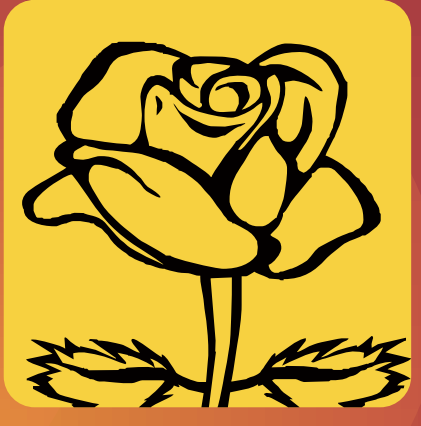
RNI No. UPENGO3865/24/1/2013-TC

ISSN 2347-7377

Current Horticulture

(A Journal Dedicated for the Advancement of Horticultural Science)

Vol. 5 No. 2 July–December 2017



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CURRENT HORTICULTURE

Vol **5**, No. 2, July–December 2017 ISSN: 2347-7377; RNI No.: UPENG03865/24/1/2013-TC

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HAPPY AND PROSPEROUS NEW YEAR 2018

Dear valuable members

We are extremely happy and feel proud that CURRENT HORTICULTURE, though the journal is comparatively new , but cruishing its way through our joint efforts during all these years , before the journal achieved its first NAAS rating of 3.71, the highest among all newly- submitted journals to the NAAS. Your contribution to the society as a member, author and reviewer has made such a feat possible really possible.We do appreciate your patience and belief in the society for the cause of science, and hope that your contribution will enhance the credibility of the journal manifold as we enter into a new year of 2018. With your efforts, we can anticipate that the journal will usher into new heights in future and serve as an excellent platform for researchers like you.

Our New year greetings of 2018….

Looking forward for your kind cooperation

Thanking you and our best regards

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Research Review

Current Horticulture **5**(2): 3–14, July–December 2017 ISSN: 2347-7377; RNI No.: UPENG03865/24/1/2013-TC

Breaking seed dormancy in flower crops: a review

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Received: January 2016; **Revised:** June 2017

ABSTRACT

The seed dormancy in flower crops impacts both seed production and their germination. Flower crops display diverse mechanisms for seed dormancy like hard seed coat, immature, rudimentary embryo and inhibitors. In some seeds which are dormant at harvesting, dormancy breaks down naturally over the time whereas other crops require some form of pre-treatment. There are several methods used for specific genera. It can be broken by soil melting and freezing, microorganism's activity, forest fires, soil activity and being eaten by animals, in normal conditions. This review surveys and categorizes of different seed dormancy conditions found in flowering plants. Flower crops are listed according to their dormancy types. There are two types of dormancy, primary and secondar. Specific examples are given for each type of dormancy along with their methods to alleviate dormancy

Key Words: Seed dormancy, Flower crops Genera, Scarification, Leaching, Germination, Embryo Dormancy

In commercial floriculture, flower seed production is considered one of the profitable and remunerative enterprises (Tiwari *et al.,* 2016). This high-value and labour-intensive enterprise, taken up by small farmers, will help to reduce their poverty and lead them to live a respectful life (Kumar *et al.,* 2011; Kumar *et al.,* 2014). However, this sector is still in a nascent stage of development and accounts for a negligible share in the global exports (Tiwari *et al.,* 2015a).

Seed dormancy is a common condition found in many species of flowering plants. It is an adaptation that allows a species to determine the timing of germination in seeds in a population. A seed may be non-dormant and germinate immediately, it may be non-dormant (Chiba and Koyama 2012) and quiescent; or the seed may be dormant (Rolhauser *et al.,* 2013). Quiescent seeds are inhibited from germinating because the environment is unsuitable, (Khan *et al.,* 2004; Patel *et al.,* 2016) (for example the seed is dry or the temperature is outside the range that permits germination).

Dormancy differs from quiescence because dormant seeds fail to germinate even when environmental conditions (water, temperature and aeration) are suitable for germination. Some species use environmental cues (such as drought vs rainfall, or winter temperatures) to synchronize germination in most the seeds at a particular time of the year. Other species are adapted for asynchronous germination over an extended time. This allows periodic germination and the establishment of a persistent seed bank (Kadam *et al.,* 2014b; Ortas *et al.,* 2015).

Domestication of crop plants has led to the reduction or elimination of seed dormancy to fit cropping schedules (Tiwari *et al.,* 2015b). Although this is true in most of the major crops, many flower species still exhibit forms of seed dormancy that impact crop and seed production, and complicate seed testing (Kadam *et al.,* 2014b). Refinement of production technology to ensure higher seed yield with better quality is prerequisite to harness the export potential of flower seed (Deaker *et al.,* 2004). Propagators of cultivated plants long ago recognized that germination-delaying phenomena existed in seeds.

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Despite the fact that many researchers study dormancy, there is no unambiguous definition of the phenomenon, perhaps because it is manifest and broken in different ways in different species (Cross *et al.*, 2015). Therefore, seed dormancy is an adaptive mechanism to ensure plant survival (Tielborger *et al.*, 2012). The purpose of this review is to describe the categories of seed dormancy and identify examples of flower crops that exhibit seed dormancy. This review categorizes different seed dormancy conditions found in flower

Table 1. Categories of seed dormancy in seeds of flower crops

Type of dormancy	Causes of dormancy	Conditions to break dormancy	Representative genera of flower
Exogenous : Due to external factors (either seed structure or chemicals in seed coat have the cause)			
Physical	Impermeable seed coat	Scarification	*Baptisia, Lupinus*
Chemical	Inhibitors in seed coverings	Removal of seed coverings (fruits) Leaching seeds	*Iris, Viola*
Mechanical	Seed coverings restrict radicle growth	Removal of seed covering Cold stratification	*Echinacea purpurea, Rosea spp.*
Endogenous : embryo itself			
Morphological	The embryo is not fully developed at the time the seed sheds from the plant	Warm or cold stratification	*Narcissus pseudonarcissus Galanthus nivalis*
Rudimentary	Small undifferentiated embryo	Cold stratification and potassium nitrate	*Anemone, Ranunculus*
Undeveloped	Small differentiated embryo less than ½ size of seed	Warm stratification and gibberellic acid	*Daucus, Cyclamen*
Physiological	Factors within embryo inhibits germination	cold or warm stratification are required before germination can take place	
Nondeep	Positively photodormant Negatively photodormant	Red light Darkness	*Lactuca, Primula Cyclamen, Nigella*
	after-ripening	Short period of dry storage	*Impatiens*
Intermediate	Embryo germinates if separated from the seed coat	Moderate periods (up to 8 weeks) of cold stratification	*Aconitum, Gentiana*
Deep	Embryo does not germinate when removed from seed coat or will form a physiological dwarf	Long periods (> 8 weeks) of cold stratification	*Dictamnus*
Combinational : Combinations of different dormancy conditions that must be satisfied sequentially			
Morpho-physiological	Combination of under developed embryo and physiological dormancy	Cycles of warm and cold stratification	*Helleborus, Mertensia*
Epicotyl	Radicle is non-dormant and growth begins when temperature and water permit, but epicotyl is dormant	Warm followed by cold stratification	*Asarum, Paeonia*
Epicotyl and radicle	Radicle is dormant and growth begins after chilling stratification treatment, but epicotyl is dormant	Cold stratification followed by warm followed by a second cold stratification	*Convallaria, Trillium*
Secondary dormancy			
Thermo-dormancy	After primary dormancy is relieved, high temperature induces dormancy	Growth regulators or cold stratification	*Apium, Lactuca, Viola*

crops. Specific examples are given for each type of dormancy along with methods to alleviate. Representative flower genera for each of these categories are as under:-

METHODS TO OVERCOME EXOGENOUS DORMANCY

Tapping

Seeds impermeable to water (hard-coated seeds), impenetrability may be due to a cuticle layer or developed a layer of strong epidermal cells.Hard-coated in legume seeds is due to large reserves of suberin, lignin or cutin. Impenetrability to water in some seeds may be related to hilum building. Strophiole is an outgrowth of hilum region which restricts water movement into and out of some seeds. Strophiole can be separated or moved by vigorous shaking, and thus the seeds are permeable to water.

This procedure is called tapping; that may be used to break dormancy on sweet clover seed. In some seeds, dormancy are broken with scratch or making pierce on coat of seed. Seed dormancy in *Iliamna corei* (wild Hollyhock) is due to a water-impermeable seed coat. Its seeds require fire to germinate. They are capable of forming a long-lived seed bank and exhibit a continuum with regard to degree of seed coat dormancy. Convolvulaceae is the most advanced flowers family (asterid clade) that produces seeds with physical dormancy (water-impermeable seed coat).

In seeds of representative genus *(Ipomoea lacunose)* (Convolvulaceae) transition area between elongated and square-shaped sclereid cells is the place where the water gap opens. Morphology/anatomy of water gap in Convolvulaceae differs from that of taxa in the other 11 Angiosperm plant families that produce seeds with physical dormancy. Prior to germination, the seed or fruit coat of species with physical dormancy must become permeable in order to imbibe water. Breaking of it involves formation of a small opening(s) (water gap) in a morpho-anatomically specialized area in seeds or fruits known as water-gap complex. Based on morpho-anatomical features, three basic water-gap complexes (types-I, -II and -III) are identified in species with physical dormancy in 16 families. Depending on number of openings involved in initial imbibitions, water gap complexes are sub-divided into simple and compound.

Dormancy of *Kosteletzkya virginica* (Malvaceae) seeds is primarily due to the impermeability of seed coat to water. The impermeable structure is assumed to be, in other Malvaceae, the palisade layer of seed coat. The percentage of seeds capable of imbibitions and germination increased with increasing time of storage at low temperatures, but the release from dormancy is not accompanied by decreased seed coat resistance to pressure. Under natural conditions, mechanical damage to seed coat due to changes in temperature and/or abrasion may render the seeds water permeable. It is not clear what causes water permeability during storage under laboratory conditions. During seed maturation and drying, the inner epidermis of the tegmen partly separate from the rest of the seed coat and an air space, which makes the seed buoyant, is formed around the region of chalazal cleft. The optimal temperature for germination of K. virginica seeds is 28-30°C in light or darkness.

Allow gas exchange

Oxygen is required by the germinating seed for metabolism. It is used in aerobic respiration, the main source of seedling's energy until it grows leaves. Some seeds have impermeable seed coats that prevent oxygen from entering the seed, causing a type of physical dormancy which is broken when the seed coat is worn away enough to allow gas exchange and water uptake from the environment (Raven *et al.,* 2005). Cocklebur and Rosa spp have impermeable coat to oxygen. There are limits to absorb oxygen at 20°C, while permeability to oxygen increases at 4°C; so maybe there is an interaction between oxygen permeability and temperature.

The seeds of *Calycotome villosa, Spartium junceum* and *Medicago arborea,* as in several woody legumes species are characterized by a hard seed coat that inhibits germination. In these seeds, inhibition of germination originates from the prevention of water uptake and gas exchange. Moreover, the emergence of radicle is suppressed due to mechanical resistance. Several treatments are used to break the seed coat dormancy. Seeds of three species were immersed in concentrated sulfuric acid for various periods of time and other seeds were immersed for 48 hours in running water.

Untreated seeds were used as the control. The treatments improved the germination percentages as well as the rate of germination in all the three species. In *Calycotome villosa,* the immersion of seeds in H_2SO_4 for 60 minutes significantly increased the germination percentage. The treatment with running water was less effective. In *Spartium junceum,* the maximum germination percentage was attained when the seeds were immersed in H_2SO_4 for 60 minutes. The running water treatment allowed some germination. In *Medicago arborea,* the treatment with H_2SO_4 for 10 minutes gave the best result. Furthermore, immersed seeds in running water resulted in satisfactory germination percentage (Pipinis *et al.,* 2010).

Breaking of mechanical resistance

In normal conditions, induction seed dormancy can

be broken by soil melting and freezing, microorganism's activity, forest fires natural, soil activity, being eaten by animals, and other factors. Each of these activities may require several years to be completed, thus increases the time that required for germination. Broken seed dormancy by removing the limitations caused by seed coat is called scarification and it can be done by mechanical and chemical ways (Ertekin, 2011).

Mechanical scarification : Mechanical scarification is a method for overcoming the effect of an impermeable seed coat. Mechanical scarification can be done by rubbing seeds between two pieces of sandpaper, abrasive, sand or with a severe shaking. Heating, cooling, extreme changes in temperature, dipping seeds in boiling water for a short period of time, piercing the coat of seeds by needle, placing the seed exposed to certain and intermittent wavelengths are other techniques that cause seeds become permeable to air and water (Mabundza *et al.*, 2010).

The majority of Arecaceae flowers seeds having difficulties to germinate due to the presence of tegument dormancy of seeds. *Mauritia flexuosa,* a representative species of this family showed the increased the germination rate after scarification (Seleguini *et al.*, 2012). For breaking of dormancy in seeds of *Brachiaria decumbens*, this methods was most effective. The seeds of *Alberta magna* (Rubiaceae) required a period of after-ripening on the tree for at least one year in order to reach full maturity. In addition embryo dormancy, pericarp exerted a two-fold coat-imposed dormancy which involved impermeability and mechanical resistance.

Germination increased by complete excision of seeds from the pericarp. Heavy predation may occur depending on the site of collection. If collected subsequent to after-ripening, fruits could be stored up to one year. No evidence was found for the presence of germination inhibitors. Seeds of *Crataegus monogyna* having endocarp needed 112 days of warm stratification, followed by cold stratification to reach a germination percentage of 75%, while seeds without endocarp could germinate without warm stratification proceding the cold stratification.

The mechanical resistance to splitting of endocarps decreased during the warm stratification period. This offers a new method for quantification of warm stratification process. The increasing germination percentage with increasing warm stratification was strongly correlated with the percentage of seeds with split endocarps. Splitting of endocarps released a possible mechanical, water deficiency or oxygen availability restraint on the embryo (Persson *et al.*, 2006).

In ornamental bush plant *(Elaeagnus mollis)* very low percentage of seed germination is due to dormancy caused by mechanical resistance of seed coat and inhibitors. When the seed coats were removed, germination rate reached >90%. Outdoor stratification (2-7° C) markedly promoted germination. In his studied Lu *et al.* (2008) and Lu *et al.* (2009) concluded that embryo was not responsible for dormancy in *Iris ensata, I. setosa, I. chrysographes* and *I. bulleyana*.

However, failure in germination of seeds was due to seed coat having mechanical resistance imposed on embryo which came from endosperm at the micropylar end. Germination requirements of three annual, *Echinops gmelinii, Epilasia acrolasia* and *Koelpinia linearis* (Asteraceae) were tested by Baskin *et al.* (2014).

They determined effects of pericarp and phyllaries on germination of *E. acrolasia* and *E. gmelinii*, respectively. Low percentages of 20-day-old seeds of *E. acrolasia* and *K. linearis* were non-dormant and germinated to low percentages over the range of temperatures, whereas all seeds of *E. gmelinii* were dormant.

As seeds of *E. acrolasia* and *E. gmelinii,* after ripening, germinated over the range of temperatures. Mechanical resistance of the pericarp and phyllaries reduced their germination. Seed scarification requirements to improve initial germination in perennial herbaceous native legumes may vary among species. All durations of mechanical abrasion and one minute hot water treatments increased germination rate of *Acacia angustissima* (Mill.) Kuntze var. *hirta* (Nutt.) B.L Bob (Dittus and Muir 2010). Seed scarification requirements to improve initial germination in perennial herbaceous Fabaceae species prairie acacia (*Acacia angustissima* (Mill.) Kuntze var. *hirta* (Nutt.) B.L Bob.), panicled tick-clover *(Desmodium paniculatum* (L) DC.), and tall bush-clover (*Lespedeza stuevei* Nutt) (Dittus and Muir, 2010). The seeds of *Sophora viciifolia* were treated with sulphuric acid, hot water and mechanical abrasion with coarse sand showed the breaking effect on *Sophora viciifolia* seeds.

Chemical scarification: Acid treatments are often used to break down especially thick impermeable seed coats. Since seeds placed in concentrated H_2SO_4 will become charcoal in time, the temperature of acid and length of time, the seeds are soaked are very important. The acid should be used at room temperature for a period of a few minutes to several hours depending on the species. When the allotted time is finished, the seeds should be removed promptly and washed thoroughly in several changes of water to neutralize completely all remaining acid. For some species, the duration of acid bath depends on specific batch of seeds and can only be determined empirically.

After treatment and a thorough washing, the seeds may be sown or dried and stored for several months

(Yang *et al.*, 2014). Scarification of seed coats with and alternate high and low temperature treatment in imbibed seeds of Sida acuta and *S. rhombifolia* had a distinct opening in chalazal region prior to germination (Seal and Gupta, 2000). In *Urena lobata,* small cracks were present near the hilar region. In *Argyreia nervosa*, seed coat was least affected by scarification. Sulfuric acid acted mainly on the micropylar and hilar regions. In *Argyreia nervosa* and *U. lobata*, the whitish soft tissue at the micropylar region had totally disintegrated into a blackish loose tissue which came off during washing with water, thereby opening the hilum or micropyle. In wet heat treatment in *U. lobata* at 100°C, the testa showed rupturing near the hilum, while presoaking the seed overnight caused uniform softening of testa and hilar region (Gupta, 2015).

Uniform germination in Senna bicapsularis *(Cassia bicapsularis)*, S. didymobotrya *(C. didymobotrya)*, *S. multiglandulosa S. occidentalis (C. occidentalis)* and *S. septemtrionalis* were enhanced by both acid and mechanical scarification. The highest germination for all species was obtained from seeds treated with H_2SO_4 for 60 minutes. Sadeghi and Khaef (2012) concluded that chemical scarification with sodium hypochlorite can effectively be used to reduce the hard seededness of Medicago spp at two per cent concentration for two minute.

In nature, impervious seed coats are softened by microorganisms in soil during warm periods of the season (Kumar *et al.*, 2014; Zalamea *et al.*, 2015) or by passage through digestive tracts of birds and mammals (Reid and Armesto, 2011), alternate freezing and thawing (Baskin and Baskin, 1997) and in Ipomoea grandiflora, by fire (Azania *et al.*, 2003). Santana *et al.* (2010) reported that ornamental trees of Fabaceae family have after a fire, the open canopy and the burnt material lying on the surface alter the thermal properties of soil, resulting in elevated soil temperatures for a long period. This effect is especially pronounced at temperatures that are expected to occur near the soil surface (0-2 cm depth). The duration of exposure interacts with temperature to break dormancy, the highest germination rates reached after the longest duration and highest temperatures.

In new techniques, selected enzymes in seed coat, such as cellulase and pectinase are used to eliminate seed coat. Organic solvents such as alcohol and acetone are also used to eliminate seed dormancy.Hard seeds are characteristic of members of Cannaceae, Convolvulaceae, Fabaceae, Geraniaceae and Malvaceae.

Breaking Morphological dormancy

Effective aids for inducing germination include : (a) exposure to temperatures of <15°C, (b) exposure to alternating temperatures, and (c) treatment with chemical additives such as potassium nitrate or gibberellic acid. Seeds with undeveloped embryos have embryos that are torpedo-shaped and up to one-half the size of the seed cavity. Important families and genera in this category are: *Umbellifereae, Primulaceae (Cyclamen, Primula),* and *Gentianaceae (Gentiana)*. Species with rudimentary embryos have little more than a proembryo embedded in a massive endosperm. These are found in *Ranunculaceae (Anemone, Ranunculus), Papaveraceae (Papaver, Romneya),* and *Araliaceae (Aralia, Fatsia)*. Warm temperatures (> 20°C) favor germination, as does gibberellic acid treatment. Orchids have rudimentary embryos, but they are not considered dormant in the same sense as others in this category and special aseptic methods are used for germination.

Breaking physiological dormancy

Some certain metabolic pathways are blocked by some compounds in seeds. For example, cyanide is an inhibitor matter that found in apples and pears seeds. Each of these compounds prevents of germination through effect on respiration. Also phenolic compounds are considered as inhibitors of the germination, and due to extensive role are known as natural germination inhibitor substances. Coumarin, Duromine and Abscisic acid also are known as natural germination inhibitor substances. Abscisic acid has an opposite effect on gibberellins and cytokinins hormones (Tieu *et al.*, 2001).

Leaching : Materials that create high osmotic pressure can prevent of germination (Vaziri *et al.*, 2011). Salinity can affect germination of seeds either by creating osmotic potential that prevents water uptake or by toxic effects of specific ions. They demonstrate that germination of *Prosopis strombulifera* is strongly influenced by the nature of ions in salt solutions and their interactions. Sugars and salts can compete with seeds to absorb water and prevent water absorption by seeds, and thus prevents germination. In this case, when osmotic inhibition was overcome, seeds are able to germinate. One of the ways to eliminate the osmotic inhibition is seed leaching. Inhibiting substances in the seed coat of sugar beet is destroyed through leaching. Suryawanshi *et al.* (2001) observed maximum germination in *Cassia angustifolia* was obtained by leaching seeds for 24 hours at 20°C.

Scarification : Metabolic inhibitor materials can be eliminated by use of scarification techniques (Malavasi *et al.*, 2004). In scarification, physiological changes occur in seeds that absorb water and are exposed to low temperatures. In scarified seeds, oxygen uptake and energy increases in the cell surface for embryo axis. Also increase enzymes such as catalase, phosphatase, lipase and peroxidase; therefore, this indicates that embryo in many stages of metabolism and development is affected by scarification. In scarified seeds, hormonal

changes also occur. For example, the amount of Abscisic acid (ABA) is reduced in apple, pine, walnut and hazelnut seeds by scarification. Gibberellins can replace with scarification in some seeds, due to it stimulator role. The amount of gibberellin was also observed during the scarification. Thus, in addition to increased growth and metabolic activity in scarified seeds, changes amount of inhibitor and stimulator materials can also be effective on eliminating seed dormancy (Chuanren *et al.,* 2004).

The germination is also increased by placing seeds in daily alternating temperatures. Scarified seeds are placed at 3 to 10°C. However in various plants, certain temperatures, and durations that seeds are treated with this temperature is different (Macchia *et al.,* 2001). For most plant species, scarification temperature is the same absolute temperature that required for germination and scarification time, is different depending on the type of plant.

Scarification is done by using various methods such as acids or piercing coat seeds. Ferreira *et al.* (2014) studied the performance of different thermal scarification methods to overcome dormancy in seeds of *Piptadenia moniliformis* and concluded that thermal scarification by using seed immersion in water at 80°C for 10 and 30 seconds was efficient in overcoming dormancy. Seleguini *et al.* (2012), evaluated the effect of seed scarification and soaking in emergence and development of Arecaceae species *(Mauritia flexuosa)* seedlings and concluded that seeds of *Mauritia flexuosa* have tegument dormancy.

