Carbohydrate (g/100g)	Protein (g/100g)	Vit. A (I.U.)	Vit. C (mg/100g)	T.S.S ^{0}Brix	Calcium (mg/100g)	Phosphorus (mg/100g)	No. of seeds/ fruit	Seed length (mm)	Seed diameter (mm)	Test weight (g)	Seed viability (%)	Germination (%)
GP-1	5.77	1.56	176.09	95.50	4.44	23.18	52.68	15.17	1.23	8.73	181.81	95.50	76.26
HP-1	5.17	1.10	191.92	84.58	5.30	17.55	56.73	14.90	1.43	8.13	175.21	98.38	75.91
HP-2	5.29	1.18	183.20	86.82	5.30	16.61	42.60	11.76	1.47	8.73	163.05	99.77	71.53
JP-1	4.72	1.25	167.59	95.09	5.79	25.31	72.82	18.47	1.15	8.13	161.41	94.40	59.93
KVS-7	5.33	1.17	178.84	62.24	5.15	17.45	69.24	13.23	1.18	9.00	171.00	99.94	78.48
MN-1	6.37	1.58	200.36	84.20	5.15	18.85	63.20	22.03	1.23	8.86	183.56	94.47	84.11
MP-1	4.64	1.60	195.75	86.15	5.55	19.75	68.44	15.76	1.41	7.90	184.04	96.54	77.11
PDM	5.36	1.28	120.25	85.09	4.82	14.82	35.71	12.78	1.26	9.00	174.34	91.98	65.18
PSPB-14	9.47	1.36	190.47	93.39	5.75	20.74	70.97	14.60	1.31	7.40	166.81	95.19	79.94
RAJ-1	5.10	1.66	180.47	86.63	5.66	20.55	46.70	20.45	1.48	8.40	171.18	99.85	68.75
RAJ-2	4.15	1.84	166.24	100.32	5.27	19.70	50.88	19.52	1.316	8.76	172.86	95.01	69.06
VRBTG-1	5.95	1.18	127.99	85.29	5.68	18.42	60.31	10.52	1.48	8.06	164.73	92.67	67.72
VRBTG-2	8.17	1.15	130.91	88.41	6.01	14.50	54.29	15.58	1.20	8.43	178.46	95.33	75.51
VRBTG-3	7.43	1.34	120.50	79.56	5.10	20.54	49.95	16.58	1.45	8.13	178.57	98.04	62.74
VRBTG-4	8.10	1.39	157.23	89.47	5.49	23.03	39.57	14.616	1.36	7.80	167.39	93.79	79.53
VRBTG-5	9.30	1.28	146.85	91.51	5.77	24.28	57.91	18.54	1.35	8.50	179.66	94.66	78.41
VRBTG-6	6.51	1.23	177.36	84.44	5.30	20.43	60.10	13.55	1.41	8.40	168.94	96.58	78.46
VRBTG-7	4.41	1.50	181.91	92.87	5.41	22.14	61.11	18.73	1.29	7.90	181.25	97.62	72.02
VRBTG-8	9.55	1.39	150.10	96.25	5.67	22.12	66.59	13.36	1.45	8.16	194.10	98.48	80.44
VRBTG-9	7.31	1.52	143.00	66.81	5.06	15.74	68.10	19.49	1.21	7.73	184.87	95.62	82.19
Range Max	9.55	1.84	200.36	100.32	6.01	25.31	72.82	22.03	1.48	9.00	194.10	99.94	84.11
Min	4.15	1.10	120.25	62.24	4.44	14.50	35.71	10.52	1.15	7.40	161.41	91.98	59.93
Mean	**6.40**	**1.38**	**164.35**	**86.73**	**5.38**	**19.78**	**57.39**	**15.98**	**1.33**	**8.31**	**175.16**	**96.19**	**74.16**
S.Em±	0.04	0.01	0.79	0.81	0.21	0.55	0.45	0.30	0.01	0.44	0.85	0.36	0.32
C.D @5%	0.12	0.02	2.28	2.32	0.61	1.58	1.29	0.87	0.03	1.27	2.43	1.03	0.93

Table 5: Estimation of genotypic and phenotypic coefficients of variation, heritability, genetic advance and genetic advance over mean for growth parameters in bitter gourd genotypes