The seed scarification increased the germination rate; however, it contributed to increase the seeds mortality rate. The mechanical scarification, without or after soaking the seeds in water, increased the in seedling mortality rate *Mauritia flexuosa* and it is not, therefore, a suitable method for dormancy breaking. Scarification with boiling water plus stratification was most effective in improving germination of *Iliamna rivularis* (Douglas ex Hook.) Greene (Malvaceae) in an experiment that compared 3 treatments.

Mechanical scarification (part of the seedcoat removed) improved germination, but not as much as the combination of boiling the seeds for 120 s plus stratifying them 28 d at 4°C. Germinant from the boiling plus stratification treatment appeared to be more vigorous. Impermeability of the seed coat is the main factor preventing germination, but the response of embryos to stratification may suggest some physiological dormancy (Himanen *et al.,* 2012).

Breaking photo dormancy: Seeds that either require light or dark conditions for germination are termed photodormant. The basic mechanism of light sensitivity in seeds involves phytochrome. Exposure of imbibed seed to red light (660-760 nm) usually stimulates germination, while far-red light (760-800 nm) or darkness causes a physiological change that inhibits germination. This was first demonstrated in the classic studies by Borthwick and co-workers at USDA in Beltsville MD using lettuce seeds. This established the concept of photoreversibility and eventually the discovery of the different forms of phytochrome. For some seeds, there is a distinct light and temperature for alleviating photodormancy.

A light requirement can be offset by cool temperature and sometimes by alternating temperatures. Seeds may also lose their requirement for light after a period of dry storage. In some cases, very low fluence rates are required to induce germination as in Celosia (Ferreira *et al.* 2012). In other cases, increasing the irradiance level (up to 150 mmol./ sec/m^2) impacts the time required to satisfy photodormancy. This can be seen in common bedding plants such as Begonia and Impatiens.

After-ripening(AR) : It is the time required for seeds in dry storage to loose dormancy. It is the general type of primary dormancy found in many freshly harvested seeds of herbaceous plants. Concept of seed AR suggested that this process triggers a widening or increasing sensitivity of seeds to environmental conditions, promoting germination, at the same time as it narrows or decreases sensitivity to conditions that repress germination (Finch-Savage and Leubner-Metzger, 2006).

Seed AR is determined by moisture and oil content, seed covering structures, and temperature, and requires seed moisture contents above a threshold value (Manz *et al.,* 2005). The main seed AR effects can be grouped as: (i) a widening of temperature range for germination (Oracz *et al.,* 2007); (ii) a lowering of ABA level and sensitivity plus a rise in sensitivity to gibberellins (GAs) or loss of requirement for GAs (Cadman *et al.,* 2006); (iii) a loss of light requirement for germination of seeds that do not germinate in darkness (Derks and Karssen, 1993) and an increase in seed sensitivity to light in seeds that do not germinate even with light (Batlla and Benech-Arnold,2005); (iv) a loss of nitrate requirement (Alboresi *et al.,* 2005); and (v) an accelerated germination velocity (Finch-Savage and Leubner-Metzger, 2006; Holdsworth *et al.,* 2008).

However, although the need for AR is well known in several species,it has been hardly studied at the molecular level with respect to changes induced by AR signals in dry viable seed and their impact during imbibition (Holdsworth *et al.,* 2008). The non-imbibed seeds (dry seeds), characterized by a low moisture level, are competent for both transcription and translation. Thus, AR process in viable dry seeds can positively or

negatively alter the level of several transcripts (Finch-Savage *et al.,* 2007; Leymarie *et al.,* 2007) and proteins. It is probable that there are zones in dry seed where moisture level is relatively high (i.e. above the threshold) to allow these alterations (Manz *et al.,* 2005). This partial and localized imbibitions environment was called low hydration by Holdsworth *et al.* (2008). The conditions that generate optimal low hydration values for seed AR have been determined (Leubner-Metzger, 2005). Likewise, complex and specific gene networks related to seed AR were recently updated (Holdsworth *et al.,* 2008).

Many plant hormones are involved in germination (Kucera *et al.,* 2005). Among these, GAs have long been known as stimulators and ABA as an inhibitor (Finkelstein *et al.,* 2008). However, role of ethylene (ET) seems less obvious than that of ABA and GAs, since intervention of ET during maintenance of seed dormancy and during the transition from dormancy to germination involves a complex network with many steps still to be clarified (Vandenbussche and Van der Straeten, 2007). Thus, opinions vary concerning the developmental stage during which ET regulates dormancy.

Some suggest that ET acts minimally during dormancy inception and that its major action is during imbibition to terminate dormancy and/or initiate germination (Matilla and Matilla-Va´zquez, 2008). In studies using ET response mutants of *Arabidopsis*, endogenous ET promoted seed germination by decreasing sensitivity to endogenous ABA (Beaudoin *et al.,* 2000). The ET appears to be a negative regulator of ABA during germination (Ghassemian *et al.,* 2000).

In short, ET seems to act antagonistically against ABA during dormancy termination but acts in concert with GAs to promote these transitional changes. Although ET and GAs work together in the process of radicle emergence, the participation of GAs appears to be quantitatively and qualitatively more important. The etr1-2 mutation confers dominant ET insensitivity and as a consequence results in mature seed populations that exhibit more pronounced primary dormancy (Chiwocha *et al.,* 2005).

Moreover, etr1-2 mutation disrupts ABA homeostasis, and auxin, cytokinin, and GA pathways are all affected in mutant seeds (Chiwocha *et al.,* 2005). Although signs of seed germination become visible with radicle emergence, it is unquestionable that during the maturation period (Holdsworth *et al.,* 2008), imbibition (Yamaguchi *et al.,* 2004; Finch- Savage and Leubner-Metzger, 2006), and dry storage (Holdsworth *et al.,* 2008) of seed a series of preparatory processes occur to break seed coats. However, identity of these processes and their hormonal regulation is far from being known in detail at the molecular level (Kucera *et al.,* 2005). Similarly, there are major gaps in our knowledge of the control of molecular mechanisms that participate in the reduction and elimination of dormancy, as in case of AR, a temporally and environmentally regulated process in dry seed, which determines the germination potential and loss of dormancy (Carrera *et al.,* 2008).

In anhydrobiotic conditions of after-ripening, nonenzymatic mechanisms would be good candidates for playing a role in seed dormancy release (Bazin *et al.,* 2011). Oxygen can diffuse within glasses, such as the vitreous cytoplasm at low seed moisture levels, and ultimately lead to reactive oxygen species (ROS) accumulation, as has been shown by Oracz *et al.* (2007). They demonstrated that ROS caused lipid peroxidation and carbonylation of a specific subset of proteins that were associated with seed dormancy release. However, lipids and proteins are not the only targets of oxidative modifications by ROS.

Nucleic acids, in particular, are very sensitive to free radicals. Oxidative DNA damage causes mutations, which have been associated with many heritable diseases and aging in mammals (Radak and Boldogh, 2010). The RNA can also be oxidized by ROS, particularly by hydroxyl radicals, and RNA has been shown to be much more vulnerable to oxidative damage than DNA (Kong and Lin, 2010).The most prevalent oxidized base of RNA is guanine, whose one electron oxidation gives 8-oxo-7,8-dihydroguanine (8-OHG). It has been proposed that RNA containing guanine could have antioxidant functions, thus preventing oxidative damage to genomic DNA (Kong and Lin, 2010). Moreover, mRNA oxidation is suspected to cause premature termination of translation and, thus to affect protein synthesis (Tanaka *et al.,* 2007).

It has been shown that de novo transcription is not essential for early stages of germination (Rajjou *et al.,* 2004), which suggests that pool of stored proteins or of mRNA that is translated into proteins during early steps of seed imbibition governs dormancy expression and germination potential. Similarly, degradation of specific mRNAs has also long been implicated in breaking of seed dormancy and it has been demonstrated that degradation of a specific subset of mRNAs might be a prerequisite to germination (Howell *et al.,* 2009; Xu and Chua, 2009). Consequently, modifications of stored mRNA during after-ripening would have the potential to regulate mRNA translation and/or mRNA degradation in early steps of seed imbibition and then to subsequently program cell functioning toward germination or dormancy maintenance.

This type of dormancy is often transitory and disappears during dry storage, so it generally not a

problem by the time the grower sows the seeds. It is however, a problem with seed testing laboratories requiring immediate germination. The time for dormancy release for hardwickii seeds in dry storage is shorter at warmer temperatures (180 days at 17°C vs. 75 days at 37°C). In seed testing laboratories, such seeds respond to various short-term treatments, including short periods of chilling, alternating temperatures, and treatment with potassium nitrate and gibberellic acid (AOSA, 1993).

Stratification: Dormant seeds are capable of remaining alive in the hydrated state for extended periods of time without losing vigour, until environmental cues or after-ripening result in release of dormancy. Seeds with intermediate and deep physiological dormancy are characterized by a requirement for a one to three (sometimes more) month period of chilling, while in an imbibed and aerated state. This is a common dormancy type tree and shrub seeds and some herbaceous plants of the temperate zone. Seeds of this type ripen in the fall, overwinter in the moist leaf litter, and germinate in the spring.

This requirement led to horticultural practice of stratification, in which seeds are placed between layers of moist sand or soil in boxes (or in the ground) and exposed to chilling temperatures, either out-of-doors or in refrigerators. Temperature is the most important factor controlling stratification. The most effective temperature near freezing (1-10°C). The time required to stratify seeds results from the interaction of the genetic characteristics of the seed population, seed development environment and the stratification environment (temperature).

William *et al.* (2010), investigated the possible role of the regulatory subunit of the sucrose non-fermenting-related kinase complex, MtSNF4b, in dormancy of *Medicago truncatula* seeds. Expression of MtSNF4b and its involvement in a high-molecular-weight complex were found in dormant seeds, whereas imbibitions of fully after-ripened, non-dormant seeds leads to dissociation of the complex. MtSNF4b is capable of complementing the yeast [DELTA]snf4 mutant and of interacting with the MtSnRK1 [alpha]-subunit in a double hybrid system.

Transcriptome analyses on freshly harvested and after-ripened RNAi Mtsnf4b and wild-type embryos implicate MtSNF4b in defense response in hydrated dormant embryonic tissues, affecting expression of genes encoding enzymes of flavonoid and phenylpropanoid metabolism, WRKY transcription factors and pathogenesis-related proteins. Silencing MtSNF4b also increased the speed of after-ripening during dry storage, an effect that appears to be related to a change in base water potential. No significant difference in ABA content or sensitivity was detected between mutant and wild-type seeds.

Pharmacological studies using hexoses and sugar analogs revealed that mannose restored germination behavior and expression of the genes PAL, CHR and IFR in RNAi Mtsnf4b seeds towards that of the wild-type, suggesting that MtSNF4b might act upstream of sugar-sensing pathways. Overall, the results suggest that MtSNF4b participates in regulation of a constitutively activated defense response in hydrated, dormant seeds.

Gibberellins (GAs) and potassium nitrate (KNO_3) are used for breaking seed dormancy and promoting seed germination. Mostly, gibberellins are directly implicated in the control and promotion of germination. A biochemical reaction known to be enhanced by GA is the synthesis of hydrolases (especially amylase) in the endosperm of cereal grains. Its breakdown is generally assumed to be an essential process of germination (Kolumbina *et al.*, 2006). GA stimulates seed germination via amylase synthesis (Finch-Savage and Leubner, 2006).

Potassium nitrate clearly stimulates the germination of dormant seeds (Alboresi *et al.*, 2005). KNO_3 is the most widely used chemical for promoting germination. Solutions of 0.1-0.2% KNO_3 are common in routine germination testing and are recommended by the Association of Official Seed Analysts and the International Seed Testing Association for germination tests of many species. The effect of KNO_3 was discovered when it was proven that Knop's solution encourages germination of some plant species. Recently, it was confirmed that potassium nitrate interacts with light and temperature.

Breaking of Combinational/Double Dormancy

Morpho-physiological dormancy (MPD) : Flower genera containing seeds that have combinational dormancy (these species require a period of warm stratification for continued development of an immature embryo or to stimulate radicle growth and cold stratification for an endogenous, physiological dormancy prior to germination). The Amaryllidaceae have underdeveloped linear embryos that are fully differentiated, thus they need to grow before the seed germinates. Nevertheless, data on embryo growth requirements are particularly scarce in this family.However, Copete *et al.* (2011), concluded that seeds of N. hispanicus have deep simple epicotyl morphophysiological dormancy (MPD), with dormancy formula C1bB (root)-C3 (epicotyl).

This includes epicotyl dormancy, one of the most fascinating dormancy patterns found in seeds. Seeds with morphophysio-logical dormancy may require simply warm (> 15°C) or cold (1-10°C) conditions

during which time the embryo develops and then breaks physiological dormancy. More complex forms of morphophysiological dormancy require extended cycles of warm and cold temperatures to satisfy dormancy. In some species, there is a difference between cultivated and wild forms with respect to combinational dormancy. For example, in Anemone, cultivated 'de Caen' seeds showed only morphological dormancy (required only warm treatment), while wild populations of *A. coronaria* displayed morphophysiological dormancy and required warm followed by cold stratification .

Epicotyl- dormancy: Seeds with epicotyl dormancy have separate dormancy conditions for the radicle and epicotyls. These species fall into two subgroups. In one group, only the epicotyl is dormant.

Breaking of Secondary Dormancy

In nature, primary dormancy is an adaptation to control the time and conditions for seed germination. Secondary dormancy is a further adaptation to prevent germination of an imbibed seed when environmental conditions are not favorable for seedling growth. These conditions can include unfavorable temperatures, prolonged light or darkness, water stress, or anoxia. These are involved in the seasonal rhythms (conditional dormancy) and prolonged survival of weed seeds in soil banks (Baskin and Baskin 1997).

If germinated at 25°C, seeds required light, but if imbibed for two days in the dark, excised embryos germinated immediately, illustrating that only primary dormancy was present. If imbibition continued for as long as eight days, however, excised embryos did not germinate since they had developed secondary dormancy. Release from secondary dormancy can be induced by chilling, sometimes by light, and in various cases, treatment with germination-stimulating hormones, particularly gibberellic acid. *Nemophilla* seeds require darkness to germinate. If these seeds are exposed to light for a period of time, they enter secondary dormancy and will no longer germinate in the dark without a chilling treatment.

For some species, such as pansy (Viola), germination at high temperatures (>25°C) can induce thermodormancy. This should not be confused with the thermal inhibition most seeds experience when the temperature exceeds the maximum temperature for germination. Seeds experiencing thermodormancy will not germinate when the temperature returns to near optimum temperatures, while thermal-inhibited seeds will germinate when temperatures are lowered. Commercially important crops that are prone to thermodormancy (such as summer-sown pansy) can be primed prior to sowing to avoid germination problems.

CONCLUSION

The seed development and germination environment plays a critical role in dormancy induction of a particular seed lot and can complicate determining the dormancy status of a species . This review has been an attempt to bring together dormancy information concerning flower seeds. Hopefully, it will serve as a stimulus to further refine our knowledge concerning dormancy in these important economic crops as additional scientific information becomes available. The main purpose of this study was to evaluate economical and simple techniques to remove or reduce dormancy effects in seeds of flower.

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Current Horticulture **5**(2): 15–21, July–December 2017 ISSN: 2347-7377; RNI No.: UPENG03865/24/1/2013-TC

Characterization of Nagpur mandarin *(Citrus reticulata)* growing soils in central India

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Received: December 2015; **Revised:** January 2017

ABSTRACT

An experiment was conducted to find out the role of soil in sustaining quality fruit production of Nagpur mandarin (*Citrus reticulata* Blanco). A total of six healthy (10-12-years-old trees) orchards of Nagpur mandarin representing different no cations were identified and characterized through depth-wise analysis of soil physico-chemical properties including soil fertility. The results showed that soils were medium to very deep. The soil was brown (10YR 5/3) to grayish brown (10YR 5/2). The soil structure was sub angular blocky, hard consistency in dry condition and firm in moist condition coupled with neutral to moderately alkaline. The organic carbon in soil was found to be very low to high (1.60-8.91 g/kg). The calcium carbonate in soil increased with depth (2.11-14.21%) and predominantly calcareous in nature. The available nitrogen ($KMnO_4$-N) was low (170.2-232.0 Kg/ha), phosphorus (Olsen-P) was very low to high (5.0-343.3 kg/ha), potassium (NH_4OAc-K) was low to high (150.3-612.0 kg/ha) and sulphur ($Cacl_2$-S) was low to moderate (8.2-14.6 kg/ha). The exchangeable calcium and magnesium (NH_4OAc-extractable) in soil varied from 30.6 to 39.8 cmol (p+)/kg, 6.0 to 7.9 cmol (p+)/kg respectively. The DTPA extractable micronutrients in soil varied from low to moderately high for zinc (0.31-1.66 mg/kg), moderately high to high for iron (9.6-24.5 mg/kg), moderately high to very high for copper (0.69-3.49 mg/kg) and moderately high to very high for manganese (6.50-16.3 mg/kg), respectively. Based on climatic condition and soil site suitability criteria for citrus all the pedons were found marginally suitable for Nagpur mandarin plantation with limitations of temperature, depth and presence of $CaCO_3$ in high amount.

Key Words: Soil profile, Nagpur mandarin, Morphological properties, Physical properties, Chemical properties

Citrus is globally one of the leading fruit crop with a total production of 112.8 million tonnes (Mt), maximum production being 32.6 Mt in Asia, followed by 25.8 Mt in South America (Srivastava, 2014). Countrywise, Brazil tops the list with a total production of 19.9 Mt, followed by USA and India (Srivastava and Singh, 2008). The highest global citrus production comes from soils represented by order Alfisol, Ultisols, Entisols and Inceptisol (Srivastava and Singh, 2002; 2003; 2004). In India, citrus is grown in 5.63 lakh with a total production of 56.8 lakh tonnes and productivity 10.1 tonnes/ha (Srivastava and Singh, 2009). In recent past, Nagpur mandarin has been subjected to various kinds of abiotic stress (Dass *et al.* 1998), nature and properties of soils govern their success to great an extent (Srivastava and Singh 2001a, 2001b, 2001c; Ghagare, *et al.*, 2017) considering the limited availability of land for citrus (Srivastava and Kohli, 1997: Srivastava and Patil, 2014). Soil suitability classification is strongly advocated to appraise the most suitable soils for Nagpur mandarin, where we need to raise the productivity level (Srivastava and Malhotra 2014). However, attempts made in the past have demonstrated some thumping success in order to streamline the most deciding criteria responsible for success of Nagpur mandarin in Central India (Srivastava and Kohli, 1997: Srivastava *et al.*, 2008). This formed the very basis of our study to evaluate some representative mandarin-growing soil properties, contributing towards higher orchard performance under climatic conditions in central India.

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MATERIALS AND METHODS

The study was undertaken during 2015-2016 to assess soil site suitability for Nagpur mandarin grown in Umred and Bhiwapur blocks of Nagpur, the epicenter of Nagpur mandarin belts. As many six Nagpur mandarin orchards were selected and soil samples were collected depth-wise. Different soil properties, maximum up to 1.5 m long, 1 m wide and 1.5 feet deep were dug at all the selected six sites. Characteristics of pedon and also depth-wise soil characteristics were studied for morphological characters in the field as per the procedures laid out in Soil Survey Manual (Soil Survey Staff, 1998). The soil profile samples from various depths were collected for physical and chemical analysis. About 1.5 kg representative soil sample from each horizons at various depths were collected in cloth bag for laboratory characterization.

The bulk soil samples were allowed to air dry in shade and then weighed soil were passed through 2 mm and sieve and used for laboratory analysis. The soil samples were subjected to morphological characteristics (color, texture, structure, consistence and effervescence) chemical properties (p^H, EC, $CaCO_3$ and organic carbon) and available pool of nutrients ($KMnO_4$-N, Olsen-P, NH_4OAc-K, $CaCl_2$-S, NH4OAc-Ca, NH_4OAc-Mg, DTPA-Fe, DTPA-Mn, DTPA-Zn and DTPA- Cu).

All the soil morphological characteristics were determined as per guidelines proposed Soil Survey Staff (1998). Soil pH and electrical conductivity were determined in soil suspension (1: 2.5 soil: water suspension) by a glass electrode pH meter and conductivity bridge (Jackson, 1967). Organic carbon was determined by the Walkley and Black rapid titration procedure by using 0.5 mm sample (Jackson, 1967). The calcium carbonate was estimated by rapid titration method from different size aggregate (Piper, 1966). Exchangeable calcium and magnesium were determined by using 1 N KCl triethanolamine buffer solution (p^H 8.2) and titrating the leachate with standard EDTA solution using mureoxide and Erichrome Black T (EBT) as an indicator (Richard, 1954). The available N was determined by alkaline permanganate method as described by Subbiah and Asija (1956). The soil was extracted with Olsen's reagent 0.5 m $NaHCO_3$ of pH 8.5 and in the extract, available P was estimated colorimetrically (Olsen, 1954). The available potassium was determined by flame photometer method using neutral ammonium acetate as extractant (Jackson, 1967). The sulphur was estimated by extracting soil with Morgan's solution and the resultant turbidity was measured colorimetrically using blue filter (Chesnin and Yien, 1951). The DTPA (Diethylene triamine penta-acetic acid, 0.005 M) Fe, Mn, Zn and Cu were determined as per the procedure outlined by Lindsay and Norvell, (1978) using Atomic Absorption Spectrophotometer.

RESULTS AND DISCUSSION

Soil profiles were subjected evaluation of different soil morphological, physical and chemical properties including soil fertility parameters.

Morphological evaluation

Morphology of soil has profaning effects on entire range of soil properties. The surface horizons of soils had brown (Pedon 3, 5, 6), yellowish brown (Pedon 1), grayish brown (Pedon 2) and grey in colour (Pedon 4). The soil of subsurface horizons of Pedon 3 and 5 showed pale brown to light grey and Pedon 6 grayish brown and brown colour in Pedon 1and 2 (Table 1). All pedons have clay texture, smectite mineralogy, organic carbon and drainage condition. However, subsurface horizon of Pedon 5 and Pedon 6 grey colour (rubbed) due to presence of powdery lime resulting in variegated colour. The variation in soil colour was a function of chemical and mineralogical composition, topographic position, and textural makeup and moisture regimes of the soils. The results are in conformity with those earlier reported by Thangasamy *et al.* (2005).The soil profiles were observed predominantly clay in nature with sub surface being clay loam in Pedon 6, while all the soil profiles were observed having sub-angular blocky soil structure. On calcareous nature of soil profiles was evident from strong to violent effervescence with 10% dilute HCl. In earlier studies, Srivastava and Singh (2001a) reported that form of $CaCO_3$ and its presence within the rooling depth are very important with regard to regular flowering in Nagpur mandarin orchards.

Evaluation of physical properties

The soil pH varied within 7.42-7.53 in Pedon 1,7.62-7.63 in Pedon 2, 7.74-8.07 in Pedon 3, 7.21-7.82 in Pedon 3, 7.21-7.82 in Pedon 4, 7.80-8.14 in Pedon 5 and 7.00-7.76 in Pedon 6, suggesting that though, soil pH is on alkaline side, but still manageable from fertility point of view. While EC on an index of soil appeared to vary from 0.28-0.37 dS/m in Pedon, 0.26-0.33 in Pedon 2, 0.15-0.19 in Pedon 3, 0.25-0.28 dS/m in Pedon 4, 0.25-0.35 dS/m in Pedon 5 and 0.28-0.39 dS/m in Pedon 6. Citrus grows and fruits well in p^H range of 6.5-7.5, however lower limit is 4 and upper limit is 8.5. The electrical conductivity of soil should be below 1 dS/m and calcium carbonate content below 10 per cent. (Srivastava and Kohli, 1997). Calcium Carbonat, though was on a safe side (up to 9.2%) except in some soil profiles (Pedons 3, Pedon5 and Pedon 6) reading $CaCO_3$ as high as 14.2% but still supposed to produce no

Table 1. Morphological characteristics of different soil pedons growing Nagpur mandarin

Depth (Cm)	Munsell colour	Texture	Structure	Consistence			Effervescence (10% dilute HCl)
	Dry			Dry	Moist	Wet	
Pedon 1: Clayey, Fine, Calcareous, Typic Haplustert							
0-30	10YR 5/4	Clay	Sbk	sh	fl	s	Slight
30-60	10YR 5/3	Clay	Sbk	sh	F	ss	Strong
60-90	10YR 5/3	Clay	Sbk	sh	vfl	ss	Strong
90-120	10YR 5/2	Clay	Sbk	sh	F	ss	Strong
Pedon 2: Clayey, Fine, Smectitic, Calcareous, Vertic Haplustept							
0-30	10YR 5/2	Clay	Sbk	sh	F	s	Strong
30-60	10YR 5/2	Clay	Sbk	sh	F	s	Strong
60-90	10YR 5/3	Clay	Sbk	sh	F	ns	Strong
90-120	10YR 5/4	Clay	Sbk	sh	F	ns	Strong
Pedon 3: Clayey, Fine, Smectite, Calcareous, Vertic Haplustert							
0-30	10YR 5/3	Clay	Sbk	sh	F	p	Strong
30-60	10YR 7/2	Clay	Sbk	sh	F	p	Strong
60-90	10YR 6/3	Clay	Sbk	sh	F	vp	Violent
90-120	10YR 5/3	Clay	Sbk	sh	F	vp	Violent
Pedon 4: Clayey, Fine, Smectite, Calcareous, Typic Haplustept							
0-30	10YR 5/1	Clay	Sbk	sh	F	s	Slight
30-60	10YR 5/2	Clay	Sbk	sh	F	ss	Slight
60-80	10YR 5/4	Clay	Sbk	sh	F	ns	Strong
Pedon 5: Clayey, Fine, Smectite Calcareous, Typic Haplustept							
0-30	10YR 5/3	Clay	Sbk	sh	fl	ss	Slight
30-60	10YR 4/2	Clay	Sbk	sh	F	ss	Strong
60-90	10YR 4/2	Clay	Sbk	sh	efl	ns	Strong
90-110	10YR 5/1	Clay	Sbk	sh	efl	ns	Violent
Pedon 6: Clayey, Fine, Smectite, Calcareous, Vertic Haplustert							
0-30	10YR 5/3	Clay	Sbk	sh	F	ss	Strong
30-60	10YR 5/2	Clay	Sbk	sh	F	ss	Strong
60-90	10YR 5/2	Clay	Sbk	sh	F	ss	Strong
90-120	10YR 5/1	Clay loam	Sbk	sh	fl	ss	Violent
120-150	10YR 5/1	Clay loam	Sbk	sh	F	ns	Violent

Note: Symbols used are according to Soil Survey Manual notations (Soil Survey Staff, 1998).

adverse effect plan performance. Organic carbon is such a soil property which has a strong cascading effect on most of the soil physico-chemical properties (Srivastava and Singh 2003).

Organic carbon in these soil profiles showed a vertical decline in its concentration. Interestingly, organic carbon was observed decreasing from 4.60 to 3.04 g/kg in Pedons, 5.50 to 1.60 g/kg in Pedon 2, 7.20 to 4.12 g/kg in Pedon 3, 5.10 to 4.30 g/kg in Pedon 4, 8.91 to 7.51 g/kg in Pedon 5 and 7.30 to 5.23 g/kg in Pedon 6. And these soil profiles displayed a much higher soil organic carbon content, especially in their rhizosphere soil depth.

Evaluation of fertility status

Soil fertility status is considered most responsive to any management input (Srivastava and Malhotra-2014). The $KMnO_4$-N in soil varied from 168.70 to 232.02 kg/ha. In surface samples, it varied from 220.7 to 232.0 kg/ha. The $KMnO_4$-N showed a decreasing trend with depth in all the soil profiles. All soil profiles had low to medium $KMnO_4$-N. The higher $KMnO_4$-N was observed in Pedon 2 and 4. The Olsen-P on the other hand, varied from 5.01 to 34.35 kg/ha but in surface layers it ranged from 22.70 to 34.35 kg/ha and was very low to high. The higher Olsen-P phosphorus was observed in Pedon 3 and Pedon 1. The NH_4OAc-K varied from 150.3 to 612.0 kg/ha. In surface layer, the NH_4OAc-K varied

Table 2. Chemical properties of different soil pedons growing Nagpur mandarin

Depth (cm)	pH (1:2)	EC (dS m^{-1})	CaCO3 (%)	OC (g kg^{-1})
Pedon 1: Clayey, Fine, Smectitic, Calcareous, Typic Haplustert				
0-30	7.45	0.28	2.85	4.60
30-60	7.50	0.36	3.70	4.20
60-90	7.53	0.37	5.35	3.10
90-120	7.42	0.34	5.45	3.04
Pedon 2: Clayey, Fine, Smectitic, Calcareous, Vertic Haplustept				
0-30	7.62	0.27	2.89	5.50
30-60	7.63	0.26	4.5	2.50
60-90	7.62	0.31	7.6	2.50
90-120	7.60	0.33	8.8	1.60
Pedon 3: Clayey, Fine, Smectite, Calcareous, Vertic Haplustert				
0-30	7.74	0.17	8.1	7.20
30-60	8.07	0.19	9.2	5.70
60-90	7.99	0.16	12.6	4.41
90-120	7.90	0.15	12.8	4.12
Pedon 4: Clayey, Fine, Smectitic, Calcareous, Typic Haplustept				
0-30	7.60	0.28	2.1	5.10
30-60	7.82	0.25	2.2	4.50
60-80	7.21	0.26	4.89	4.30
Pedon 5: Clayey, Fine, Smectite, Calcareous, Typic Haplustert				
0-30	7.80	0.35	2.56	8.91
30-60	8.27	0.31	6.43	7.80
60-90	7.89	0.25	8.2	7.60
90-110	8.14	0.33	11.67	7.51
Pedon 6: Clayey, Fine, Smectitic, Calcareous, Vertic Haplustert				
0-30	7.19	0.33	4.5	7.30
30-60	7.07	0.33	6.56	7.60
60-90	7.76	0.28	7.5	6.60
90-120	7.74	0.39	12.45	6.00
120-150	7.00	0.37	14.2	5.23

from 216.8 to 616.00 kg/ha and later decreased with depth in all the soil profile except in Pedon 1 and Pedon 2. This soil was rated as low to very high for NH_4OAc-K and all the Pedons were in optimum level for NH_4OAc-K. The CaCl2-S was low to moderate (8.2 - 17.8 mg/kg). No trend observed with depth for availability of $CaCl_2$-S. The exchangeable calcium in soil varied from 30.6 to 39.8 cmol (p+)/kg. The KCP-Ca was increased with increase in depth. The KCl-Mg in soil varied from 6.0 to 7.9 cmol (p+)/kg. The maximum KCl-Mg content was observed in 30-60 cm depth of Pedon 5 and minimum in 60-90 cm depth of Pedon 1. The KCl-Mg value was observed decreasing with the increase in soil depth.

Micronutrients have a significant role in fruit yield as well as fruit quality (Srivastava *et al.,* 2008). The DTPA extractable-Zn in soils varied from 0.30 to 1.66 mg/kg, which was low to moderately high and higher values were observed in Pedon 5. The DTPA-Cu varied from 0.69 to 3.49 mg/kg (moderately high to high in category). DTPA-Cu content was higher in surface samples decreased with depth. DTPA-Fe content ranged from 9.6 to 24.5 mg/kg, moderately high to very high and decreased with depth. The DTPA-Mn varied from 4.80 to 16.4 mg/kg, moderately high to very high in category in surface soils (Table 4).

Suitability appraisal

The ideal soils for citrus is deep (above 150 cm), well-drained and well-structured silty clay to clayey with a lot of organic matter. The physico-chemical characteristics of soil influenced the yield and quality parameters of citrus, which are pH, EC, texture, structure, content of organic matter and water-retention

Table 3. Available supply of different macronutrients in soil depthwise in different Nagpur mandarin growing pedon

Pedon	Depth (cm)	$KMnO_4$-N (kg/ha)	Olsen-P (kg/ha)	NH_4OAc-K (kg/ha)	$CaCl_2$-S (mg/kg)	KCl-Ca (cmol (p+)/kg)	KCl-Mg (cmol (p+)/kg)
Pedon 1: Clayey, Fine, Smectitic, Calcareous, Typic Haplustert							
1	0-30	223.2	27.2	325.6	11.7	30.6	7.8
	30-60	211.5	15.2	291.2	11.8	32.5	6.2
	60-90	180.8	12.6	224.0	10.2	32.6	6.0
	90-120	168.7	12.4	251.21	9.6	33.5	6.1
Pedon 2: Clayey, Fine, Smectitic, Calcareous, Vertic Haplustept							
2	0-30	232.0	24.1	257.6	13.2	36.9	7.0
	30-60	200.2	23.0	224.0	12.7	38.1	7.2
	60-90	172.8	13.8	212.8	11.9	38.2	7.1
	90-120	170.3	11.9	235.2	11.3	39.8	6.9
Pedon 3: Clayey, Fine, Smectite, Calcareous, Vertic Haplustert							
3	0-30	224.8	34.3	364.2	13.8	32.3	7.3
	30-60	213.2	28.7	280.0	11.4	33.0	7.5
	60-90	200.7	20.5	168.0	11.5	34.5	6.4
	90-120	199.2	20.1	167.1	10.4	34.1	7.0
Pedon 4: Clayey, Fine, Smectitic, Calcareous, Typic Haplustept							
4	0-30	230.4	23.2	235.4	14.6	34.2	7.3
	30-60	218.2	17.3	212.0	12.9	35.6	6.6
	60-80	203.9	9.1	200.8	9.2	36.2	6.3
Pedon 5: Clayey, Fine, Smectite, Calcareous, Typic Haplustert							
5	0-30	220.7	24.8	612.0	12.8	34.4	7.8
	30-60	218.2	21.6	588.2	11.5	35.2	7.9
	60-90	225.2	19.4	476.2	12.6	35.1	7.4
	90-110	200.7	15.4	420.5	9.5	38.8	7.1
Pedon 6: Clayey, Fine, Smectitic, Calcareous, Vertic Haplustert							
6	0-30	225.7	22.7	216.8	12.4	37.1	7.2
	30-60	218.2	17.7	168.4	11.8	38.6	7.1
	60-90	184.5	17.3	160.0	10.6	38.4	7.0
	90-120	188.0	7.1	152.3	9.4	38.4	6.4
	120-150	170.2	5.0	150.3	8.2	38.9	6.9

capacity (Srivastava and Singh, 2001a). Citrus grows and fruits well in soil pH range of 6.5-7.5, however lower limit is 4 and upper limit is 8.5 frequently encountered . The electrical conductivity of soil should be below 1 dS/m and calcium carbonate content below 10%. (Srivastava and Kohli, 1997).

As per criteria given by NBSS & LUP, (1994), all pedons were marginally suitable for citrus cultivation. The climatic characteristics in the study area were moderately suitable under total rainfall condition, highly suitable in length of growing period, *i.e.* 240-265 days and marginally suitable under mean temperature in growing season for citrus. As per soil site characteristics, slope of study area was ideal for citrus cultivation, *i.e.* 1 - 3%, while drainage of study area was moderately well and shows moderate limitation. As per the soil texture all pedon were suitable for plantation of citrus. According to soil depth, all pedons were moderately to marginally suitable for citrus plantation. All soil pedons were found to be marginally suitable for citrus cultivation inspite of severe limitation of calcium carbonate in Pedon 2, Pedon 3, Pedon 4, Pedon 6 which directly or indirectly affected the soil fertility which under certain management condition, can be made suitable for cultivation of citrus.

Thus, all the pedons were classified suitable under certain management condition like land configuration for plantation of citrus with management of nutrients required by the crop, high content of total calcium carbonate in pedons can be made suitable for plantation of citrus using preferably organic manuring and with proper care for soil fertility constrataints.

Table 4. Available supply of micronutrients in soil depth-wise in different Nagpur mandarin-growing Pedons

Depth (cm)	DTPA-Cu (mg kg^{-1})	DTPA-Fe (mg kg^{-1})	DTPA-Zn (mg kg^{-1})	DTPA-Mn (mg kg^{-1})
Pedon 1: Clayey, Fine, Smectitic, Calcareous, Typic Haplustert				
0-30	1.88	21.2	0.59	16.3
30-60	1.73	19.4	0.37	15.4
60-90	1.54	17.3	0.38	12.2
90-120	1.45	17.2	0.36	11.2
Pedon 2: Clayey, Fine, Smectitic, Calcareous, Vertic Haplustept				
0-30	2.10	22.4	0.78	16.4
30-60	0.73	20.1	0.65	12.6
60-90	1.90	16.4	0.42	11.7
90-120	2.30	13.3	0.30	11.2
Pedon 3: Clayey, Fine, Smectite, Calcareous, Vertic Haplustert				
0-30	2.67	18.0	0.43	8.78
30-60	1.73	20.4	0.35	5.44
60-90	1.66	19.0	0.38	4.80
90-120	1.25	18.2	0.36	5.02
Pedon 4: Clayey, Fine, Smectitic, Calcareous, Typic Haplustept				
0-30	2.15	19.5	1.02	15.6
30-60	1.52	18.2	0.91	13.2
60-80	1.51	16.4	0.70	10.3
Pedon 5: Clayey, Fine, Smectite, Calcareous, Typic Haplustert				
0-30	3.49	24.5	1.66	15.2
30-60	2.33	22.6	0.91	12.4
60-90	2.12	15.2	0.89	10.5
90-110	2.29	12.5	0.78	10.2
Pedon 6: Clayey, Fine, Smectitic, Calcareous, Vertic Haplustert				
0-30	1.23	15.4	0.38	9.67
30-60	0.84	15.2	0.33	8.21
60-90	0.69	12.5	0.32	7.54
90-120	0.93	10.2	0.33	7.50
120-150	0.98	9.6	0.31	6.50

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Current Horticulture **5**(2): 22–24, July–December 2017 ISSN: 2347-7377; RNI No.: UPENG03865/24/1/2013-TC

Evaluation of mango (*Mangifera indica*) genotypes for fruit and quality characters

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Received: January 2016; **Revised:** March 2017

ABSTRACT

Twenty mango (*Mangifera indica* L.) genotypes were evaluated for fruit characters and quality attributes at Horticultural Research Farm, Department of Horticulture, B A College of Agriculture, Anand Agricultural University, Anand, during 2013. There was a variation among genotypes. The maximum fruit yield (100.25 kg) and fruit length (11.02 cm) were recorded in Totapuri, whereas GAMLS-2, showed maximum fruit width (7.49 cm) and fruit volume (535.53 cc). The fruits of Vasi Badami were heaviest (367.67 g) with pulp weight (222.48 g). Minimum peel weight (16.45 g) and stone weight (14.03 g) were found in GAMLS-34. While, maximum pulp: stone ratio (11.88) was observed in Amrutang. Maximum TSS (22.15%) and reducing sugar (8.96%) were recorded in Dashehari, whereas minimum acidity (0.P21%) was found in Amrapali. The heighest non-reducing sugar (11.34%) was observed in GAMLS-67, whereas maximum total sugar (18.05%) was found in GAMLS-30.

Key Words: Evaluation, Genotypes, Fruit, Quality characters, Pulp weight, Reducing sugar, Total sugar

Mango (*Mangifera indica* L.) is a national fruit of India because of its excellent flavour, delicious taste, delicate fragrance and attractive colour. A number of varieties are cultivated in our country having diversity in flovour, taste and nutritive quality and vary with the variations in environment (Jagmohan and Bhutani, 1989). The information on genetic divergence is very useful for explorer, geneticists and breeders to conduct studies concerning germplasm collection, genetic erosion and use of accessions in breeding programmes (Dhillon *et al.*, 2007). Many cultivars are being grown in Gujarat, all the genotypes do not meet the requirement of an ideal commercial cultivar for consumer acceptability and to get greater remuneration. Hence, it is imperative to study the performance of different leading genotypes under Central Gujarat conditions. Keeping in view, a study was carried out to find out the variability prsent among its germplasm.

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MATERIALS AND METHODS

The study was carried out on pre-established mango orchard at Horticultural Research Farm, Department of Horticulture, B A College of Agriculture, Anand Agricultural University, Anand, during 2013. The evaluation was carried out for 20 mango genotypes viz. Amrapali, Amrutang, Dashehari, Kesar, Langra, Maddrashi Haphus, Mallika, Nileshan, Neelphanso, Ratna, Sonpari, Totapuri, Vanraj, Vasi Badami, GAMLS-2, GAMLS-29, GAMLS-30, GAMLS-34, GAMLS-67 and GAMLS-88. The experiment was laid out in a randomized block design with two replications using individual tree plant in each genotype. Performance of each genotype was evaluated for fruit and quality characters.

For fruit characters, five uniform and fully ripen fruits of each genotype were selected. Fruit length of five randomly selected fruits from each tree was measured with the help of a standard still scale, whereas width of fruits was measured with the help of Vernier

caliper and average was computed and expressed in centimeter. Volume of fruit was estimated by water displacement method. The pulp was extracted manually and the stone clean thoroughly. Then pulp, peel and stone were weighed on electronic balance and pulp: stone ratio was calculated. Total soluble solid was determined with the help of hand refractrometer (ranging from 0-32° Brix). Acidity was determined by alkali titration method (Ranganna,1979) and results were expressed in term of percentage. Sugar (reducing and non-reducing) were estimated by the titrimetric method of Lane and Eynon as described by Ranganna (1979).

Table 1. Fruit characterstics of mango genotypes

Genotype	Fruit yield (kg/tree)	Fruit length (cm)	Fruit width (cm)	Fruit volume (cc)	Fruit weight (g)	Pulp weight (g)	Peel weight (g)	Stone weight (g)	Pulp: stone ratio
Amrapali	43.75	8.59	5.44	169.87	142.21	123.03	21.90	23.95	5.14
Amrutang	59.50	9.91	5.50	352.21	233.74	187.38	25.23	15.79	11.88
Dashehari	95.50	8.09	4.41	209.10	169.48	106.58	22.57	21.76	4.91
GAMLS-2	16.25	9.62	7.49	535.53	228.42	137.60	27.48	28.76	4.79
GAMLS-29	82.25	3.96	3.71	149.50	166.79	103.53	21.68	15.50	6.68
GAMLS-30	15.50	6.33	5.10	160.47	210.85	137.68	36.39	32.60	4.22
GAMLS-34	44.25	8.25	4.24	208.03	145.80	96.63	16.45	14.03	6.90
GAMLS-67	28.50	9.80	6.52	296.99	241.94	128.18	38.15	39.01	3.29
GAMLS-88	37.50	6.43	4.21	151.57	156.59	68.93	41.03	21.63	3.19
Kesar	96.50	8.11	4.58	285.63	184.75	88.30	37.53	26.47	3.34
Langra	38.25	8.92	4.91	474.80	231.20	145.70	27.85	30.02	4.85
Maddrashi Haphus	52.50	7.14	3.64	382.20	163.55	109.82	21.08	29.65	3.71
Mallika	48.00	10.31	5.68	420.13	289.33	181.99	42.55	24.05	7.57
Nileshan	16.75	7.52	5.20	172.03	180.80	112.95	38.95	23.40	4.83
Nilphanso	34.75	7.61	4.65	199.78	153.33	106.35	18.33	23.83	4.47
Ratna	35.50	7.27	5.24	264.71	292.75	188.88	35.65	48.80	3.89
Sonpari	43.50	7.36	5.20	182.95	248.78	156.58	37.50	41.48	3.78
Totapuri	100.25	11.02	5.92	412.60	271.42	192.03	43.48	30.79	6.24
Vanraj	33.25	7.07	5.26	376.60	262.58	201.32	27.27	25.42	7.93
Vasi Badami	95.75	10.91	5.23	368.18	367.67	222.48	77.25	56.63	3.93
CD (P=0.05)	11.17	0.72	0.50	25.27	28.67	14.39	5.07	3.03	0.60

Table 2. Quality characters of mango genotypes

Genotype	TSS (%)	Acidity (%)	Reducing sugar (%)	Non reducing sugar (%)	Total sugar (%)
Amrapali	18.70	0.21	5.09	10.05	15.14
Amrutang	17.75	0.32	7.08	8.02	15.09
Dashehari	22.15	0.28	8.96	7.09	16.05
GAMLS-2	12.10	0.23	5.15	7.35	12.50
GAMLS-29	15.85	0.37	4.68	8.83	13.50
GAMLS-30	12.00	0.51	6.90	11.15	18.05
GAMLS-34	18.85	0.63	4.35	7.73	12.08
GAMLS-67	15.65	0.24	3.60	11.34	14.94
GAMLS-88	20.65	0.35	6.79	6.40	13.19
Kesar	17.25	0.29	7.03	8.77	15.80
Langra	19.40	0.35	6.28	8.26	14.65
Maddrashi Haphus	14.25	0.35	6.18	10.00	16.18
Mallika	21.05	0.31	4.62	9.04	13.66
Nileshan	14.30	0.32	5.98	7.40	13.38
Nilphanso	16.25	0.28	5.30	7.13	12.43
Ratna	16.45	0.49	7.23	7.43	14.65
Sonpari	18.40	0.32	6.73	8.85	15.58
Totapuri	14.00	0.33	4.68	10.60	15.28
Vanraj	18.75	0.28	3.07	9.95	13.02
Vasi Badami	14.90	0.23	7.83	8.40	16.23
CD (P=0.05)	0.86	0.07	0.81	0.75	1.47

RESULTS AND DISCUSSION

The result revealed that genotype, Totapuri, recorded maximum fruit length (11.02 cm) and yield (100.25 kg), followed by Kesar (96.50 kg), Vasi Badami (95.75 kg) and Dashehari (95.50). Maximum fruit width and fruit volume (7.49 cm and 535.53 cc) were observed in GAMLS-2. While, highest fruit weight and pulp weight (367.67 and 222.48 g) were recorded in Vasi Badami, whereas minimum peel weight and stone weight (16.45 and 14.03 g) was found in genotype GAMLS-34 (Table 1). The cultivar Amrutang, showed its superiority for pulp: stone ratio (11.88). Such type of variability among fruit characters of different mango genotypes was also reported by Patel (2002), Singh and Singh (2004), Singh *et al.* (2010), Bakshi *et al.* (2013) and Mishra *et al.* (2014).