Characters	Range	Coefficients of variance (%)		Heritability h^2 (%)	Genetic advance (GA)	Genetic advance over mean (%)
		GCV	PCV			
Days to first seed germination	9-15	14.05	17.60	64	2.72	23.11
Days to 50% seed germination	11-18.33	11.92	13.05	84	3.47	22.45
Germination rate	2.12-3.52	14.02	18.21	59	0.62	22.23
Length of vine (cm)	163.44-351.50	17.31	17.32	100	101.37	35.66
Diameter of vine (mm)	3.10-5.20	14.99	15.51	93	0.13	29.82
Number of primary branches per vine	6.02-8.68	15.90	16.30	95	2.78	31.96
Number of nodes per vine	27.71-71.43	22.89	22.91	100	22.83	47.10
Leaf area (cm^2)	79.67-128.50	11.53	11.54	100	26.05	23.76
Days taken to opening of first male flower	54.83-72.90	9.76	9.81	99	12.45	20.00
Number of nodes bearing first male flower	6.65-10.49	11.73	12.95	82	1.91	21.90
Days taken to opening of first female flower	58.01-77.33	9.65	9.70	99	13.20	19.79
Number of nodes bearing first female flower	10.77-16.38	11.30	11.79	92	3.01	22.30

Table 6: Estimation of genotypic and phenotypic coefficients of variation, heritability, genetic advance and genetic advance over mean for yield parameters in bitter gourd genotypes

Characters	Range	Coefficients of variance (%)		Heritability h^2 (%)	Genetic advance (GA)	Genetic advance over mean (%)
		GCV	PCV			
Percent of fruit setting	76.48-92.28	5.82	5.88	98	10.09	11.88
Days to first fruit harvest	61.71-95.91	10.99	11.01	100	18.23	22.60
Number of fruits per vine	29.60-49.61	11.74	11.75	100	9.74	24.18
Fruit yield per vine (kg)	1.15-3.64	33.95	33.96	100	1.80	69.93
Length of fruit (cm)	7.53-23.55	25.82	25.84	100	9.19	53.15
Weight of fruit (g)	38.74-100.28	26.85	26.85	100	40.56	55.30
Diameter of fruit (cm)	2.25-5.53	23.74	23.81	99	2.01	48.77
Rind thickness (cm)	0.32-0.62	18.57	18.69	99	0.17	38.00
Number of locules per fruit	2.33-4.36	18.03	23.41	59	0.98	28.61
Fruit yield per plot (kg)	13.80-37.68	27.33	28.94	89	14.43	53.16
Fruit yield per hectare (tonnes)	15.28-36.06	25.01	25.01	100	14.83	51.51
Harvesting duration	72.70-103.01	9.51	9.63	97	16.64	19.33

Table 7: Estimation of genotypic and phenotypic coefficients of variation, heritability, genetic advance and genetic advance over mean for quality and seed parameters in bitter gourd genotypes

Characters	Range	Coefficient of variance (%)		Heritability h^2 (%)	Genetic Advance (GA)	Genetic advance over mean (%)
		GCV	PCV			
Carbohydrate (g/100g)	4.15-9.55	27.23	27.26	100	3.59	56.05
Protein (g/100g)	1.10-1.84	14.50	14.55	99	0.41	29.75
Vitamin A (I.U.)	120.25-200.36	15.60	15.62	100	52.75	32.09
Vitamin C (mg/100g)	62.24-100.32	10.56	10.68	98	18.65	21.50
T.S.S. (^{0} Brix)	4.44-6.01	5.72	8.94	41	0.41	7.54
Calcium (mg/100g)	14.50-25.31	15.23	15.99	91	5.92	29.90
Phosphorus (mg/100g)	35.71-72.82	18.73	18.77	99	22.08	38.47
Number of seeds per fruit	10.52-22.03	19.48	19.76	97	6.32	39.57
Seed length (mm)	1.15-1.48	8.17	8.32	96	0.22	16.52
Seed diameter (mm)	7.40-9.00	0.76	9.29	10	0.01	0.13
Test weight (g)	161.40-194.10	4.84	4.91	97	17.20	9.82
Seed viability (%)	91.98-99.94	2.41	2.49	93	4.60	4.79
Germination percentage	59.93-84.11	9.06	9.09	99	13.79	18.60

Conclusion

In the present investigation, it can be concluded that the strains used for this research work showed high amount of genetic variability with negligible differences between GCV and PCV, high to moderate heritability with genetic advance over mean for most of the characters that indicates good scope for selection and improvement in the future breeding programmed of bitter gourd.