For qualitative attributes, Dashehari recorded highest total soluble solids and reducing sugar content (22.15 and 8.96%). These findings are in accordance with Hoda *et al.* (2003). The fruit of Amrapalli cultivar contain minimum acidity (0.21%), whereas GAMLS-34 recorded highest acidity (0.63%). Among all genotypes, GAMLS-67, showed maximum non-reducing sugar (11.34%), followed by GAMLS-30 (11.15%) and Totapuri (10.60%) (Table 2). The maximum total sugar was recorded in GAMLS-30 (18.05%), whereas minimum total sugar content was recorded in GAMLS-34 (12.08%). Similar varietal difference in fruit quality attributes in mango also observed by Singh and Singh (2004), Kevadiya (2006), Singh *et al.* (2010) and Mishra *et al.* (2014). Thus, it can be concluded that fruit and quality characters showed significant variation among genotypes. Totapuri, Vasi Badami and Amrutang were found promising for yield parameters, while for quality attributes Amrapali and Dashehari were found the best.

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Current Horticulture **5**(2): 25–28, July–December 2017 ISSN: 2347-7377; RNI No.: UPENG03865/24/1/2013-TC

Comparative effect of organic manures and inorganic fertilizers on vegetative growth, yield and quality of ber (*Zizyphus mauritiana*) cv. Gola under semi-arid conditions

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Received: September 2016; **Revised:** February 2017

ABSTRACT

An experiment was conducted at SKN College of Agriculture, Jobner (Jaipur) Rajasthan, to find out the comparative effect of organic manures and inorganic fertilizers on growth parameters of three year-old ber (*Zizyphus mauritiana* Lamk.) cv. Gola during 2015-16. Four levels of organic manures (control, FYM @ 20 kg/plant, vermicompost @ 6 kg/plant and poultry manure @ 8 kg/plant) and five levels of RDF (control, 50% RDF, 75% RDF, 100% RDF and 125% RDF) were used in a randomized block design with three replications to balance fertilizer requirement under semi-arid region of northern India. The application of vermicompost @ 6 kg/plant and 125% recommended dose of fertilizers significantly influenceal growth parameters (plant height, plant spread (E-W and N-S), number of primary branches, average length of primary branches, number of secondary branches/ primary branche and leaf area), fruit yield (kg/plant and q/ha) and fruit quality (TSS and acidity content.

Key Words: Organic manures, Inorganic fertilizers, Growth, Yield, Quality, Semi-arid conditions

Indian jujube (*Zizyphus mauritiana* Lamk.) is an important fruit crop of hot arid ecosystem due to less water requirement, wider adaptability, hardy nature and its ability to flourish well even in inferior soil. Known as king of arid fruits, ber belongs to family Rhamnaceae consisting of 50 genera and more than 600 species (Pareek, 1983). In India, ber is being cultivated in 4,845 hectares with total production of 66,296 tonnes (NHB, 2014). Madhya Pradesh, Bihar, Punjab, Haryana, Gujarat and Rajasthan are major ber-growing states. Several products, ber butter, ber squash or juice, bermurabba, ber pulp, ber jam and dehydrated or dried products may also be made out of ber fruits (Pareek, 1983 and Yamdgni, 1985. It has a remarkable adaptability enabling it to grow in a wide range of agroclimatic situation and soils (Rana *et al.*, 1979). The growth and yield of its trees are greatly influenced by a wide range of nutrients.

Its cultivation in arid and semi-arid regions is mainly done but, due to one or another reason farmers are not harnessing its desired production potential. The potent reason for lesser productivity could be attributed to poor management. Since ber produces fruits continuously for a long time, thus it needs proper and integrated nutrients to have regular feeding at vegetative as well as reproductive phases. The intensively cultivated soils do have the problems of fast depletion of plant nutrients and become deficient not only in macro but also in micro nutrients (Singh *et al.*, 1998).An approach involving chemical fertilizers and organic manures to bridge this gap between nutrient demand and supply for giving a boost to crop production is only the solution. The situation further aggravates for light soil of Rajasthan, where nutrient use remains much lesser than the removal (Gupta, 2001). Keeping in new, an experiment was conducted to find out comparative effect of organic and inorganic of nutrients on ber.

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MATERIALS AND METHODS

An experiment was conducted on ber cv. Gola grown under loamy sand soil at Horticulture farm, SKN College of Agriculture, Jobner (Jaipur) during 2015 - 2016. The plants of uniform size, vigorously grown and approximately three-year-old after budding spaced at 6 m × 6 m were selected. The experiment consisted of 20 treatment combinations with four levels of organic

manures (M_0-control, M_1-FYM @ 20 kg/plant, M_2-vermicompost @ 6 kg/plant and M_3-poultry manure @ 8 kg/plant) and five levels of RDF (F_0-control, F_1-50% RDF, F_2-75% RDF, F_3-100% RDF and F_4-125% RDF) in a randomized block design with three replications.

The full dose of organic manures was applied as soil application during July 2015.The recommended doses of fertilizers, 1100 g urea, 1400 g SSP and 200 g MoP per tree were applied afterwards. Full dose of SSP, MoP and half of urea in various treatments were applied as basal dose during July 2015. Remaining half dose of urea was applied before flowering. The fertilizers were applied to the top soil around the plant. The fertilizers uniformly mixed into the soil and then levelled. Irrigation was applied immediately after application of manures and fertilizers. The role of nutrient elements either alone or in combination with other sources (organic manures/fertilizers) has been well established in many fruit crops; while such studies are very meagrely available in ber (Katiyar *et al.*, 2012).

The plant height (cm), trunk girth (cm), plant spread (E-W and N-S in cm), average length of primary branch (cm) and number of secondary branches/primary branch of experimental plants were recorded twice in a year, before application of treatments in July 2015 and at full bloom stage in October 2015. These parameters were calculated with the help of thread and meter scale. The number of primary branches/plant and average leaf area using Leaf Area Meter, LICOR-3000 Lincoln, USA and expressed as cm^2 was measured at full bloom stage in October 2015.

The ripe fruits were harvested and weight was recorded by summing up the total of fruits at different pickings obtained during 8 January - 25 February 2016 from each experimental plant. Quality components, *viz*. total soluble solids (°Brix)with the help of Zeiss^{Tm} hand refractometerand acidity content (AOAC, 1980) of ripe fruits were also analyzed.

To test the significance of variation in data obtained from various growth, yield and quality characters, the technique of statistical analysis of variance was suggested by Fisher (1950) for a randomized block design. Significance of difference in treatment effect was tested through 'F' tests at 5 per cent level of significance and CD (critical difference) was calculated, wherever the results were significant.

RESULTS AND DISCUSSION

A data on plant height, plant spread (E-W and N-S), number of primary branches, average length of primary branch, number of secondary branches/ primary branch and average leaf area of were affected significantly by application of various organic manures and fertility levels (Table 1). The maximum gain in plant height (77.15 cm), plant spread in E-W direction (111.85 cm) and N-S direction (109.58 cm), number of primary branches (22.00), average length of primary branch (91.25 cm), number of secondary branches (8.51) and average leaf area (29.12 cm^2) observed in treatment M2 (vermicompost @ 6 kg/plant) which is significantly superior than rest of the treatments except M3 (poultry manure @ 8 kg/plant). The data indicates that application of different organic manures and fertility

Table 1. Effect of organic manures and fertility levels on vegetative growth parameters of ber cv. Gola

Treatment	Plant height (cm)	Trunk girth (cm)	Plant spread in E-W direction (cm)	Plant spread in N-S direction (cm)	Number of primary branches	Average length of primary branch (cm)	Number of secondary branches	Average leaf area (cm^2)
Organic manures								
M_0 Control	66.12	2.55	88.64	86.92	18.55	69.20	4.65	23.23
M_1 FYM 20 kg/plant	72.04	2.65	101.54	98.20	20.01	80.40	6.71	26.12
M_2 Vermi compost 6 kg/p	77.15	2.76	111.85	109.58	22.00	91.25	8.51	29.12
M_3 Poultry manure 8 kg/p	75.30	2.71	110.36	107.31	21.22	89.28	8.35	28.11
SEm+	1.29	0.07	2.25	2.92	0.36	2.02	0.14	0.58
CD (P=0.05)	3.69	NS	6.43	8.37	1.02	5.78	0.40	1.66
Fertility level								
F_0 Control	63.14	2.52	77.95	75.09	17.84	56.69	4.33	23.42
F_1 50% RDF	69.79	2.62	94.66	92.35	19.43	75.71	6.20	25.56
F_2 75% RDF	74.36	2.70	108.48	105.22	20.81	87.63	7.60	26.76
F_3 100% RDF	77.22	2.74	115.89	114.68	21.99	95.36	8.52	28.65
F_4 125% RDF	78.75	2.75	118.51	115.17	22.15	97.28	8.62	28.83
SEm+	1.44	0.08	2.51	3.27	0.40	2.26	0.15	0.65
CD (P=0.05)	4.16	NS	7.25	9.44	1.15	6.52	0.45	1.87

levels brought about non-percetible variation to gain in trunk girth (Table 1). All the vegetative growth parameters were significantly poor under the control.

Vermicompost is slow releasing organic manure which containing most of the macro as well as micro nutrients in chelated form and fulfill the nutrient requirement of plant for a longer period. It helps in reducing C:N ratio, increasing humic acid content, cation exchange capacity and water soluble carbohydrates (Talashilkar *et al.,* 1999).The improvement in plant height by the application of vermicompost might be due to better moisture retention capacity, supply of micronutrients and easy availability of major nutrients of soil (Reddy *et al.,* 1998). Improvement in soil parameters might have helped in increasing the absorption of nutrients from soil, enhancing carbohydrate assimilation and production of new tissues, which ultimately increased vegetative growth.

The application of treatment F_4 (125% RDF) recorded maximum gain in plant height (78.75 cm), plant spread in E-W direction (118.51 cm) and N-S direction (115.17 cm), number of primary branches (22.15), average length of primary branch (97.28 cm), number of secondary branches (8.62) and average leaf area (28.83 cm^2) which was statistically at par with treatment F_3 (100% RDF (Table 1). This treatment was significantly higher as compared to the control, 50% RDF and 75% RDF. The application of any of the treatment does not enhanced trunk girth significantly. The better growth and development of plant under this treatment might be due to better nutritional environment in root zone as well as in plant system.

The biological role of NPK as an essential constituent of chlorophyll and nucleic acid, in harvesting solar energy, energy transformation from phosphorylated compound, transfer of genetic information, regulation of cellular metabolism and structural unit compound is well known. All these are found abundantly in the growing and storage organ, promote healthy root, shoot and full development (Devlin and Witham, 1986). The findings are in agreement with those of Lal and Dhaka (2003), Prasad (2005) and Devashi (2012).

The application of organic manures affected significantly fruit yield. Fruit yield (15.31 kg/plant and 42.56 q/ha) was significantly higher under treatment M_2 (vermicompost @ 6 kg/plant) as compared to the control and M1 (FYM @ 20 kg/plant. This treatment was statistically at par with treatment M_3 (poultry manure @ 8 kg/plant).

The significant improvement in fruit yield due to vermicompost application was largely a function of improved growth, *i.e.* multiplication, cell elongation, tissue differentiation and therefore consequent increase in yield attributes and yield (Singh and Meena, 2004). The increase in yield with application of vermicompost may also be ascribed to sustained availability of balanced nutrient throughout the growing period, which resulted in increased vegetative growth. The narrow C:N ratio might also have helped in increased nutrient uptake and synthesis of carbohydrates which ultimately enhanced yield.

Similarly, application of various fertility levels (NPK) had also significantly affected the fruit yield. The maximum fruit yield (15.11 kg/plant and 42.02q/ha) was found under treatment F_4 (125% RDF) which was statistically at par with F_3 (100% RDF). The application of inorganic fertilizers might have also increased the availability of nutrients directly which in

Table 2. Effect of organic manures and fertility levels on fruit yield and quality of ber cv. Gola

Treatment	Fruit yield (kg/plant)	Fruit yield (q/ha)	TSS (°Brix)	Acidity (%)
Organic manures				
M_0 Control	8.03	22.32	17.35	0.448
M_1 FYM 20 kg/plant	12.00	33.36	18.38	0.421
M_2 Vermi compost 6kg/plant	15.31	42.56	19.55	0.397
M_3 Poultry manure 8kg/plant	14.59	40.56	19.31	0.414
SEm+ s	0.26	0.70	0.29	0.007
CD (P=0.05)	0.73	2.01	0.82	0.020
Fertility levels				
F_0 Control	7.61	21.16	16.33	0.483
F_1 50% RDF	11.01	30.60	17.87	0.449
F_2 75% RDF	13.82	38.41	18.96	0.418
F_3 100% RDF	14.86	41.31	19.90	0.383
F_4 125% RDF	15.11	42.02	20.19	0.367
SEm+	0.29	0.78	0.32	0.008
CD (P=0.05)	0.83	2.26	0.93	0.023

turn increased fruit yield. The findings of present investigation are in agreement with those of Prasad (2005), Dalal *et al.* (2011), Dayal *et al.* (2011), Dhomane and Kadam (2013).

The application of different organic manures resulted in significant results. The maximum total soluble solids (19.55°Brix) and minimum acidity (0.397%) were observed in treatment M_2 (vermicompost @ 6 kg/plant) which was significantly higher to rest of the treatments except M_3 (poulttry manure @ 8 kg/ plant). The increase in TSS content and decrease in acidity content in fruits might be clear to better availability of desired and required quantity of nutrients for a longer period in root zones of plant, resulting from its solubilization of organic matter and chelation of available nutrients.

The TSS and acidity content in fruits also affected significantly by application of various fertility levels of NPK. The application of treatment F_4 (125% RDF) recorded maximum TSS (20.19°Brix) and minimum acidity (0.367%) in fruits which was statistically at par with F_3 (100% RDF) but significantly higher to other treatments. Arora *et al.* (2012) reported that potassium is a major nutrient element essential for translocation of sugar and increase TSS content in fruits. The increase in TSS content and decrease in acidity content in ber fruits may also be due to increased activity of nitrate reductase enzyme and enhanced synthesis of certain amino acid and proteins. Similar results were also obtained by Bhatia *et al.* (2001), Mahalle *et al.* (2001) and Kundu *et al.* (2011).

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Current Horticulture **5**(2): 29–35, July–December 2017 ISSN: 2347-7377; RNI No.: UPENG03865/24/1/2013-TC

Heterosis for fruit yield and yield-contributing characters in okra (*Abelmoschus esculentus)*

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Received: December 2015; **Revised:** June 2017

ABSTRACT

The experiment was conducted to estimate the magnitude of heterosis for fruit yield and yield-contributing characters in okra [*Abelmoschus esculentus* (L.) Moench]. Eight genetically diverse parents namely, Hisar Naveen, Pusa Makhmali, Kashi Pragati, Hisar Unnat, Pusa A-4, No. 315, Varsha Uphar and Kashi Kranti were crossed in a diallel fashion (excluding reciprocals) to develop 28 F_1s. These crosses along with their parents were evaluated in a randomized block design with three replications during *kharif* 2014 and *zaid* 2015 at Swami Keshwanand Rajasthan Agricultural University, Bikaner. Significance of mean squares due to genotypes revealed the presence of considerable genetic variability among them for all yield and yield-attributing characters except days taken to 50% flowering and days to first harvesting. Negatively heterotic crosses like Kashi Pragati × Varsha Uphar for days to 50% flowering (-6.62%) and Varsha Uphar × Kashi Kranti for first flowering nodes (-6.98 %), respectively, were important to exploit heterosis for earliness in okra. An appreciable heterosis was observed over better parent (28.90%) and mid parent (29.02%) for marketable fruit yield/plant which showed good scope of heterosis breeding in okra. The most heterotic crosses for marketable fruit yield/plant and most of the other yield-contributing characters were found in Kashi Pragati × Varsha Uphar, No. 315 × Varsha Uphar, Kashi Pragati × Pusa A-4 and Hisar Naveen × Varsha Uphar. These crosses were considered promising for their use for yield improvement in okra.

Key Words: Heterosis, F_1 hybrids, Half diallel crosses, Yield, Earliness, Heterotic crosses, Marketable yield

Okra [*Abelmoschus esculentus* L. Moench] is an important vegetable crop in tropical and subtropical region of the world. Exploitation of heterosis in okra has been recognized as an important method for improving the yield and other important traits. One of the most important factors in determining the feasibility of hybrid is the nature and extent of heterosis and its exploitation. Hence, for improving the genetic yield potential of varieties and hybrids, choice of right parents for hybridization is important. Okra is an often cross-pollinated crop as the natural crossing occurs in this crop up to a range of 4-19% (Purewal and Randhawa, 1947; Kumar *et al.*, 2010). Marked heterosis (28.28-75.16%) has been reported in okra for yield and yield components (Jagan *et al.*, 2013). The occurrence of heterosis in considerable quantities has been reported for fruit yield and its various components (Partap *et al.*, 1981; Weerasekara *et al.*, 2007, Jindal *et al.*, 2009). Owing to large flower size, ease in emasculation followed by hand-pollination along resulted in very high percentage of fruit setting and good number of seeds/fruit (50-70) offers great scope for commercial exploitation of heterosis in okra. The hybrid base has been further widened in the country through extension of heterosis breeding work. However, there are very few hybrids that occupy less than 5 per cent of total area under okra cultivation in India. Therefore, a study was undertaken to develop hybrids, which will ultimately help in increasing area, production and productivity of okra under arid regions. Since okra is categorized under cross-pollinated group, it showed easy in emasculation and more number of seeds in pollination. Therefore, an experiment was conducted to estimate the magnitude of heterosis for fruit yield and yield-contributing characters in okra.

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MATERIALS AND METHODS

The experiment was conducted at Swami Keshwan and Rajasthan Agricultural University, Bikaner during 2014-15. Geographically, Bikaner is situated at 28'01°N latitude and 73'22°E longitude at an altitude of 234.7 m above mean sea-level. The experimental material comprised eight diverse varieties of okra selected on the basis of their diverse geographical origin and wide variation in morphological characters. The seeds of lines/varieties were collected from their respective originating university/institutes and maintained through selfing. These genotypes were crossed in (n-1)/2 possible combinations during *zaid* season of 2014 to develop 28 F_1s.

The resulting 28 one-way crosses along with their 8 counterpart parental line were evaluated in a randomized complete block design with three replicates during *kharif* season of 2014 and zaid season of 2015. But here we discussed about the pooled data only. The seeds were sown in line maintaining 60 cm spacing between rows and 45 cm between plants. A highly susceptible variety, Pusa Sawani, to YVMV was grown all around the experimental field to create natural epiphytotic conditions.

The standard package of cultivation practices was followed. The observations were recorded on plant height (at 60 DAS), internodal length, number of branches/plant (60 DAS), days to 50 per cent flowering, days to first fruit harvesting, YVMV incidence, node number at which first flowers appear, fruit weight, fruit length, fruit diameter, number of marketable fruits/plant and marketable fruit yield/plant. The observations on disease incidence of YVMV were recorded 30, 60 and 90 days after sowing on 10 randomly selected plants of each genotype from each replication. Observations were based on visual symptoms like vein and veinlet chlorosis and chlorotic spots appearing regularly in the interveinal region. The data were averaged and per cent disease intensity (PDI) was calculated by using formulae given below :

$$\text{PDI (\%)} = \frac{\text{Number of infected plants}}{\text{Total number of plants}} \times 100$$

The scoring of disease was done following self made disease rating scale (0 to 6) by Ali *et al.* (2005) as given below :

The replicate mean values of YVMV incidence on plants (%) were subjected to arc sin transformation to restore distribution to normality. Relative heterosis and heterobeltiosis were determined as percent increase (+) or decrease (-) of F_1 over mid parent (MP) and better parent (BP) using the formulae (F_1-MP/MP × 100) and (F_1-BP/BP × 100), respectively (Singh, 1973).

Table 1. Analysis of variance for yield and yield-contributing characters in okra

Source of variation	d.f.	Plant height (cm)	Internodal length (cm)	Number of branches /plant	Days to 50% flower-ing	Days to first fruit harvesti-ing	YVMV incidence (%)	Node number at which first flower appears	Fruit weight (g)	Fruit length (cm)	Fruit diameter (cm)	Number of marketable fruits/plant	Marketable fruit yield/ plant (g)
Replication	2	14.65	0.08	0.20	3.79	4.39	2.54	0.07	0.01	0.34	0.00	0.25	2.94
Treatment	35	371.74**	4.11**	0.39**	6.00**	7.12**	68.00**	1.56**	1.28**	1.12**	0.03**	6.80**	2545.74**
Parent (P)	7	444.71**	3.26**	0.24*	2.43	2.40	163.17**	1.37**	0.90**	0.61*	0.02**	6.73**	1898.97**
F1s (H)	27	343.53**	4.34**	0.36**	5.78**	5.25**	45.05**	1.35**	0.74**	0.92**	0.03**	4.69**	1700.11**
P v/s H	1	622.41**	3.98**	2.42**	37.15**	90.64**	21.85*	8.61**	18.54**	10.12**	0.26**	64.42**	29904.99**
Error	70	56.28	0.41	0.09	2.03	2.39	4.51	0.15	0.14	0.25	0.01	1.33	262.46

*, ** Significant at 5 and 1 per cent level of significance, respectively

Rating scale	Disease intensity (%)	Disease reaction
0	0	Immune (I)
1	1-10	Highly resistant (HR)
2	11-25	Moderate resistant (MR)
3	26-50	Tolerant (T)
4	51-60	Moderate susceptible (MS)
5	61-70	Susceptible (S)
6	71-100	High susceptible (HS)

Where, F_1= mean performance of cross; MP, mean performance of mid parent (average of both parents) and BP, mean performance of better parent and significance of heterosis is tested with the help of standard error using 't' test.