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APPLICATION OF HYDROGELS AS AN AGRICULTURAL AND PESTICIDAL CONTROLLED RELEASE FORMULATION

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Abstract

The super absorbents are cross-linked, 3D structured high water retention capacity containing molecular compounds also known as smart hydrogels are utilised for agricultural application. The previous studies show their widespread application in Agriculture and horticulture as regulated slow release fertilizers or controlled release pesticides formulations. The current review discusses about the common characteristics, synthesis, techniques to evaluate hydrogels properties and application in agriculture.

Keywords: Smart hydrogels, slow release fertilizers, controlled release pesticides, application in agriculture.

Introduction

Hydrogels are polymer super absorbents that are high in molecular weight with cross linking behavior. They are biomaterial which possesses high water holding tendency than their original dry mass. The cross linking promotes absorption of physiochemical fluid from 10 times to 100 times. Hydrogels shows extensive H- bonding among solvents or water and polymerase chain that that supports its 3D structure. Previous studies emphasized the role of different global participants who are master players for the synthesis of these super absorbent capacities displaying hydrogels. The companies like Sanyo chemical, DuPont, Dow chemical laxness (Germany), Sumitomo Chemical are few names (Dorota Kołodyńska et al . 2016). The first company which developed superabsorbent was reported in united states Department of agriculture in 1960s. They used Acrylonitrile (AN) for grafting of AN onto corn starch followed by saponification. These hydrogels are also called as "smart hydrogels" as they have super capacity of absorption up to 1000g of water with respect to their dry mass. Hydrogels absorbs water because of separation of polymer chain network manifested by swelling of polymer material (Ahmed et al. 2015). The hydrogels show the characteristics of bio compatibility, reversibility, flexible functionality with biological systems, therefore they have wide applications in agriculture field. There worldwide demand as super absorbent polymers is increases in 1.9 million metric tonnes in future. Upcoming airs for purpose of novel application. (Witono et al. 2014 and Ullah et al. 2015). The applications such as microfluidic control, biosensor, bio-activator, drug delivery, ceiling, coal, dewatering, separation of biomolecule or cells and barrier material to regulate biological additions. The hydrogels are made of non-toxic polymers that are soluble in water (Kabiri et al. 2012, Bhattarai et al. 2010, Das et al. 2013, Gao et al. 2013 and Samal et al. 2014). They exhibit properly

of re-wetness, optimise absorption capacity and rate, optimum pH @neutral conditions mostly, colourless, odourless, stability at light exposer because of photosensitive monomers for polymerisation reactions, economic price and biodegradability in nature (Jyothi et al. 2010 and Samchenko et al. 2011).

Types of hydrogels according to the property

Table1: The types of hydrogels are summarized according to their characteristics

Types of hydrogel	Special characteristic	References
Physical hydrogels	-Physical-cross linking -Gelatine and agar -Reversible and unstable -Electrostatic bonds, -Hydrostatic bonds/ hydrophobic bonds. -Depend on pressure, light, sound, temperature and electric fuel in chemical nature	Ahmed et al. 2015 and Osada et al. 2001
Chemical hydrogels	-Stable/ irreversible -Vinyl monomers -Chemical covalent cross linking Covalent bond -Molecules dependent on pH ions and solvent	Osada et al. 2001, Lee et al. 1999, Li et al. 2015, Whitcombe et al. 2011.and Buwalda et al. 2014.
Natural hydrogel	-Physical crosslinking -Biodegradable -Non-biodegradable	Osada et al. 2001, Lee et al. 1999, Li et al. 2015 and Whitcombe et al. 2011.
Synthetic hydrogels	-Chemical cross linking -Biodegradable -Non-biodegradable	Osada et al. 2001, Lee et al. 1999, Li et al. 2015 and Whitcombe et al. 2011.
Homo polymer hydrogel	-Monomeric units are same -Hydrophobic -Hydrophilic	Osada et al. 2001, Lee et al. 1999, Li et al. 2015 and Whitcombe et al. 2011.
Co polymeric hydrogel	-Different types of monomeric units -Hydrophobic -Hydrophilic	Osada et al. 2001, Lee et al. 1999, Li et al. 2015 and Whitcombe et al. 2011.
Ionic hydrogel	-Cation -Anions	Osada et al. 2001, Lee et al. 1999, Li et al. 2015 and Whitcombe et al. 2011.
Neutral hydrogel	-Both anion and cation	Osada et al. 2001, Lee et al. 1999, Li et al. 2015 and Whitcombe et al. 2011.
Amphoteric hydrogel	-Amphoteric and zwitter ion	Osada et al. 2001, Lee et al. 1999, Li et al. 2015 and Whitcombe et al. 2011.
Physical hydrogel	-Depends upon pressure, light, sound, temperature, electric field.	Buwalda et al. 2014
Biochemical hydrogels	-Use of biological origin molecules	Buwalda et al. 2014
Cross-linking hydrogels	-Amorphous -Crystalline -Semi- crystalline -Hydro colloids	Buwalda et al. 2014

Types of hydrogels according to the synthesis protocol

Table 2: Types of hydrogels are summarized according to preparation

Types of hydrogels	Preparations	References
Natural hydrogels	-Preparation by addition of synthetic parts on natural substrates. -Basic groups as polysaccharides and polypeptides -Vinyl monomers through Graft polymerization on polysaccharides -Factors affecting polymerisation as light and heat	Lucas et al. 2008 and Kuang et al. 2011.
Synthetic/ artificial polymers	-Linking of polymers by chemical reactions. -Linking of polymers by irradiations -Linking of polymers using crystalline, electrostatic interactions.	Francis et al. 2005 and Raafat et al. 2012
Natural and synthetic polymer	-Polymerization technique such as graft polymerization. -Cross- linking polymerization solution polymerization -Aqueous medium for neutral formulation used for synthesis of both natural and synthetic polymer	Coutinho et al. 2010, Parlak et al. 2015 and Sharma at al. 2016

Technique for investigation of functional properties of hydrogels

Table 3: Techniques for the study of properties Hydrogels

Technique	Functions
FTIR (Fourier transform IR analysis)	-Study of hydrogel structure -Study of biodegradable, moisture uptake
AFM (Atomic Force Monopoly)	-Study of topography of gel
XRD (X Ray diffraction)	-Study of plane of network of gel
TGA (Thermogravimetric analysis)	-Study of decomposition of hydrogels
SEM (Scanning electronic microscope)	-Observation of porosity, crosslinking and surface morphology.
TOC (Total organic carbon analyser)	-To measure amount of water dissolved in water.

Applications of hydrogels in agricultural field

Table 4: Application of hydrogels in agriculture are Summarized

Hydrogels	Application	References
CR pesticide devices	C-R release pesticide (PDS)	Kenawy et al. 1992 and Greene et al. 1998
CR pH sensitive Biopesticide	Biopesticide (PDS) (pH sensitive)	Dunkle et al. 1989 and Beyerinck et al. 1995
CR encapsulated fertilizer	Encapsulated fertilizer (PDS)	Dave et al. 1999
Glutaraldehyde cross linked sodium alginate beads	Soil application	Kulkarni et al. 2000
Urea-formaldehyde cross linked sodium alginate beads	Liquid pesticides (PDS)	Kumbar et al. 2001
Starch grafted poly Acylonitrite HSPAN (sumikagel)	Micro irrigation, mulching, seed watering and tissue culture (PDS)	Weaver et al. (100) 1976, Weaver et al. (484) 1976, Weaver et al. 1979, Fanta et. al 1979, Fanta et. al 1984 and Fujimoto et al. 1979.
Radiation induced acrylamide gel/ crotonic acid gel	Controlled release of Agrochemical (PDS)	Saraydin et al. 1998
Cross- linked hydrogel of polyacrylamide, polyacrylic acid, poly methacrylic acid	-For release of fertilizer and pesticide near root zone. -Increase water capacity of soil and maintain moisture	Senna at al. 2005, Liang et al. 2007, Liu at al. 2007, Davidson et al. 2012, Azeem at al. 2014, Sempeho et al. 2014, Aouada et al. 2015, Guilherme et al. 2015 and Saruchi et al. 2015.
	-Prevent water loss and seepage. -Increase water uptake, nutrient uptake and transformation	
Blend of slow release fertilizer and super absorbents	-High release rate -Increase water retention -Cultivation of nursery plants	Coviello et al. 2007 and Xiaoyu et al. 2013
Alginate and chitosan microcapsules	Bio pesticides carrier matrix	Kashyap et al. 2015
Bio nanocomposite materials of chitosan and clay bends	Absorbent of herbicide	Rudzinski et al. 2003

Conclusion

The polymers have super tendency for salt and water- absorption, slow release of fertilizers, pesticides, biodegradation and eventually increase in nutrient absorption for the root of plants. The current studies invite the development of non-toxic and environment friendly biodegradable polymers for the application of agriculture. The work upon improvement of swelling properties, strength of hydrogels and reduction in cost application is required in the field of horticulture and agriculture.