RESULTS AND DISCUSSION

Analysis of variance

The variances were partitioned into replications, treatments, parents, hybrids, parents vs hybrids and

Table 2. Mean values of parents and hybrids for growth and flowering characters in okra

Parents and F_1s	Plant height (cm)	Internodal length (cm)	Number of branches/ plant	Days to 50% flowering	Days to first fruit harvesting	Node number at which first flower appears
Hisar Naveen	64.97	7.57	4.03	48.50	53.67	7.37
Pusa Makhmali	82.87	8.58	3.93	47.33	53.50	8.03
Kashi Pragati	75.77	8.25	4.47	48.17	53.33	7.37
Hisar Unnat	85.47	9.05	4.30	47.17	52.33	7.13
Pusa A-4	84.47	8.42	4.63	49.17	54.33	7.33
No. 315	55.67	5.92	3.77	49.83	55.00	5.73
Varsha Uphar	88.47	8.75	4.37	47.83	52.50	7.03
Kashi Kranti	89.60	9.08	4.23	48.00	53.00	7.70
Hisar Naveen × Pusa Makhmali	85.37	7.85	4.10	47.50	52.00	7.07
Hisar Naveen × Kashi Pragati	90.07	8.02	4.33	46.00	50.67	7.07
Hisar Naveen × Hisar Unnat	90.30	8.02	4.25	45.83	50.33	6.93
Hisar Naveen × Pusa A-4	85.72	7.54	4.52	47.50	52.00	7.03
Hisar Naveen × No. 315	65.67	5.92	4.37	45.33	50.00	6.20
Hisar Naveen × Varsha Uphar	86.80	7.32	4.50	46.17	50.67	7.03
Hisar Naveen × Kashi Kranti	85.47	7.82	4.27	46.50	51.00	7.20
Pusa Makhmali × Kashi Pragati	80.27	7.42	4.37	48.67	53.50	7.00
Pusa Makhmali × Hisar Unnat	93.93	9.42	4.57	47.67	53.17	6.97
Pusa Makhmali × Pusa A-4	96.50	9.08	4.70	49.00	53.50	6.83
Pusa Makhmali × No. 315	71.73	6.32	4.10	49.50	53.33	5.80
Pusa Makhmali × Varsha Uphar	91.67	9.38	4.40	48.00	52.50	7.13
Pusa Makhmali × Kashi Kranti	83.37	9.43	4.30	47.67	52.17	7.17
Kashi Pragati × Hisar Unnat	89.17	8.56	4.47	47.33	51.83	6.83
Kashi Pragati × Pusa A-4	90.00	7.65	5.37	46.00	50.67	6.37
Kashi Pragati × No. 315	76.67	5.92	4.57	48.17	52.17	5.90
Kashi Pragati × Varsha Uphar	90.07	7.65	5.20	44.67	49.33	6.00
Kashi Pragati × Kashi Kranti	91.77	8.58	4.63	48.33	52.33	7.13
Hisar Unnat × Pusa A-4	94.17	8.58	5.03	45.67	49.83	6.20
Hisar Unnat × No. 315	66.93	6.25	4.37	46.67	50.67	5.73
Hisar Unnat × Varsha Uphar	96.63	8.42	4.50	44.83	49.50	6.87
Hisar Unnat × Kashi Kranti	86.33	9.00	4.30	45.57	49.57	6.83
Pusa A-4 × No. 315	64.53	6.05	4.77	46.83	51.00	5.13
Pusa A-4 × Varsha Uphar	90.00	8.35	5.33	45.00	50.17	6.80
Pusa A-4 × Kashi Kranti	93.20	9.20	4.73	47.43	51.43	6.67
No. 315 × Varsha Uphar	61.83	5.75	4.77	46.33	51.00	4.80
No. 315 × Kashi Kranti	65.67	5.75	4.30	48.67	52.00	5.40
Varsha Uphar × Kashi Kranti	93.30	7.48	5.03	44.67	48.83	6.83
SEm±	4.33	0.37	0.18	0.82	0.89	0.22
CD (5%)	12.22	1.05	0.49	2.32	2.52	0.63
CD (1%)	16.22	1.39	0.65	3.08	3.34	0.84
CV (%)	9.05	8.20	6.74	3.03	2.99	5.81

Table 3. Heterobeltiosis and relative heterosis per cent for growth and flowering characters in okra

Parents and F_1s	Plant height (cm)		Internodal length (cm)		Number of branches /plant		Days to 50% flowering		Days to first fruit harvesting		Node number at which first flower appears	
	HBT%	RH%	HBT%	RH%	HBT%	RH%	HBT%	RH%	HBT%	RH%	HBT%	RH%
Hisar Naveen × Pusa Makhmali	3.02	15.49	3.74	-2.79	1.65	2.93	0.35	-0.87	-2.80	-2.95	-4.07	-8.23*
Hisar Naveen × Kashi Pragati	18.87*	28.00**	5.95	1.37	-2.99	1.96	-4.50	-4.83*	-5.00*	-5.30*	-4.07	-4.07
Hisar Naveen × Hisar Unnat	5.66	20.05**	5.95	-3.51	-1.16	2.00	-2.83	-4.18	-3.82	-5.03*	-2.81	-4.38
Hisar Naveen × Pusa A-4	1.48	14.72	-0.31	-5.61	-2.52	4.23	-2.06	-2.73	-3.11	-3.70	-4.10	-4.32
Hisar Naveen × No. 315	1.08	8.87	0.00	-12.24	8.26	11.97	-6.53**	-7.80**	-6.83**	-7.98**	8.14	-5.34
Hisar Naveen × Varsha Uphar	-1.88	13.14	-3.30	-10.32	3.05	7.14	-3.48	-4.15	-3.49	-4.55	0.00	-2.31
Hisar Naveen × Kashi Kranti	-4.61	10.59	3.30	-6.11	0.79	3.23	-3.13	-3.63	-3.77	-4.37	-2.26	-4.42
Pusa Makhmali × Kashi Pragati	-3.14	1.20	-10.02	-11.80	-2.24	3.97	1.04	1.92	0.31	0.16	-4.98	-9.09*
Pusa Makhmali × Hisar Unnat	9.91	11.60	9.71	6.81	6.20	10.93	1.06	0.88	1.59	0.47	-2.34	-8.13
Pusa Makhmali × Pusa A-4	14.25	15.34*	7.92	6.86	1.44	9.73	3.52	1.55	0.00	-0.77	-6.82*	-11.06**
Pusa Makhmali × No. 315	-13.44	3.56	6.76	-12.87	4.24	6.49	4.58	1.89	-0.31	-1.69	1.16	-15.74**
Pusa Makhmali × Varsha Uphar	3.62	7.00	9.32	8.27	0.76	6.02	0.35	0.88	0.00	-0.94	1.43	-5.30
Pusa Makhmali × Kashi Kranti	-6.96	-3.32	9.90	6.79	1.57	5.31	-0.69	0.00	-1.57	-2.03	-6.93*	-8.90*
Kashi Pragati × Hisar Unnat	4.33	10.61	3.76	-1.04	0.00	1.90	0.35	-0.70	-0.96	-1.89	-4.21	-5.75
Kashi Pragati × Pusa A-4	6.55	12.34	-7.27	-8.20	15.83**	17.95**	-4.50	-5.48*	-5.00*	-5.88**	-13.18**	-13.38**
Kashi Pragati × No. 315	1.19	16.66*	0.00	-16.47**	2.24	10.93	0.00	-1.70	-2.19	-3.69	2.91	-9.92*
Kashi Pragati × Varsha Uphar	1.81	9.68	-7.27	-10.00	16.42**	17.74**	-6.62**	-6.94**	-6.03*	-6.77**	-14.69**	-16.67**
Kashi Pragati × Kashi Kranti	2.42	10.99	4.04	-0.96	3.73	6.51	0.69	0.52	-1.26	-1.57	-3.17	-5.31
Hisar Unnat × Pusa A-4	10.18	10.83	1.98	-1.72	8.63	12.69*	-3.18	-5.19*	-4.78	-6.56**	-13.08**	-14.29**
Hisar Unnat × No. 315	-21.68**	-5.15	5.63	-16.48*	1.55	8.26	-1.06	-3.78	-3.18	-5.59**	0.00	-10.88*
Hisar Unnat × Varsha Uphar	9.23	11.12	-3.81	-5.43	3.05	3.85	-4.95*	-5.61*	-5.41*	-5.56**	-2.37	-3.06
Hisar Unnat × Kashi Kranti	-3.65	-1.37	-0.55	-0.74	0.00	0.78	-3.39	-4.24	-5.29*	-5.89**	-4.21	-7.87
Pusa A-4 × No. 315	-23.60**	-7.90	2.25	-15.58*	2.88	13.49*	-4.75*	-5.39*	-6.13*	-6.71**	-10.47*	-21.43**
Pusa A-4 × Varsha Uphar	1.73	4.09	-0.79	-2.72	15.11**	18.52**	-5.92*	-7.22**	-4.44	-6.08**	-3.32	-5.34
Pusa A-4 × Kashi Kranti	4.02	7.09	9.31	5.14	2.16	6.77	-1.18	-2.37	-2.96	-4.16	-9.09*	-11.31**
No. 315 × Varsha Uphar	-30.11**	-14.20	-2.82	-21.59**	9.16	17.21**	-3.14	-5.12*	-2.86	-5.12*	-16.28**	-24.80**
No. 315 × Kashi Kranti	-26.71**	-9.59	-2.82	-23.33**	1.57	7.50	1.39	-0.51	-1.89	-3.70	-5.81	-19.60**
Varsha Uphar × Kashi Kranti	4.13	4.79	-14.48*	-16.07**	15.27**	17.05**	-6.62**	-6.78**	-6.98**	-7.42**	-2.84	-7.24

*, ** Significant at 5 and 1 per cent level of significance, respectively

errors. The mean squares due to genotypes were significant for all the traits, indicating the presence of wide range of variability. ANOVA indicated that the mean squares due to parents were highly significant for almost all characters under study except days taken to 50 % flowering and days to first fruit harvesting (Table 1). The mean squares due to hybrids were highly significant for almost all characters. The mean squares due to parents vs hybrids, which are a measure of importance of average heterosis, were highly significant for majority of characters except YVMV incidence.

Heterosis was estimated as per cent increase or decrease of F_1 values over mid-parent (relative heterosis) and better parent (heterobeltiosis). The mean values of

Table 4. Mean value of parents and hybrids for fruit and yield characters in okra.

Parents and F_1s	Fruit weight (g)	Fruit length (cm)	Fruit diameter (cm)	Number of marketable fruits/plant	Marketable fruit yield plant (g)	YVMV incidence (%)
Hisar Naveen	9.10	9.63	1.46	18.53	169.26	47.01 (53.17)
Pusa Makhmali	8.80	9.30	1.50	17.80	157.87	50.04 (58.75)
Kashi Pragati	10.13	10.27	1.66	20.97	213.00	33.92 (31.17)
Hisar Unnat	10.13	10.30	1.61	21.80	222.32	29.69 (24.58)
Pusa A-4	10.03	10.17	1.56	21.07	211.99	42.66 (45.92)
No. 315	10.25	9.23	1.74	21.67	223.13	29.84 (24.83)
Varsha Uphar	10.05	10.30	1.59	21.13	213.40	31.94 (28.00)
Kashi Kranti	9.48	9.70	1.55	19.60	186.32	44.42 (49.00)
Hisar Naveen × Pusa Makhmali	9.73	9.80	1.52	18.97	184.24	39.72 (40.83)
Hisar Naveen × Kashi Pragati	10.53	10.47	1.67	21.73	229.35	39.96 (41.25)
Hisar Naveen × Hisar Unnat	10.53	10.97	1.63	21.87	231.29	39.71 (40.83)
Hisar Naveen × Pusa A-4	10.37	10.33	1.59	21.97	228.43	39.23 (40.00)
Hisar Naveen × No. 315	10.72	10.33	1.74	21.93	235.89	40.59 (42.33)
Hisar Naveen × Varsha Uphar	10.83	10.37	1.61	22.43	245.19	36.29 (35.08)
Hisar Naveen × Kashi Kranti	9.97	10.10	1.61	19.97	199.36	40.20 (41.67)
Pusa Makhmali × Kashi Pragati	10.28	10.33	1.66	21.57	223.17	45.00 (50.00)
Pusa Makhmali × Hisar Unnat	10.37	10.33	1.64	21.93	228.65	45.00 (50.00)
Pusa Makhmali × Pusa A-4	10.27	10.97	1.60	21.30	219.32	40.68 (45.00)
Pusa Makhmali × No. 315	10.55	9.70	1.72	21.93	232.12	42.12 (42.50)
Pusa Makhmali × Varsha Uphar	10.50	10.47	1.63	21.47	226.15	39.46 (40.42)
Pusa Makhmali × Kashi Kranti	9.67	10.30	1.61	19.67	190.89	43.33 (47.08)
Kashi Pragati × Hisar Unnat	11.03	10.37	1.67	22.93	253.37	36.48 (35.42)
Kashi Pragati × Pusa A-4	11.43	11.80	1.81	23.67	270.87	33.92 (31.17)
Kashi Pragati × No. 315	10.93	10.30	1.83	22.47	246.51	38.58 (38.92)
Kashi Pragati × Varsha Uphar	11.43	11.87	1.81	24.00	275.07	32.29 (28.58)
Kashi Pragati × Kashi Kranti	10.87	10.53	1.68	22.07	240.67	42.85 (46.25)
Hisar Unnat × Pusa A-4	11.05	11.23	1.76	23.83	264.90	33.35 (30.33)
Hisar Unnat × No. 315	11.08	10.53	1.82	22.27	246.71	41.14 (43.33)
Hisar Unnat × Varsha Uphar	11.20	10.87	1.71	24.40	274.89	29.79 (24.75)
Hisar Unnat × Kashi Kranti	10.77	10.33	1.66	21.90	237.23	41.37 (43.75)
Pusa A-4 × No. 315	10.83	10.40	1.85	22.90	248.18	39.94 (41.25)
Pusa A-4 × Varsha Uphar	11.28	11.37	1.75	23.00	260.95	29.16 (25.42)
Pusa A-4 × Kashi Kranti	10.83	10.23	1.65	22.00	239.05	34.17 (31.58)
No. 315 × Varsha Uphar	11.63	10.90	1.87	23.93	280.23	29.28 (24.00)
No. 315 × Kashi Kranti	10.82	10.00	1.87	22.40	242.94	36.59 (35.58)
Varsha Uphar × Kashi Kranti	11.33	11.57	1.68	22.50	255.60	36.96 (36.25)
SEm±	0.21	0.29	0.048	0.67	9.35	1.52
CD at 5%	0.61	0.82	0.137	1.88	26.38	4.29
CV (%)	3.53	4.88	5.011	5.31	7.02	5.70

Table 5. The heterobeltiosis and relative heterosis per cent for fruit yield characters of okra.

Parents and F_1s	Fruit weight (g)		Fruit length (cm)		Fruit diameter (cm)		Number of marketable fruits/plant		Marketable fruit yield /plant (g)		YVMV incidence (%)	
	HBT%	RH%	HBT%	RH%	HBT%	RH%	HBT%	RH%	HBT%	RH%	HBT%	RH%
Hisar Naveen × Pusa Makhmali	6.96*	8.75**	1.73	3.52	1.33	2.70	2.34	4.40	8.85	12.64	-6.87	-11.88**
Hisar Naveen × Kashi Pragati	3.95	9.53**	1.95	5.19	0.80	7.26	3.66	10.04*	7.67	19.99**	15.20	2.08
Hisar Naveen × Hisar Unnat	3.95	9.53**	6.47	10.03**	1.09	6.00	0.31	8.43	4.03	18.13**	15.65	1.99
Hisar Naveen × Pusa A-4	3.32	8.36**	1.64	4.38	1.92	5.40	4.27	10.94**	7.76	19.83**	0.25	-4.97
Hisar Naveen × No. 315	4.55	10.77**	7.27	9.54*	0.03	8.77?	1.23	9.12	5.72	20.24**	18.93	4.24
Hisar Naveen × Varsha Uphar	7.79*	13.14**	0.65	4.01	1.48	5.80	6.15	13.11**	14.90*	28.15**	-1.99	-5.85
Hisar Naveen × Kashi Kranti	5.10	7.27*	4.12	4.48	3.66	6.76	1.87	4.72	7.00	12.13	-7.92	-11.73**
Pusa Makhmali × Kashi Pragati	1.48	8.62**	0.65	5.62	0.00	5.06	2.86	11.26**	4.77	20.35**	22.67	2.23
Pusa Makhmali × Hisar Unnat	2.30	9.51**	0.32	5.44	1.91	5.49	0.61	10.77*	2.85	20.28**	28.21	6.32*
Pusa Makhmali × Pusa A-4	2.33	9.03**	7.87	12.67**	2.32	4.44	1.11	9.61	3.46	18.60**	6.16	-5.04
Pusa Makhmali × No. 315	2.93	10.76**	4.30	4.68	-1.31	5.98	1.23	11.15**	4.03	21.85**	19.15	-1.83
Pusa Makhmali × Varsha Uphar	4.48	11.41**	1.62	6.80	2.32	5.29	1.58	10.27*	5.98	21.83**	-1.75	-10.88**
Pusa Makhmali × Kashi Kranti	1.94	5.74	6.19	8.42	3.66	5.36	0.34	5.17	2.45	10.92	-4.02	-5.21
Kashi Pragati × Hisar Unnat	8.88**	8.88**	0.65	0.81	0.80	2.37	5.20	7.25	13.97*	16.41**	8.55	8.08*
Kashi Pragati × Pusa A-4	12.83**	13.39**	14.94**	15.50**	8.84?	12.10??	12.34**	12.61**	27.17**	27.47**	-4.92	-10.83**
Kashi Pragati × No. 315	6.67*	7.28**	0.32	5.64	5.20	7.66	3.69	5.39	10.48	13.05*	-0.10	-1.08
Kashi Pragati × Varsha Uphar	12.83**	13.29**	15.21**	15.40**	9.04?	11.39??	13.56**	14.01**	28.90**	29.02**	-3.32	-10.55**
Kashi Pragati × Kashi Kranti	7.24*	10.79**	2.60	5.51	1.00	4.47	5.25	8.79	12.99*	20.54**	21.94	3.10
Hisar Unnat × Pusa A-4	9.05**	9.59**	9.06*	9.77**	9.58??	11.16??	9.33*	11.20**	19.15**	21.99**	3.56	-3.32
Hisar Unnat × No. 315	8.13**	8.75**	2.27	7.85	4.44	8.50?	2.14	2.45	10.57	10.77	11.27	10.66**
Hisar Unnat × Varsha Uphar	10.53**	10.98**	5.50	5.50	6.48	7.13	11.93**	13.66**	23.65**	26.18**	-1.19	-9.00*
Hisar Unnat × Kashi Kranti	6.25*	9.77**	0.32	3.33	3.16	5.09	0.46	5.80	6.71	16.11**	19.64	0.65
Pusa A-4 × No. 315	5.69	6.82*	2.30	7.22	6.16	11.82??	5.69	7.18	11.23	14.08**	12.52	4.43
Pusa A-4 × Varsha Uphar	12.27**	12.37**	10.36*	11.07**	10.08??	11.00??	8.83*	9.00*	22.28**	22.69**	-1.66	-2.91
Pusa A-4 × Kashi Kranti	7.97*	11.02**	0.66	3.02	5.54	6.00	4.43	8.20	12.77*	20.03**	-1.18	-10.39**
No. 315 × Varsha Uphar	13.50**	14.61**	5.83	11.60**	7.74	12.58??	10.46*	11.84**	25.59**	28.39**	0.56	-7.94*
No. 315 × Kashi Kranti	5.53	9.63**	3.09	5.63	7.31	13.49??	3.38	8.56	8.88	18.66**	19.83	0.17
Varsha Uphar × Kashi Kranti	12.77**	16.04**	12.30**	15.67**	5.89	7.23	6.47	10.47*	19.78**	27.89**	-8.68	-16.04**

*, ** Significant at 5 and 1 per cent level of significance, respectively

parents, hybrids as well as nature and magnitude of heterosis are presented in Tables 2-5.

Out of 28 crosses, four displayed significant and negative heterobeltiosis for plant height, *viz*. No. 315 × Varsha Uphar (-30.11 %), No. 315 × Kashi Kranti (-26.71 %), Pusa A-4 × No. 315 (-23.60 %) and Hisar Unnat × No. 315 (-21.68 %). Significant and negative heterosis for internodal length over mid parent ranged from –23.33 (No. 315 × Kashi Kranti) to 8.27 per cent (Pusa Makhmali × Varsha Uphar). Negative heterosis is desirable for days to 50% flowering because this will help the hybrid to form fruit earlier. Six cross combinations showed negative and significant heterobeltiosis for days to 50 % flowering (Kumar *et al.*, 2013).

Out of 28 crosses, 7 showed significant and positive relative heterosis for number of primary branches ranged from 0.78 (Hisar Unnat × Kashi Kranti) to 18.52 per cent (Pusa A-4 × Varsha Uphar). For days to first harvesting, 13 crosses represent highly significant and negative relative heterosis ranged from -7.42 (Varsha Uphar × Kashi Kranti) to 0.47 per cent (Pusa Makhmali × Hisar Unnat), while 8 crosses showed highly significant and negative heterobeltiosis for days to first harvesting that reflects earliness.

For fruit weight, maximum increase in fruit weight observed over better parent was 13.50 per cent (No. 315 × Varsha Uphar) in pooled data (Table 5). Out of 28, 27 crosses surpassed the mid-parent for fruit weight and showed significantly higher heterosis over mid-parent in positive (desirable) direction. These results are in line with those of Bhalekar *et al.* (2004), Singh *et al.* (2004), Singh and Syamal (2006) and Weerasekara *et al.* (2007).

For fruit length, nine hybrids showed positively significant heterosis over mid parent. Five hybrids showed significant positive heterobeltiosis. The heterobeltiotic effects ranged from 0.32 (Pusa Makhmali × Hisar Unnat) to 15.21 per cent (Kashi Pragati × Varsha Uphar). The average heterosis ranged from 0.81 (Kashi Pragati × Hisar Unnat) to 15.67 per cent (Varsha Uphar × Kashi Kranti). Similar results were presented by Rewale *et al.* (2003), Hosamani *et al.* (2008) and Kumar and Sreeparvathy (2010).

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Current Horticulture **5**(2): 36–39, July–December 2017 ISSN: 2347-7377; RNI No.: UPENG03865/24/1/2013-TC

Effect of different fertility levels and biofertilizers on growth and yield of knol-khol (*Brassica oleracea var.* caulorapa) under agroclimatic condition of Bikaner

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Received: December 2015; **Revised:** May 2017

ABSTRACT

A field experiment consisting of 16 treatments, viz. four levels each of fertility and different biofertilizer inoculations alone and in combination was laid out in a randomized block design with three replications at Horticulture Farm, College of Agriculture, Bikaner, during 2010-11. The treatment combination consisting of 100 per cent recommended dose of NPK + PSB showed plant height, number of leaves, yield per plot and total yield significantly higher over the control application of fertilizers and biofertilizers alone. It was statistically at par with 150 per cent recommended dose of NPK in combination with other biofertilizers inoculations.

Key Words: NPK, PSB, Growth, Yield, Fertility levels, Biofertilizers, Growth, Agroclimatic conditions

The plants of knol-knol (*Brassica oleracea var. caulorapa* L.) requires food for growth and development in the form of proper doses of NPK. About 175 million tonnes of nitrogen is obtained annually (Meelu, 1996). Similarly, phosphorus is indispensable constituent of nucleic acid, phospholipids and several enzymes. Most of the soils of Rajasthan are poor in phosphorus and low in organic matter. About 93-99% of the total phosphorus is soil in insoluble form and is directly not available to plants. Only about a quarter of water-soluble phosphate is taken up by plants in the season of its application and the remaining is converted into insoluble, unavailable forms (Verma, 1993). Potassium is the other most abundant nutrient constituting about 2.5% of the lithosphere. However, actual soil concentration of this nutrient vary widely ranging from 0.04 to 3.00 per cent. Potassium also plays a vital role in crop productivity. It imparts increased vigour and disease resistance to plants and functions as an activator of numerous enzymes like pyruvic kinase, cytoplasmic enzymes *etc.*

Biofertilizers have emerged as a promising component of integrated nutrient supply system. Among biofertilizers, biological nitrogen fixers are largely exploited. This assumes greater significance as a complement or supplement to the inorganic nitrogen fertilizers because of their high nutrient turnover, low costs and soil, and environmental protection (Bahadur and Manohar, 2001). Phosphate Solubilizing Bacteria (PSB) and Vesicular Arbuscular Mycorrhiza (VAM) are important microbes in releasing and making available phosphorus by colonizing the root surface of growing plant root. They also improve the uptake particularly of phosphorus, zinc and other micronutrients (Asokan *et al.*, 2000). Keeping in view, an experiment was conducted to find out the effect of fertility levels and biofertilizers on growth and yield of knoll-khol.

MATERIALS AND METHODS

The experiment was conducted during *rabi*, 2010-11 at Horticulture farm, College of Agriculture, Bikaner, in a randomized block design with three replications. The Bikaner zone has arid climatic conditions with scorching summer, cold winter scantly and scattered

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rainfall. Dusty storms, frost and hailstorms are typical weather hazards of this region. The annual average rainfall is about 260 mm and more than 80 per cent rainfall is received during South-West monsoon season. During summers, maximum temperature may goes as high as 48°C, while in winter, it may fall as low as 0°C. The region is prone to high wind velocity and soil erosion. Soil drifting due high speed of winds leads to soil erosion which is a major problem in summers. The soil of experimental field was loamy sand in texture, slightly alkaline in reaction and poor in organic carbon with low available nitrogen (< 250 kg/ha), phosphorus (< 20 kg/ha) and medium in potassium contents (125-300 kg/ha).

RESULTS AND DISCUSSION

The results showed that different fertility levels significantly affected the plant height (45 days after transplanting and at harvesting) and number of leaves (45 days after transplanting and at harvesting), diameter of knob (Table 1). The maximum value of these characters was recorded under F_3, *i.e.* 150% recommended dose of NPK. However, 100% recommended dose of NPK (F_2) remained statistically at par to F_3 in plant height at harvesting and number of leaves 45 days after transplanting and at harvesting. This might be due to increase in availability of N, P and K, resulting into better nutritional environment in root zone, leading to better growth and development. Nitrogen is most indispensable of all the mineral nutrient for growth and development.

Since it is the basis of fundamental constituents of all living matter, it also plays an important role in plant metabolism by virtue of being an essential constituent of divers type of matabolitically active compounds like amino acids, proteins, nucleic acids, prophyrins, flavins, purine and pyrimidine, nucleotides, flavin nucleotides, enzymes, co-enzymes and alkaloids *etc*, released due to application of 100 per cent recommended dose of NPK (Yadav, 2000; Soni, 2004) in onion.

Phosphorus is main constituent of HDP and ATP which acts as 'energy currency' and all the metabolic reactions of any significance proceeds via phosphate derivatives, phosphorus application influences photosynthesis, biosynthesis of proteins and phospholipids, nucleic acid synthesis, membrane transport and cytoplasmic streaming. The beneficial effect of phosphorus in early stages of growth was due to early stimulation of root system, efficient translocation of compounds in phosphorus fed plant, leading to enhanced absorption and neutralization of nitrogen and other nutrients. This adequate neutralization due to direct supply at the early stages of plant life played a vital role in lying down of root primordial for a reproductive part of cauliflower and broccoli (Kumhar, 2004; Singh, 2008; Rodhiguez and Fraga, 1999).

Potassium helps in protein synthesis, chlorophyll formation and in increasing resistance to various biotic and abiotic stresses, which might have improved the growth and development of plant. The results obtained in present investigation are in line of the findings of Zhao *et al.* (2004).

Application of 150 per cent recommended dose of

Table 1. Effect of different fertility levels and biofertilizers on growth and yield parameters

Treatment	Plant height (cm)		Number of leaves/plant		Diameter of knob (cm)	Biological yield/ plant (g)	Volume of knob (cc)	Average weight of knob (g)	Knob yield (kg/plot)	Total knob yield (q ha)
	At 45 DAT	At harvesting	At 45 DAT	At harvesting						
Fertility levels										
F_0	8.68	22.23	6.35	76.73	13.57	3.42	37.13	42.19	3.03	52.63
F_1	10.20	26.69	8.43	120.85	17.77	3.88	54.31	61.89	4.82	83.72
F_2	15.28	31.93	12.62	192.38	21.13	5.67	81.36	86.82	6.29	109.23
F_3	16.48	32.72	13.26	205.75	21.63	6.41	89.30	93.93	6.42	111.40
SEm+	0.242	0.42	0.23	2.337	0.27	0.130	1.06	1.55	0.11	1.95
CD 5%	0.700	1.41	0.68	6.749	0.78	0.376	3.06	4.47	0.32	5.63
Biofertilizers										
B_0	10.93	25.93	8.85	127.73	17.23	4.26	58.54	63.77	4.47	77.68
B_1	12.83	28.26	10.26	151.85	18.15	4.93	66.64	73.39	5.31	92.10
B_2	13.10	29.28	10.53	155.44	19.02	5.02	68.90	74.76	5.33	92.56
B_3	13.77	30.11	11.02	160.68	19.69	5.18	68.02	72.91	5.45	94.65
SEm+	0.242	0.49	0.23	2.337	0.27	0.130	1.06	1.55	0.11	1.95
CD 5%	0.700	1.41	0.68	6.749	0.78	0.376	3.06	4.47	0.32	5.63

NPK significantly increased the biological yield per plant, volume of knob, average weight of knob, yield/ plot and total yield over the control (Table 1). Significantly higher values for all these yield-attributing characters and yield were recorded with the application of F_3 (150% recommended dose of NPK), However, it was statistically at par with 100% recommended dose of NPK (F_2) in knob yield 6.29 kg/plot and total knob yield 109.23 q/ha. The increase in yield with availability of sufficient amount of nutrients through direct addition of soil which might have in turned into traits and finally yield of knol-khol. The adequate supply of phosphorus along with starter dose of nitrogen play a vital role in metabolic process of photosynthesis and carbohydrate metabolism that results in increased knob formation, biological yield, average weight of knob and finally the total yield/ha. The adequate availability of nutrients regulates the starch/sucrose ratio in reproductive organs and also influences stomatal resistance and activity of ribulaze bio-phosphate carboxylase. Manohar (2006) reported maximum average weight of knob (136.45 g) and yield (2.46 kg/ bed).

The application of increasing fertility levels favoured the metabolic as well as hormonal activity in plants, which ultimately resulted in the increased knob formation, weight of knob and finally the yield. Thus, present findings also corroborate to those of Manohar (2006); Singh (2008).

The application of biofertilizers increased height, number of leaves and diameter of knob at different growth stages (Table 1). Inoculation of PSB significantly increased the plant height, number of leaves and diameter of knob over the control and Azotobacter, but remained at par with VAM. Since, phosphorus is one of the essential nutrients and its availability in an adequate amount leads to its better growth and reproduction in plant. Inoculation with PSB enhanced its availability through solubilization of insoluble phosphorus through exertion of organic acids like succinic, lactic, oxalic, glycoxalic, malic, formalic, tartaric, citric, a- ketobutaric, propionic, formic, 2- ketogluconic acid acts as chelaters of calcium (Chen *et al.,* 2006). Moreover, adequate utilization of phosphorus was due to direct supply and solubilisation of native and added phosphorus by PSB. Microorganisms at early stages of plant life also played a vital role in laying down and formation of root primordial, which ultimately helped in the formation of reproductive portion (Rodriguez and Fraga, 1999).

In addition to solubilisation these microbes mineralize organic phosphorus in soluble form and also improve availability of phosphorus in alkaline soil (Kumawat, 2008), thereby increasing their utility in problematic soil as well. These results are in conformity with those of Gajbhiye *et al.* (2003) in tomato, Singh (2008) in cauliflower, Kumawat (2009) in cabbage and Kumawat (2010) in broccoli.

The inoculation with PSB and VAM significantly increased the biological yield, volume of knob, average weight of knob, knob yield over the control and Azotobacter but PSB were at par to VAM in volume of knob, weight of knob, knob yield and total knob yield ha. Phosphorus-solubilising bacteria (PSB) nourishes the crop and soil by liberating the growth promoting substances and vitamins, whereas vesicular arbuscular mycorrhizae (VAM) improve the uptake of NPK and Zn in plants. It also helps in stabilization of soil aggregates through binding the sand particles by VAM mycelium. The improvement in yield attributes with inoculation with PSB was due to solubilisation and increased availability of phosphorus from insoluble. The beneficial effect of PSB along with other nutrients increased the yield of crop might have resulted due to higher rate in partitioning of different reproductive structures and yield attributes which might have influenced ultimately in higher yield of crop. These findings corroborate to those of Vimala and Natrajan

Table 2. Interaction effect of different fertility levels and biofertilizers on diameter of knob (cm) and biological yield/plant (g)

Treatment	Diameter of knob (cm)					Treatment	Biological yield/plant (g)				
	B_0	B_1	B_2	B_3	Mean		B_0	B_1	B_2	B_3	Mean
F_0	3.00	3.53	3.50	3.63	3.42	F_0	67.50	73.30	78.10	88.00	76.73
F_1	3.70	3.80	3.93	4.10	3.88	F_1	101.47	115.80	130.60	135.53	120.85
F_2	4.20	6.07	6.13	6.27	5.67	F_2	156.53	202.87	204.60	205.53	192.38
F_3	6.13	6.30	6.50	6.70	6.41	F_3	185.43	215.43	208.47	213.67	205.75
Mean	4.26	4.93	5.02	5.18		Mean	127.73	151.85	155.44	160.68	
		SEm+	CD 5%					SEm+	CD 5%		
	F	0.130	0.376				F	2.337	6.749		
	B	0.130	0.376				B	2.337	6.749		
	F × B	0.260	0.751				F × B	4.674	13.498		

(2000) in pea, Kadlag *et al.* (2007) in tomato, Singh (2008) in cauliflower, Kumawat (2009) in cabbage and Kumawat (2010) in broccoli.

The interaction effect of fertility levels and biofertilizers was significant for biological yield, plant height and diameter of knob (Table 2). Maximum plant height, biological yield and diameter were observed when 100 per cent recommended dose of NPK (100, 60, 60 kg/ha) was applied + inoculation with PSB (B_3). Although, both fertility levels and biofertilizers independently brought significant variation in growth and yield characters, the interaction of F_2B_3 showed that response of fertility levels was governed by bio-fertilizers and vice-versa. Thus, exhibiting there inter dependence for obtaining higher values of these parameters, Hence, it is clear that application of F_2 fertility level (100% recommended dose of NPK) in combination with B_2 (inoculation with PSB) influenced the availability and uptake of nutrients and ultimately the growth and development of plant obtained in the present study. This might be due to supply of nutrients to plant. These findings corroborate with these of Singh (2008) in cauliflower.

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Current Horticulture **5**(2): 40–43, July–December 2017 ISSN: 2347-7377; RNI No.: UPENG03865/24/1/2013-TC

Effect of thiourea and zinc on growth and yield of cauliflower *(Brassica oleracea* var botrytis L.)

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Received: April 2016; **Revised:** July 2017

ABSTRACT

A field experiment was conducted to study the effect of thiourea and zinc on growth, and yield of cauliflower (*Brassica oleracea* var. botrytis L.) during *rabi* season of 2015-16 at Horticulture Farm, SKN. College of Agriculture, Jobner. The experiment consisted of 16 treatment combinations with four levels of thiourea (control, 500, 750 and 1000 ppm) and four levels of zinc (control, 2.5, 5.0 and 7.5 kg/ha) in a randomized block design with three replications. The results revealed that T_3Z_3 (thiourea 1000 ppm + zinc 7.5 kg/ha) significantly increased leaf area, total chlorophyll content, curd weight and curd yield, showing statistical equality with T_3Z_2 (1000 ppm thiourea + zinc 5.0 kg/ha). It could be recommended that thiourea in combination with micronutrient (zinc) are the most essential plant mineral nutrients for growth and curd yield of cauliflower under loamy sand soils of semi-arid condition.

Key Words: Thiourea, Zinc, Growth, Yield, Chlofophyll content, Curd

Cauliflower (*Brassica oleracea* var. botryitis L.) is an important vegetable crop. It is grown round the year for its white tender curd which is a form of shortened flower bud. It is evident that without use of some micronutrient, viz. Zn, Cu, Fe *etc*. it is not possible to get maximum benefit of N, P and K in cauliflower, being heavy feeder of mineral elements. Zinc is an essential nutrient and taken up by the plant in ionic form (Zn^{++}). It is applied in the form of complex with a chelating agent like EDTA or $ZnSO_4$, *i.e.* principal salt, used as fertilizer. Zinc is a co-factor of over 300 enzymes and constituent of many proteins that are involved in cell division, nucleic acid metabolism and protein synthesis. Crop yield is often limited by low level of Zn in soils of arid and semi-arid regions (Cakmak *et al.*, 1999). Zinc is essential for the synthesis of tryptophan, a precursor of IAA which is essential for normal cell division and other metabolic processes and helps in the formation of chlorophyll (Wear and Hagler, 1968). Availability of zinc might have stimulated the metabolic and enzymatic activities, thereby increasing plant growth parameters (Kasturikrishana and Ahlawat, 2003) in pea.

Besides, thiourea also plays an important role in maximizing yield potential of crop in arid and semi-arid regions as it may prove beneficial by inducing stress tolerance. The stimulating action of thiourea in various physiological activities of plant is well known. It plays a vital role in physiology of plants both as a sulphydryl compound and to some extent as an amino compound like urea. Since thiourea regulates plant growth by maintaining higher photosynthetic rate up to reproductive stage and increases yield by improving carbon partitioning towards sink, an experiment was conducted to see the effect of thiourea and zinc on yield of cauliflower.

MATERIALS AND METHODS

A field experiment was conducted to find out the effect of thiourea and zinc on growth, yield and quality of cauliflower during *rabi* season 2015-16 at Horticulture Farm, SKN College of Agriculture, Jobner, Jaipur. The

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experiment was laid out in a randomized block design with three replications. This experiment comprised 16 treatment combinations with four levels of each thiourea (control, 500, 750 and 1000 ppm) and zinc (control, 2.5, 5.0 and 7.5 kg/ha). The mean daily temperature fluctuated from 37.2 to 2.1°C, relative humidity ranged from 41 to 67 per cent and total rainfall 3.6 mm during the period of experiment.

The soil analysis of experimental area showed that soil was loamy sand in texture, slightly alkaline in reaction, poor in organic carbon (0.15%) with low available nitrogen (128 kg/ha), phosphorus (16.63 kg/ha) and sulphur (8.4 mg/g) and medium in potassium content (154.1 kg/ha). The treatments were randomly allotted to different plots using random number table of Fisher and Yates (1963). Thiourea was applied before transplanting as roots dip of seedling for 15 minutes and foliar spray 25 days after transplanting, whereas zinc was applied through fertilizer grade $ZnSO_4$ (21% Zn) and mixed with soil before transplanting.

RESULTS AND DISCUSSION

The results revealed that plant height was maximum at thiourea 1000 ppm (T_3) which was outstanding being significantly superior to other levels of thiourea except T_2 (thiourea 750 ppm), being at par with each other (Tables 1 and 2). The effect of zinc was also found significant on plant height. The highest plant height was noted at zinc 7.5 kg/ha (Z_3). Number of leaves/plant was maximum at thiourea 1000 ppm (T_3) which was at par with thiourea 750 ppm (T_2). Zinc @ 7.5 kg/ha (Z_3) produced significantly maximum number of leaves/plant, being at par to zinc 5 kg/ha (Z_2). The interaction of thiourea and zinc were found to be non-significant on plant height and number of leaves. Treatment T_3 (1000 ppm thiourea) recorded maximum leaf area (970.81 cm^2) and total chlorophyll content in leaves (1.901 mg/g) and significantly better among all the treatments except T_2 (750 ppm thiourea) which remained at par.

Similarly, data given in same table further revealed that zinc 7.5 kg/ha (Z_3) also significantly increased leaf area (cm^2) and total chlorophyll content over the control and zinc 2.5 kg/ha, however, zinc 5.0 kg/ha (Z_2) was found statistically at par for both parameters. The treatment combination T_3Z_3 (1000 ppm + 7.5 kg/ha) gave maximum leaf area and total chlorophyll content which was recorded at par with T_3Z_2 (1000 ppm + 5 kg/ha), T_2Z_3 (750 ppm + 7.5 kg/ha) and T_2Z_2 (750 ppm + 5 kg/ha).

It is pertinent to mention that thiourea is a sulphydryl compound which plays bioregulatory role in plants due to presence of -SH group. Moreover -SH group has been diverse biological activities (Jocelyn, 1972). The involvement of -SH group in phloem for sucrose transport was also noted by Giaguinta (1976). The positive action of thiourea on growth could be

Table 1. Effect of thiourea and zinc on growth and yield parameters of cauliflower

Treatment	Plant height at harvesting (cm)	Number of leaves/ plant at harvesting	Leaf area (cm^2)	Total chlorophyll content (mg/ g) at 40 DAT	Days taken to curd initiation	Days taken to curd maturity	Average weight of curd (g/plant)	Curd yield (q /ha)
Thiourea levels								
T_0 (Control)	28.12	19.12	610.22	0.988	69.15	88.75	217	107.16
T_1 (500 ppm)	31.54	24.54	790.12	1.525	67.47	81.45	292	144.07
T_2 (750 ppm)	34.22	27.12	955.15	1.885	65.10	75.15	318	156.91
T_3 (1000 ppm)	34.45	28.10	970.81	1.901	64.00	73.55	362	178.77
SEm+	0.67	0.72	10.88	0.038	1.33	2.17	4	1.77
CD (P=0.05)	1.92	2.09	31.42	0.108	3.83	6.25	11	5.10
Zinc levels								
Z_0 (Control)	28.25	19.37	619.94	0.989	69.42	88.97	257	126.79
Z_1 (2.5 kg/ha)	31.36	24.30	794.61	1.538	67.21	81.66	285	140.86
Z_2 (5.0 kg/ha)	34.19	27.27	947.09	1.879	65.07	75.06	311	153.46
Z_3 (7.5 kg/ha)	34.54	27.94	964.66	1.893	64.02	73.21	336	165.80
SEm+	0.67	0.72	10.88	0.038	1.33	2.17	4	1.77
CD (P=0.05)	1.92	2.09	31.42	0.108	3.83	6.25	11	5.10
Interaction (TxZ)	NS	NS	Sig.	Sig.	NS	NS	Sig.	Sig.

Table 2. Interactive effect of thiourea and zinc on growth and yield parameters of cauliflower

Treatment	Leaf area (cm^2)	Total chlorophyll content (mg/g) at 40 DAT	Average weight of curd (g/plant)	Curd yield (q /ha)
T_0 Z_0	454.92	0.620	185	91.36
T_0 Z_1	583.09	0.965	199	98.27
T_0 Z_2	694.99	1.179	226	111.60
T_0 Z_3	707.88	1.188	258	127.41
T_1 Z_0	589.04	0.958	262	129.38
T_1 Z_1	754.99	1.489	273	134.81
T_1 Z_2	899.88	1.820	308	152.10
T_1 Z_3	916.57	1.833	324	160.00
T_2 Z_0	712.07	1.184	282	139.26
T_2 Z_1	912.69	1.841	312	154.07
T_2 Z_2	1087.83	2.249	323	159.51
T_2 Z_3	1108.01	2.266	354	174.81
T_3 Z_0	723.74	1.194	298	147.16
T_3 Z_1	927.65	1.856	357	176.30
T_3 Z_2	1105.67	2.268	386	190.62
T_3 Z_3	1126.17	2.285	407	200.99
SEm+	21.76	0.075	8	3.60
CD (P=0.05)	62.85	0.217	22	10.40

described due to one or more number of reasons. It might be due to change in metabolites present in seedlings as a result in change of activity of hydrolytic enzymes or due to change in oxidation mechanisms, especially those concerned with electron transport (Polyakoff-mayber *et al.*, 1960). Thus, it is fairly conceivable that thiourea might have increased photosynthesis, which in turn significantly increased in plant height, number of leaves, leaf area, plant spread and total chlorophyll content in leaves.

The application of zinc led to an increase in plant growth attributes due to active synthesis of tryptophane, a precursor of auxin, besides synergistic effect of zinc which may serve as a source of energy for synthesis of auxin. The same could be attributed as one of the factors for growth of plant (Raghav and Singh, 2004). This could be attributed to its role in metabolic activity mainly in protein synthesis in plant (Nagaraju and Yadahalli, 1996). Increase in growth attributes might be due to the fact that besides the role of zinc in chlorophyll formation, it also influenced cell division, meristematic activity of tissues, and expansion of cell and formation of cell wall. Similar results were also reported by Chhipa (2005) in cauliflower, Moniruzzaman *et al.* (2008) in broccoli and Sammauria and Yadav (2008) in fenugreek and Dubey *et al.* (2013) in mustard.