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HABIT MANUPULATION: A NEW ASPECT OF PEST MANAGEMENT

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Abstract

This article focuses on the problem caused by the insect pest imbalance in natural habitats because of different factors. These factors include biotic and abiotic factors which indirectly influences the agricultural practices. It eventually causes the economic loss to the farmers. The various possible solution with different approaches as regulatory source of pest management has been discussed in the current article.

Keywords: Ecological Engineering, Judicial use of insecticide, Plant variety, Alternative host

Introduction

Insect pest is a one a major constrain in the field of agriculture. This problem causes a heavy loss of more than 30% of agriculture crops. Every insect has its predators which not only follows but also leads to the destruction of the explained by Linnaeus in 1745. Martin listener also noted that the ichneumon adult emerge from caterpillar.

Further, the practice of intensive agriculture and excessive use of agrochemicals have resulted in the sudden declination of the wildlife in agricultural landscapes. The decline of semi-natural habitats, simplification of crop rotations, monoculture as well as high use of fertilizers and pesticides is considered to be responsible for the severe decline of biological diversity that has been observed (Aebischer et al., 1991). These practices can reduce habitat quality and remove the necessary habitat structure that is important to many natural enemies. Fragmentation and loss of suitable habitats has caused natural enemies to decline in species diversity and abundance, and has even resulted in extinctions and loss of biological control functions (Fahrig 1997).

Current scenario

Nowadays, a desirable goal in agricultural land is the enhancement of biotic diversity through the use of sustainable farming methods and the conservation and re-establishment of non-crop habitats. Habitat manipulation, which is also known as "Ecological Engineering", focuses on reducing mortality of natural enemies, providing the supplementary resources and manipulating host plant attributes for the benefit of natural bio-agents. This can be achieved by enhancing the plant diversity, the establishment of non-crop habitat and by providing adequate refugee in the agro-ecosystem.

Approaches of habit manipulation

Judicial use of insecticide

Insecticide, chemical used to kills insect pest. The indiscriminate use of pesticide causes death of Natural enemy survives on the crop. Due to which problem like resurgence is develop. These conflicts can be reduced by use of following selectivity principles of insecticides. This selectivity is needed for the management of those pests which are not managed by biological control but also careful for natural enemy for the control of secondary pest. The Pesticide control Act of 1972, came into being. It emphasizes the proper application of pesticides to ensure the greater protection of man and the environment. To spare the natural enemies, insecticidal application should be based on selectivity principles such as physiologically selectivity, ecologically selectivity, behavioral selectivity and selectivity through improved application (Marino et al). The new type of bio insecticide is available like Bt insecticide, that contain toxins of *Bacillus thuringiensis* (Bt) and it is used to kill lepidopteron pest such as Cabbage butterfly, Sugarcane bore, *Helicoverpa armigera.* The virus active ingredient such as Nucleo poly hydrolis virus NPV has been commercialized and most of these are used to kill Lepidoptera (80%), Hymenoptera (7%) and Diptera (3%).

Transgenic Crops

Transfer of desirable genes into crops through recombinant DNA technology responsible for the production of the crystal proteins for killing the pests has been achieved on cotton, corn, and potato. Generally the transgenic crops are considered safer to predators and parasitoids. The crystal proteins and the pollen produced from these plants were generally considered safe to Anthocorids and Chrysopids.

Plant variety

Although combining natural enemies and plant resistance may slow the adaptation of some insect pests, it may speed up adaptations of others. It is observed that variation of variety in rice field attract different natural enemy.

Alternative host

Colonization of alternate host near the field provides a habitat to the natural enemy when the host crops are not available. Plant diversity also act as a breeding site where they can multiply in large number. They could breed before attacking the largest host. Marino and Landis observed that wasp species, the braconid, *Meterous communis* (Cresson) showed more parasitism of true armyworm, *Pseudaletia unipuncta* (Haworth) in structurally-complex agricultural landscapes than simple.

Intercropping

Intercropping can also modify the microclimate of crop fields making them more favorable for parasitoids. It should provide the important resource, such as pollen, nectar, alternate prey, shelter, or overwintering sites. Intercropping chickpea with coriander was found to increase the activity of Campoletis chloridae and decrease the population Helicoverpa armigea.

Vegetation on empty land

The growing of non-crop plants on an empty land provides a home to natural enemy and acts as a breeding site.

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