Minimum days were taken to curd initiation and curd maturity at thiourea 1000 ppm (T_3) which was at par with thiourea 750 ppm (T_2) and zinc @ 7.5 kg/ha (Z_3), being at par to zinc 5 kg/ha (Z_2). The interaction of thiourea and zinc were found to be non-significant for days taken to curd initiation and curd maturity. The maximum curd weight and curd yield were observed with application of thiourea 1000 ppm (T_3). Similarly, effect of zinc was also found to be significant. The maximum curd weight and curd yield were recorded in Z_3 (zinc 7.5 kg/ha). The highest curd weight and marketable yield were obtained with the treatment combination of T_3Z_3 (1000 ppm + 7.5 kg/ha) which were statistically at par with treatment combination T_3Z_2 (1000 ppm + 5 kg/ha). The significant variation in yield attributes and yield obtained with thiourea application was most probably due to increased photosynthesis favoured by both improved photosynthetic effect and source to sink relationship.

Giaguinta (1976) reported the bio-regulatory effect of thiourea, chiefly through mobilization of dry matter and translocation of photosynthates to sink which ultimately improved the yield. Favourable effect of thiourea on yield attributes and yield was reported by Singh *et al.* (2012) in okra, Mani *et al.* (2013) in potato and Meena *et al.* (2014) in coriander. This might be due

to the main function of zinc in plant as a metal activator of several enzymes like dehydrogenase, proteinase and peptides (Prasad and Kumar, 2010).

The beneficial effect of zinc on yield and yield parameters may be attributed due to that soil application of zinc resulted in increased supply of available zinc to plants which led proper growth and development because essential role of zinc has been established as a component of several enzymes which are concerned with carbohydrate and nitrogen metabolism, in addition to its involvement directly or indirectly in regulating various physiological processes of plants (Marschner,1995). The present findings are in close conformity with the findings of Jamre *et al*. (2010) in cauliflower, Naher *et al*. (2014) in cabbage and Dadhich *et al.* (2015) in mustard.

Thus, increase in curd yield by the application of these micronutrients may be attributed to their role in enhancing the translocation of carbohydrates from the site of their synthesis to storage tissue in curd. These findings are in close conformity with those of Varghese and Duraisami (2005).

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Current Horticulture **5**(2): 44–47, July–December 2017 ISSN: 2347-7377; RNI No.: UPENG03865/24/1/2013-TC

Effect of frontline demonstrations on yield enhancement of pea (*Pisum sativum* L.) in Pratapgarh district of Rajasthan

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Received: December 2015; **Revised:** January 2017

ABSTRACT

The study was carried out in Pratapgarh district of Rajasthan, with 25 demonstrations on pea (*Pisum sativum* L.) during *rabi* season of 2013-14 and 2014-15. To increase the productivity, high pod yield of pea variety, Azad P 3 was evaluated at tribal farmers' fields. The pod yield under improved package of practices was 70.30 and 70.40 q/ha, increasing significantly by 30.13 - 31.15 per cent over farmers' practices (53.60 q/ha and 54.10 q/ha). The ranges of average yield were 62.40 - 75.60 q/ha and 64.20 - 75.70 q/ha in demonstration fields and 51.20 q/ha - 56.20 q/ha and 50.30 q/ha - 58.70 q/ha at farmers' fields during both years. The technological gap existing between the potential and demonstrable yields was substantial (16.70 q/ha and 16.30 q/ha). Technology index of 20.87 and 20.37% gave evidence that there was a scope for further improvement in productivity. There was extension gap between improved technology and farmers' practices (9.70 q/ha and 9.60 q/ha) during both years. Therefore, frontline demonstration programme was an effective tool for increasing the productivity of vegetable pea. This created greater awareness and motivated other farmers for adoption to improved practices of pea production technology. These demonstrations also built the relationship and confidence between farmers and scientists. The beneficiary tribal farmers of FLDs also play an important role as a source of information and pure vegetable seeds and planting material for wider dissemination of high-yielding varieties of pea for nearby farmers. Thus, cultivation of pea with improved technology is more productive and pod yield might increase up to 31.5 per cent.

Key Words: Frontline demonstration, Transfer of technology, Demonstration, Improved practice, Farmers practices, Adoption, Production, Pod yield

Field pea (*Pisum sativum* L.) is an important vegetable crop commonly grown in Uttar Pradesh, Bihar, Madhya Pradesh and Rajasthan in India. It is grown mainly as a winter vegetable in plains of north India and as a summer vegetable in hills. It is a cool weather crop and grown at optimum mean monthly temperature of 10°C - 18°C. The plants are able to withstand relatively low temperature, especially during early stage but may not withstand a severe continued frost. The pod yield of peas is adversely affected by incidence of powdery mildew disease and attack of aphids. Therefore, frontline demonstration programme was an effective tool for increasing its productivity. Though several factors and conditions are responsible for such yield gaps. Therefore, a study was carried out in tribal part of Rajasthan to examine important aspects related to the utilization of recommended package of production technology.

MATERIALS AND METHODS

Twenty-five frontline demonstrations were conducted at farmers' fields in Pratapgarh district of Rajasthan during 2013-14 and 2014-15. The crop was sown during first to third week of October. The extension activities like farmers' trainings, literature, SMS, and diagnostic visits were undertaken. The farmers selection was done as per the guidelines provided by Zonal Project Directorate to bridge the gap existing between state productivity and district productivity and the whole package of practices was demonstrated to farmers through FLDs trials including component such as variety, seed rate, seed treatment, weed management and irrigation schedules through sprinkler, fertilizers and plant-protection measures, under strict supervision of KVK scientists from sowing to harvesting. The FLDs is an important method of transfer of latest package of

practices in totality to farmers.

The main objective of this programme is to demonstrate newly released crop production and protection technologies and management practices at tribal farmers' fields under real farming situation at his own field under different agroclimate regions. The farmers learn the latest technology that may lead to higher production or adoption. Realizing the importance of frontline demonstrations in transfer of latest technologies through KVKs, the present study has been undertaken to study the difference between demonstration package and farmers practices of pea and to assess effect of FLDs technology on increasing the productivity of pea. The primary data were collected from farmers with the help of interview schedule and interpreted and presented in terms of percentage, qualitative data were converted into quantitative form and expressed in terms of percent increased yield. The data were collected with help of well structured interview schedule, which was pretested before application. To measure the knowledge level of farmers they were requested to reply 32 questions on selected components of recommended package of production technology.

$$\% \text{ increase in yield} = \frac{\text{Demonstration yield - farmers yield}}{\text{Farmers yield}} \times 100$$

Technology gap: potential yield - demonstration yield

Extension gap: potential yield - improved yield

$$\text{Technology Index} = \frac{\text{Technology gap}}{\text{Potential yield}} \times 100$$

RESULTS AND DISCUSSION

The data revealed that improved technology (70.30 and 70.40 q/ha) registered 30 and 31 per cent increase in pod yield over farmers' practices (53.60 and 54.10 q/ha) during 2013-14 and 2014-15 (Table 1). The range of average pod yield was 62.40 - 75.60 and 64.20 - 75.70 q/ha in demonstrations fields and 51.20 - 56.20 q/ha and 50.30 - 58.70 q/ha in farmers' fields, respectively (Table 2). The highest yield in demonstrations were 75.60 and 75.70 q/ha compared with farmers' practices (56.20 and 58.70q/ha, respectively) recorded during both seasons. The results indicated that frontline demonstrations have given a good impact over the vegetable farming community in Pratapgarh district as they were motivated by new vegetable technologies applied in frontline demonstrations. These results corroborate to those of Singh *et al.* (2014; Balai *et al.*, 2013; Khaiwal, 2014; Balai, *et al.*, 2014), vegetables pulse crops (Das and Willey, 1991; Khan and Chouhan, 2005; Raj, *et. al.*, 2013; Rajiv and Singh 2014) and cumin (Choudhary, 2012; Choudhary and Kantwa, 2014). Overall, the pod yield of demonstrations plots exceeded to that of farmers' plots. This was attributed to the quality seed used, adequate seed rate, management practices and judicious use of fertilizers.

The net gain per hectare was ₹ 58670 and ₹ 59360 and ₹ 30110 and ₹ 31630 higher by investing additionally ₹ 4890 and ₹ 5000 during 2013-14 and 2014-15. Improved package of practice fetched a higher benefit : cost (B:C) ratio of 2.47 and 2.49, while farmers practices gave 1.80 and 1.77 during 2013-14 and 2014-15 (Table 1). This may be due to higher yield obtained under improved technologies, compared to local check (farmers' practices). These findings are in conformity with those of Singh, *et al.* (2004), Choudhary (2012), Balai *et al.*, (2013), Raj *et al.*, (2013), Balai *et al.*, (2014), Choudhary and Kantwa, (2014) and Rajiv and Singh (2014).

The technological gap existing between potential and demonstrable yields was not substantial (16.70 q/ha and 16.30 q/ha) during 2013-14 and 2014-15 (Table 2). Thus, it was possible to replicate the result obtained in research experiments in real farm situation too. The technological gap may be attributed to the dissimilarity in soil fertility status, horticultural practices and local climatic situation. This finding is in corroboration with those of Choudhary and Kantwa (2014). There was an extension gap between improved technology and farmers' practices. Due to this, a gap of 9.70 q/ha and

Table 1. Impact of improved technology on economics of pea cultivation

Particulars	Years	
	2013-14	2014-15
Production cost		
Improved practice	39,750	39,890
Farmers practice	35,760	35,790
Additional cost over FP	4,890	5,000
Gross return		
Improved practice	98,420	99,250
Farmers practice	64,320	63,520
Net return		
Improved practice	58,670	59,360
Farmers practice	28,560	27,730
B:C ratio		
Improved practice	2.47	2.49
Farmers practice	1.80	1.77
Additional return	30,110	31,630
Increase in net return (%)	105.42	114.06
B:C ratio additional input demonstration	6.16	6.33

IP, Improved practice; FP, Farmers practices

Table 2. Impact of improved technologies on productivity and gaps in pea cultivation

No. of FLDs	Variety	Mean yield (q/ha)		Range yield index (q/ha)		Techno-logy gap (q/ha)	Extension gap (q/ha)	Techno logy in dex (%)	Increase in yield (%)
		Improved practice	Farmers practice	Improved practice	Farmers practice				
2013-14 (25)	Azad Pea-3	70.3	53.6	62.4-75.6	51.2-56.2	16.7	9.7	20.87	30.13
2014-15 (25)	Azad Pea-3	70.4	54.1	64.2-75.7	50.3-58.7	16.3	9.6	20.37	31.15

Potential yield of pea (Azad P 3), 80 q/ha, TG, PY, IP, EG = PY - IP and TI = TG/PY*100

9.60 q/ha was in yield and which could be overcome by adopting improved varieties and efficient management practices during both years (Table 2). This emphasized the need to educate the farmers through various means for adoption of improved production technologies. More and more use of latest vegetable production technologies with high-yielding variety will subsequently change this alarming trend of galloping extension gap. The new technologies will eventually lead to farmers to discontinue old technology and to adopt new ones. This finding is in corroboration with the finding of Hiremath and Nagaraju (2010).

The technology index shows feasibility of evolved technology index more is the feasibility of technology (Jeengar *et al.,* 2006). The technology index 30.13% and 31.15% gave evidence that there was a scope for further improvement in productivity of peas (Table 2). There was marginal difference between benefit : cost ratio of improved technologies by the farmers. However, to further bridge the gap between technology developed and technology transferred, there is a need to strengthen the extension network besides emphasis on specific local recommendations. These results confirm to those obtained by conducting in FLD trials on various seed spices crops (Singh and Varshney, 2010; Veerasamy *et al.,* 2003; Verma *et al.,* 2010; Choudhary, 2012; Choudhary and Kantwa, 2014) and vegetable crops (Singh, *et. al.,* 2004; Balai, *et al.,* 2013; Khaiwal, 2014; Balai, *et al.,* 2014).

Optimum sowing time is not followed due to non-availability of quality seed. More than 90 per cent of farmer's field pea seed sowing as broadcast method and most of situation the plat population of farmer's field is very high or two-three times high of the recommended stand. Lack of popularization of seed-cum-fertilizers drill for sowing and use of inadequate and imbalance dose of fertilizers, especially the nitrogenous and phasphatic fertilizers by farmers does not make possible to fetch potential yield. Mechanical weed control is costly and chemical control is quite uncommon in this region.

Thus, frontline demonstrations programme was an effective tool for increasing the productivity of vegetable pea. This created greater awareness and motivated the other tribal farmers for adoption of improved practices of pea production technology. These demonstrations also built the relationship and confidence between farmers and scientists. The beneficiary farmers of FLDs also play an important role as source of information and pure vegetable seeds and planting material for wider dissemination of HYV of pea for other nearby farmers. Thus, cultivation of pea with improved technology has been found more productive and pod yield might be increased up to 31.5 per cent during both years. Technological and extension gap extended which can be bridged by popularity package of practices with emphasis of improved variety, use of proper seed rate, balance nutrient application and proper use of plant-protection measures. Replacement of local variety with the newly released variety of pea would result in increased in production and net income.

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Current Horticulture **5**(2): 48–52, July–December 2017 ISSN: 2347-7377; RNI No.: UPENG03865/24/1/2013-TC

Evaluation of performance of flowering, fruiting and quality characters of twenty genotypes of ber (*Zizyphus mauritiana*) under semi-arid conditions of Rajasthan

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Received: January 2016; **Revised:** May 2017

ABSTRACT

The experiment was conducted to evaluate 20 diverse genotype of ber (*Zizyphus mauritiana* Lamk.) during 2014-15 and 2015-16 at Asalpur Farm, Department of Horticulture, SKN College of Agriculture, Jobner. Maximum mean duration of flowering was observed in Sukhawani genotype in pooled data, while maximum fruit setting, fruit retention and minimum fruit drop were observed in Gola. The highest mean duration of fruiting, initial date of first harvesting, fruit picking and minimum total days taken to first harvesting were recorded in Gola, whereas maximum total days taken to complete harvesting were found in Sukhawani. The maximum mean TSS and total sugars were observed in Meharun, while minimum total acidity was found in Sukhawani. The maximum mean ascorbic acid was recorded in Lakhan. The highest reducing sugar was observed in Gola and maximum non-reducing sugar in Ilaichi. The highest mean TSS: acid ratio was observed in Tikadi during both the years as well as in pooled analysis under semi-arid condition of Rajasthan.

Key Words: Flowering, Fruiting, Quality, Comparative performance, Diverse genotypes, Harvesting

Indian jujube (*Ziziphus mauritiana* Lamk.) commonly known as, ber, belongs to family Rhamnaceae, consisting of 45 genera and 550 species. The genus *Zizyphus* has approximately 40 species, including *Zizyphus mauritiana* Lamk., which is indigenous to India. Ber is one of the important fruit trees that can be successfully cultivated in the hot arid regions of India. It is one of most ancient and common fruits in India (Rai and Gupta, 1994). Ber is widely distributed in tropical and subtropical regions of the world (Mukhtar *et al.*, 2004). Ber is cultivated in Madhya Pradesh, Bihar, Punjab, Haryana, Gujarat and Rajasthan. In Rajasthan, ber orchards are manly spread around Tijara, Alwar, Deeg, Chomu, Jaipur and Jodhpur. Ber is quite popular due to high economic returns, low cost of cultivation, wider adaptability and ability to stand with drought (Chadha and Pareek, 1993). It can provide food security, due to sustained production of fruit, irrespective of drought, as the tree is drought and saline tolerant and can grow on poor degraded land (Pareek, 2001).

Ber fruits are very nutritious and usually eaten fresh. Fruits are also consumed in dried and preserved form as candy, pickle, juice and ber butter (Maydell, 1986). Arid regions are now facing a grave situation because of ecological deterioration. These areas have been subjected to unprecedented biotic pressure, creating variety of scarcity conditions and need increased food supply. Inherently, desert environment imposes biophysical constraints for intensive production. Therefore, there is a need for greater attention on drought and heat tolerant fruit tree species and ber being the most predominant among them. The chance of a suitable cultivar is of paramount importance for successful cultivation. Therefore, an experiment was conducted to find out suitable ber cultivars for semi-arid condition of Rajasthan.

MATERIALS AND METHODS

The experiment was conducted to study the comparative performance of flowering, fruiting and quality character of 20 genotypes of ber under semi-

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arid condition of Rajasthan, during 2014-15 and 2015-16 seasons. The genotypes consisted of Saphar Chandni, Gola, Tikadi, Phalisa Alwari, Thornless, Katha, Katha Bombay, Tabes Taso, Meharun, Dharkhi, Lakhan, Ilaichi, Pathani, Chhuhara, Nazuk, Kheera, ZG-3, Kathaphal, Sukhawani and Ashapuri 2. The 14-year-old trees were selected in a randomized block design with three replications at Asalpur Farm, Department of Horticulture, SKN College of Agriculture, Jobner, Jaipur. The soil was loamy sand in texture, alkaline with low in available nitrogen and phosphorus and medium in potash.

The pH and Ec of water were 8.5 and 5.2 ds/m respectively during 2014-15 and 8.7 and 6.1 ds/m respectively during 2015-16. The mean daily maximum and minimum temperature during the growing season fluctuated between 20.2 to 30.7°C and 3.3 to 13.0°C, respectively during 2014-15. The corresponding values for 2015-16 were between 18.5 to 32.5°C and 2.3 to 14.2°C. Similarly, mean daily relative humidity fluctuated between 52 and 70 per cent during 2014-15 and 50 and 77 per cent during 2015-16. Rainfall received during the crop period was 21.2 and 19.0 mm during 2014-15 and 2015-16, respectively. The data on different flowering, fruiting and quality characters were recorded.

The data on different flowering, fruiting and quality characters were recorded. The duration of flowering was obtained by days from the initiation of flowering to appearance of last flower appearance were counted and considered. Total number of fully opened flowers were counted at the time of flowering on tagged shoots and after fruit setting total number of fruits at pea-sized stage were counted on the basis of flowers which set were counted and fruit setting in per cent was calculated. The difference between total number of fruits remained on tagged shoots at harvesting out of the total number of fruits at fruit setting were counted and fruit drop in per cent was calculated.

The fruit retention was calculated on the basis of initial number of fruits set. The duration of fruiting was estimated by days from first harvesting to last harvesting was recorded. Date on first harvesting was recorded at the day of first harvesting (when the colour of fruits turned to yellowish) during both the years. Total number of days taken to first harvesting were counted from the date of initiation of flowering to date of first picking of fruits. Total numbers of days taken to complete harvesting were counted from the date of initiation of flowering to last picking of fruits.

Fruit picking from first harvesting to last harvesting were recorded and number of fruit picking were estimated. Total soluble solids (TSS) of juice was determined by using a hand refractometer of 0-32 per cent range. Total acidity was determined by phenolphthalein method. The ascorbic acid (vitamin 'C') content of pulp was determined by metaphosphoric acid method. Total sugars content was determined by using anthrone reagent method (Dubois *et al.,* 1951). Reducing sugar content was measured by following 'Nelsons' Modifications of 'Somogyis Method' (Somogyi, 1952). The amount of non-reducing sugar was obtained by subtracting reducing sugar from the amount of total sugar and multiplying the resultant by factor 0.95. The TSS: acid ratio was calculated by dividing the values of TSS by values of acidity determined. The recorded data were averaged and statistically analysed as per Steel and Torrie (1981) using the statistical programme OPSTAT.

RESULTS AND DISCUSSION

There was significant variation in mean values of flowering, fruiting and quality characters among genotypes during both the years and pooled data. The estimates of mean value for flowering, fruiting and quality characters during both the years as well as in pooled analysis are presented in Tables 1-3. The flowering characters of ber genotypes during both the years as well as in pooled analysis affected significantly. The maximum mean duration of flowering (80.50 days) was observed in Sukhawani in pooled data, which was statistically at par with Saphar Chandni (78.17 days), Katha Bombay (77.50 days), Thornless (76.50 days), Phalisa Alwari (75.33 days) and Gola (74.33 days), while minimum mean duration of flowering was found in Tikadi (49.83 days) in pooled analysis.

The maximum average fruit setting (20.77 per cent) was observed in Gola, which was significantly superior over all other genotypes, whereas minimum average fruit setting (5.54 per cent) was recorded in Sukhawani in pooled analysis. The minimum average fruit drop (39.58 per cent) was recorded in Gola in pooled analysis, which was found statistically significant over all other genotypes. However, maximum average fruit drop was found in Sukhawani (83.88 per cent), followed by Tikadi (72.76 per cent) in pooled analysis. The highest mean fruit retention (55.95 per cent) was observed in Gola, which was statistically significant over all other genotypes, whereas lowest mean fruit retention was found in Sukhawani (19.94 per cent) during pooled analysis. Similar results were reported by Dhingra *et al.,* 1971; Chadha *et al.,* 1972; Tomer and Singh, 1987; Chadha and Pareek, 1993; Aulakh *et al.,* 2000; Gupta *et al.,* 2003; Aulakh *et al.,* 2005, Lal *et al.,* 2004 Abbas *et al.,* 2012 in ber.

The data on fruiting characters for both the years and pooled mean are presented affected significantly (Table 2). The highest mean duration of fruiting (68.83

Table 1. Estimates of mean value for flowering characters for different genotypes of ber (pooled data)

Genotype	Duration of flowering (days)	Fruit setting (%)*	Fruit drop (%)**	Fruit retention (%)*
Saphar Chandni	78.17	9.97 (3.23)	71.00 (57.42)	30.66 (29.01)
Gola	74.33	20.77 (4.61)	39.58 (38.97)	55.95 (60.43)
Tikadi	49.83	9.37 (3.14)	72.76 (58.56)	29.29 (27.25)
Phalisa Alwari	75.33	10.06 (3.25)	70.75 (57.26)	30.86 (29.26)
Thornless	76.50	10.34 (3.29)	69.90 (56.74)	31.71 (30.10)
Katha	71.67	14.39 (3.86)	58.12 (49.67)	41.14 (41.89)
Katha Bombay	77.50	15.58 (4.00)	54.69 (47.69)	43.72 (45.32)
Tabes Taso	70.83	9.76 (3.20)	71.61 (57.81)	30.22 (28.40)
Meharun	67.00	12.73 (3.63)	62.96 (52.52)	37.26 (37.05)
Dharkhi	66.67	11.87 (3.50)	65.47 (54.02)	35.34 (34.53)
Lakhan	57.00	10.64 (3.33)	69.06 (56.21)	32.32 (30.94)
Ilaichi	61.83	9.44 (3.15)	72.53 (58.41)	29.50 (27.48)
Pathani	71.00	9.90 (3.22)	71.19 (57.54)	30.51 (28.81)
Chhuhara	62.83	12.98 (3.67)	62.25 (52.09)	37.73 (37.76)
Nazuk	63.00	12.56 (3.61)	63.45 (52.81)	36.96 (36.55)
Kheera	63.00	14.51 (3.87)	57.29 (49.18)	41.83 (42.72)
ZG-3	61.33	12.25 (3.56)	64.38 (53.38)	36.16 (35.63)
Kathaphal	68.83	9.70 (3.19)	71.79 (57.92)	30.12 (28.22)
Sukhawani	80.50	5.54 (2.44)	83.88 (66.39)	19.94 (16.12)
Ashapuri-2	65.83	8.67 (3.02)	72.47 (58.41)	29.15 (27.53)
SEm ±	2.52	0.09	0.99	1.60
CD (5%)	7.22	0.27	2.83	4.59
CV	6.41	4.66	3.13	8.22

*, ** Figures in parentheses are square root and angular transformed values, respectively

Table 2. Estimates of mean value for fruiting attributes for different genotypes of ber (pooled data)

Genotype	Duration of fruiting (days)	Date of first harvesting	Total days taken to first harvesting	Total days taken to complete harvesting	Number of fruit pickings
Saphar Chandni	56.83	14, Jan	141.67	204.50	8.33
Gola	68.83	25, Dec	127.33	184.67	11.17
Tikadi	46.83	7, Jan	162.50	212.17	7.67
Phalisa Alwari	56.83	14, Jan	159.17	216.50	8.33
Thornless	53.83	9, Jan	166.83	223.33	8.33
Katha	51.50	8, Jan	167.83	225.00	10.00
Katha Bombay	64.83	4, Jan	153.50	217.50	10.67
Tabes Taso	55.67	8, Jan	151.50	207.17	7.67
Meharun	52.67	10, Jan	155.17	209.33	9.33
Dharkhi	53.17	8, Jan	145.33	200.33	8.50
Lakhan	43.50	6, Jan	165.00	207.67	8.50
Ilaichi	53.17	22, Jan	168.50	229.33	7.50
Pathani	60.00	14, Jan	173.17	235.33	8.33
Chhuhara	42.33	11, Jan	166.50	208.83	9.67
Nazuk	46.50	8, Jan	163.17	209.33	8.67
Kheera	48.17	20, Jan	156.83	205.00	10.33
ZG-3	43.00	22, Jan	156.00	200.00	8.67
Kathaphal	45.17	5, Jan	154.50	200.83	7.50
Sukhawani	40.17	3, March	177.83	237.83	5.67
Ashapuri-2	53.17	17, Jan	157.50	210.67	7.00
SEm ±	2.13	-	1.32	2.17	0.74
CD (5%)	6.09	-	3.77	6.22	2.12
CV	7.11	-	1.44	1.77	14.94

Table 3. Estimates of mean value for quality attributes for different genotypes of ber (pooled data)

Genotype	TSS (%)	Total acidity (%)	Ascorbic acid (mg/100 g pulp)	Total sugars	Reducing sugar	Non-reducing sugar	TSS: acid ratio
Saphar Chandni	21.60	0.62	158.75	9.40	4.76	4.41	34.52
Gola	20.89	0.49	170.38	9.30	6.78	2.40	42.77
Tikadi	21.93	0.13	130.40	9.70	5.50	4.00	178.22
Phalisa Alwari	18.48	0.32	83.38	6.17	2.80	3.20	59.26
Thornless	17.92	0.16	154.30	8.12	4.93	2.70	116.04
Katha	18.98	0.68	121.58	6.08	3.10	2.84	28.04
Katha Bombay	20.78	0.38	114.58	9.07	4.96	3.90	54.91
Tabes Taso	19.28	0.13	153.50	6.18	3.42	2.96	148.54
Meharun	23.14	0.50	101.62	9.95	5.44	4.28	46.34
Dharkhi	15.56	0.14	171.72	8.50	4.67	3.64	116.11
Lakhan	14.47	0.50	200.98	7.86	3.78	3.88	29.02
Ilaichi	19.91	0.42	180.47	8.77	3.77	4.75	48.00
Pathani	15.83	0.32	92.93	8.35	5.29	2.90	51.36
Chhuhara	19.89	0.29	92.07	8.79	4.58	4.01	69.44
Nazuk	18.48	0.28	86.73	6.43	3.60	2.69	66.77
Kheera	18.04	0.27	125.32	7.39	3.91	3.31	66.76
ZG-3	18.28	0.45	127.58	9.28	4.97	4.09	40.81
Kathaphal	19.98	1.06	195.27	8.49	5.11	3.21	18.91
Sukhawani	9.70	0.12	50.24	5.53	2.21	3.16	83.41
Ashapuri-2	20.57	0.15	167.01	8.87	4.49	4.15	138.84
SEm ±	0.91	0.01	2.28	0.24	0.55	0.19	3.89
CD (5%)	2.61	0.04	6.52	0.69	1.56	0.56	11.13
CV	8.45	6.90	2.95	5.17	21.45	9.53	9.37

days) was recorded in Gola in pooled data, which was statistically at par with Katha Bombay (64.83 days). The lowest mean duration of flowering was observed in Sukhawani (40.17 days) in pooled analysis. The initial date of first harvesting (25 December) was recorded in Gola, followed by Katha Bombay (4 January) and Kathaphal (5 January), whereas first harvesting date was observed late in Sukhawani (3 March) in pooled analysis. The minimum average total days taken to first harvesting were recorded in Gola (127.33) genotype of ber, which was statistically significant over all other genotypes. However, minimum average total days taken to first harvesting were observed in Sukhawani (177.83) in pooled analysis.

The maximum total days taken to complete harvesting (237.83) were found in Sukhawani during pooled analysis, which was statistically at par with Pathani (235.33) and minimum total days taken to complete harvesting (184.67) were recorded in Gola in pooled analysis. The maximum mean number of fruit pickings (11.17) was recorded in Gola in pooled analysis, which was statistically at par with Katha Bombay (10.67), Kheera (10.33), Katha (10.00), Chhuhara (9.67) and Meharun (9.33). Whereas, minimum mean number of fruit pickings were found in Sukhawani (5.67), followed by Kathaphal (7.00) in pooled analysis. Similar results were reported by Dhingra *et al.,* 1971, Chadha *et al.,* 1972, Tomer and Singh, 1987, Chadha and Pareek, 1993, Aulakh *et al.,* 2000, Gupta *et al.,* 2003, Aulakh *et al.,* 2005, Lal *et al.,* 2004 and Abbas *et al.,* 2012 in ber.

The quality characters of ber genotypes during both the years as well as in pooled analysis affected significantly (Table 3). The maximum mean TSS (23.14 per cent) was observed in Meharun in pooled data, which was statistically at par with Tikadi (21.93 per cent), Saphar Chandni (21.60 per cent), Gola (20.89 per cent), Katha Bombay (20.78 per cent) and Ashapuri 2 (20.57 per cent), while minimum mean TSS was found in Sukhawani (9.70 per cent), followed by Lakhan (14.47 per cent) and Dharkhi (15.56 per cent). The minimum total acidity (0.12 per cent) was recorded in Sukhawani, which was statistically at par with Tikadi (0.13 per cent), Tabes Taso (0.13 per cent), Dharkhi (0.14 per cent), Ashapuri-2 (0.15 per cent) and Thornless (0.16 per cent), while maximum total acidity was observed in Kathaphal (1.06 per cent).

The maximum mean ascorbic acid (200.98 mg/100 g pulp) was recorded in Lakhan which was statistically at par with Kathaphal (195.27 mg/100 g pulp). However, minimum mean ascorbic acid was observed in

Sukhawani (50.24 mg/ 100 g pulp) in pooled analysis. The maximum total sugars (9.95 per cent) were found in Meharun which was statistically at par with Tikadi (9.70 per cent), Saphar Chandni (9.40 per cent), Gola (9.30 per cent) and ZG-3 (9.28 per cent), whereas minimum total sugars (5.53 per cent) were recorded in Sukhawani.

The maximum mean reducing sugar (6.78 per cent) was observed in Gola, which was statistically at par with Tikadi (5.50 per cent), Meharun (5.44 per cent) and Pathani (5.29 per cent) and minimum mean reducing sugar (2.21 per cent) was recorded in Sukhawani. The maximum average non-reducing sugar (4.75 per cent) was recorded in Ilaichi, which was statistically at par with Saphar Chandni (4.41 per cent) and Meharun (4.28 per cent) and minimum average reducing sugar was found in Gola (2.40 per cent). The highest mean TSS: acid ratio (178.22) was observed under Tikadi genotype of ber during both the years, whereas lowest mean TSS: acid ratio was found in Kathaphal (18.91) in pooled analysis. Similar results were reported by Chadha *et al.*, 1972, Dhingra *et al.*, 1971, Tomer and Singh, 1987, Gupta *et al.*, 2003, Aulakh *et al.*, 2000, Aulakh *et al.*, 2005 and Abbas *et al.*, 2012 in ber. Thus, highest fruit setting and fruit retention were observed in pooled analysis of data.

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Current Horticulture **5**(2): 53–55, July–December 2017 ISSN: 2347-7377; RNI No.: UPENG03865/24/1/2013-TC

Effect of iron, zinc and boron on yield and income from *rabi* onion (*Allium cepa)* var. Agrifound Light Red

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Received: December 2015; **Revised:** May 2017

ABSTRACT

An experiment was conducted to find out the influence of iron, zinc and boron on income from *rabi* onion var. Agrifound Light Red grown under loamy sand soil (*Allium cepa* L.) at Horticulture Instructional Farm, Chimanbhai Patel College of Agriculture, Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar, in a Factorial Randomized Block Design with three replication during two consecutive *rabi* season 2013-14 and 2014-15. The application of micronutrient enhanced yield in all treatments compared to the control. The application of zinc 25 kg/ha resulted in significantly higher bulb yield up to (564.70 q/ha), net income (₹ 494621.68/ha) and B:C ratio 7.06. In case of net income, and B:C ratio, iron 20 kg/ha stood as the second best treatments (547.58 q/ha, ₹ 478098.16/ha and 6.88), respectively and incase of boron maximum bulb yield (533.93 q/ha), net income (₹ 464003.00/ha) and B:C ratio (6.74) recorded with boron 5 kg/ha and 2.5 kg/ha treatment, respectively.

Key Words: *Rabi*, Income, Iron, Zinc and Boron.

Onion (*Allium cepa* L.) is most important vegetable bulb crop grown in India from ancient time. Because of its importance in cookery, onion is called as "Queen of the kitchen" (Selvaraj, 1976). The *Allium* genus comprises 300 - 500 species, which are widely distributed in northern temperate region. The common onion grown for dry bulb is *Allium cepa* L. (Thompson and Kelley, 1957). It acts as gastric stimulant and promotes digestion (Yawalkar and Har 2004). It is used as a remedy for various diseases like dysentery, convulsions, headaches, hysterial fits, rheumatic pain, malaria, fever and as a fine demulcent to give relief in piles (Sharma, 2014). The Indian soil have been chronically poor in nitrogen, phosphorus, iron, zinc, boron, magnesium and sulphur. Due to continuous cropping, multiple nutrient deficiencies have been noticed. Zinc deficiency in onion is fairly widespread and is noticed also in garlic in the sandy soils. Deficiency of iron in onion, garlic, brinjal, tomato and potato is also noticed in sandy soils. Boron deficiency is also noticed in tomato, carrot, onion, garlic, radish and pomegranate in sandy and loamy sand soil in Gujarat and Rajasthan region. Deficiency symptoms of iron causes intervenial chlorosis primarily on young tissues which may become white. It shows deficiency symptoms on poorly drained soil. Soil high in calcium, copper, zinc, phousphorus and high pH shows unavailability of iron. Toxicity symptoms are rarely observed except on flooded soils (Mishra and Rajesh Kumar 2014). Zinc is essentially required for chlorophyll production, carbohydrates and starch formation. In deficiency of zinc, young leaves become very small, sometimes even missing leaf blades. It showed short leaf length, distorted or puckered leaf margin and also chlorosis. Boron helps in the use of nutrients and regulates other nutrients. It helps in translocation of sugar and carbohydrates. It is essential for seed and fruit development. Deficiency symptoms of boron may cause plant failure to set fruits. Its deficiency cause internal break down of fruits and vegetables, giving rise to witches broom, young leaves become thick, lathery and scorcking on young stem petioles and flower stalks. Therefore an experiment was conducted to see the effect of different micronutrients on yield of onion.

MATERIALS AND METHODS

The field experiment was conducted during *rabi* season of 2013-14 and 2014-15 at the Horticulture Instructional Farm, Chimanbhai Patel College of

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Agriculture, Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar. The soil was loamy sand, rich in organic matter and had good water-holding capacity. The soil having a pH of 7.66 was low in available nitrogen (173.76 kg/ha) and available phosphorus (35.76 kg/ha) and high in potassium content (187 kg/ha). Organic carbon was 0.21 g/kg and electrical conductivity 0.16 dS/m. Available Fe, Zn and B were 1.163 mg/ha, 0.254 mg/ha and 0.474 mg/ha, respectively. The weather conditions including temperature and sunshine were favourable during entire season was almost congenial. The treatments comprised micronutrient, iron (0, 20 and 40 kg/ha), zinc (0, 25 and 50 kg/ha) and boron (0, 2.5 and 5.0 kg/ha from different source of $FeSo_4$, $ZnSo_4$ and borax were applied as soil application.

The experiment was laid out in a factorial randomised block design with three replications. Onion Agrifound Light Red. The uniform dose of 100 kg N, 50 kg P_2O_5 and 50 kg K_2O/ha was applied in each treatment through urea, SSP and MOP, respectively. The basal dose of FYM @ 10 t/ha was also applied uniformly before transplanting and 20% N was added as basal and remaining 80% in four equal splits 30, 45, 60 and 75 days after transplanting. The crop was grown as per to recommended package of cultured practices. The crop was harvested on physiological maturity. The yield attributes of onion were recorded as per the schedule. Economics of onion production by various treatments was computed on the basis of pooled data on prevailing prices of inputs and output.Statistical analysis was done by using standard techniques (Panse and Sukhatme, 1995).

RESULTS AND DISCUSSION

The details of total cost of cultivation, gross and net realization, benefit:cost ratio on pooled data for different treatments were calculated (Table 1 & Fig. 1). The total cost of cultivation per hectare was worked out for individual treatment.

The economics of different iron levels, the treatment i_1 recorded the highest gross return (₹ 5,47,580/ha), net return (₹ 4,78,098/ha) and highest benefit: cost ratio (6.88). The lowest gross return (₹ 5,05,300/ha), net return (₹ 4,32,931/ha) and benefit: cost ratio (5.98) were observed with treatment i_2. This result are in agreement with the results reported by Nasreen *et al.* (2009) in garlic, Shukla *et al.* (2015) in onion.

In case of different zinc treatments, maximum gross return (₹ 5,64,700/ha), net return (₹ 4,94,622/ha) and highest benefit: cost ratio (7.06) were obtained with treatment z_1. The treatment z_2 obtained minimum gross return (₹ 4,76,700/ha), net return (₹ 4,03,138/ha) and benefit: cost ratio (5.48). These findings are in close accordance with the findings of Nasreen *et al.* (2009) in garlic, Shukla *et al.* (2015) in onion.

Economics of different boron levels, the treatment b_2 produced the highest gross return (₹ 5,33,930/ha), net return (₹ 4,64,003/ha). The highest benefit: cost ratio (6.74) was recorded with treatment b_1. The lowest gross return (₹ 5,09,690/ha), net return (₹ 4,43,245/ha) was obtained under treatment b_0. The lowest benefit: cost ratio (6.64) was recorded with treatment b_2. These findings are in close accordance with the findings of Nasreen *et al.* (2009) in garlic, Shukla *et al.* (2015) in onion. Thus, for optimum growth, yield, quality and

Table 1. Effect of iron, zinc and boron on economics of different treatments (pooled basis)

Treatment	Yield (q/ha)	Gross realization (₹/ha)	Total cost of cultivation (₹/ha)	Net realization (₹/ha)	Benefit : cost ratio (BCR)
Iron (I)					
i_0	519.23	519230	66445.00	452785.00	6.81
i_1	547.58	547580	69481.84	478098.16	6.88
i_2	505.30	505300	72368.78	432931.22	5.98
Zinc (Z)					
z_0	530.68	530680	66445.00	464235.00	6.99
z_1	564.70	564700	70078.32	494621.68	7.06
z_2	476.70	476700	73561.63	403138.37	5.48
Boron (B)					
b_0	509.69	509690	66445.00	443245.00	6.67
b_1	528.46	528460	68261.00	460199.00	6.74
b_2	533.93	533930	69927.00	464003.00	6.64

*Selling price of onion ₹ 10.00/kg.

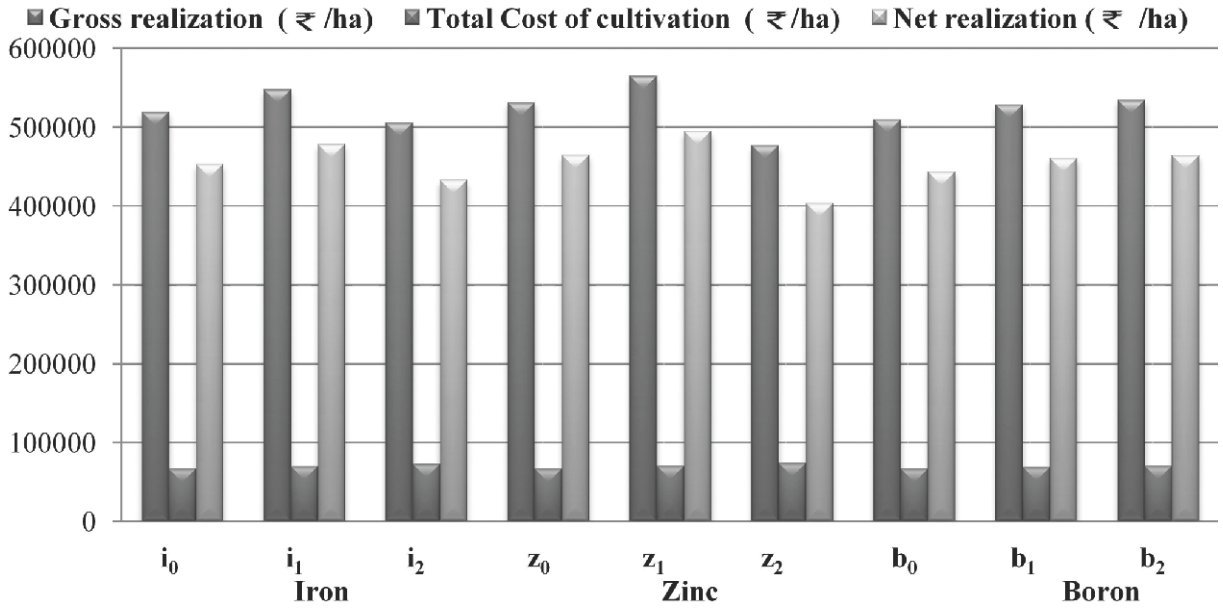

Fig. 1. Effect of iron, zinc and boron on economics of different treatments (Pooled basis)

storability of onion Agrifound Light Red, 20 kg iron/ha, 25 kg zinc/ha and 5.0 kg boron/ha should be applied.

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Current Horticulture **5**(2): 56–58, July–December 2017 ISSN: 2347-7377; RNI No.: UPENG03865/24/1/2013-TC

Evaluation of dahlia cultivars under sub-montane, subtropical, low hill zone of HP

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Received: December 2015; **Revised:** March 2017

ABSTRACT

A experiment was conducted to evaluate 15 cultivars of dahlia introduced from Forest Research Institute's central and Thakur Nursery, Dehra Dun, during October 2013-2015 to study different growth and flowering characteristics under sub-montane, subtropical and lowhill conditions at Dhaulakuan, district Sirmour (Himachal Pradesh). Early flowering cultivars belonged to Kenya series (100-110 days), i.e Kenya Pink, Kenya Dark Pink, Kenya Light Pink, Kenya Orange and Kenya Yellow. Maximum plant height was observed in cultivar, Giani Zail Singh (1.40 cm), maximum plant spread (0.85 cm) in cultivar SP Srimati. Largest flower size of 15.90 cm was recorded in cultivar, Arthur Humbley. Flowering duration was longest in cultivars, Giani Zail Singh and Maa Sharda (26.80 and 25.53 days). Both cultivars were found suitable for cut flower production, having sturdy stems of 8.05mm and 8.75 mm thickness, respectively.

Key Words: Evaluation, Sub-montane, Subtropical, Low hill zone, Bulbous flowers, Cut flowers.

Dahlia is one of the most popular bulbous flowers grown in many parts of the world for its dazzling blooms with varying shades of different colours. It is widely grown in beds, mixed borders, potted plants, cut flowers etc. It is a tuberous, half-hardy herbaceous and perennial flowering plant. The size of blooms varies from half inch pompoms to dinner plate sized dahlias that may reach 12 or more inches in diameter. Flower forms include daisy-like single types and fully double types with intermediate forms such as collarettes and anemone types. It has very attractive single, semi-double, double, pom-pom, cactus, star type of cultivars.

These are grown both in field as well as pots and are extensively used for exhibition, garden display and home decoration. Its demand is increasing day-by-day due to its flower forms, colours and natural ability to grow and adaptable to a wide range of climatic conditions (Mishra *et al.,* 1990). Medium and dwarf types are used for beds, pure and mixed borders. The long and sturdy stemmed are used as cut flowers in flower arrangements. Identifying superior genotypes to exploit full potential is important for its improvement. Keeping in view its aesthetic importance, an experiment was conducted at Regional Horticultural Research and Training Station, Dhaulakuan, to identify suitable dahlia germplasm for low hill conditions of Himachal Pradesh.

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MATERIALS AND METHODS

The experiment was conducted at Floriculture Unit of Regional Horticultural Research and Training station, Dhaulakuan, Himachal Pradesh, during 2013-2015. About 15 cultivars of dahlia, *viz*. Arthur Humbley, Bhikhu's Mother, Bhikhu's Red, Cooch Behar, Eternity, Giani Zail Singh, Kelvin, Kenya Dark Pink, Kenya Light Pink, Kenya Orange, Kenya Pink, Kenya White, Kenya Yellow, Maa Sharda, Piyushuna, Red Army, Romeo, SP Srimati were introduced from FRI, Dehra Dun and Thakur nursery, to study different growth and flowering characteristics under sub-montane, subtropical and low hill conditions. The cuttings of dahlia were taken from the newly developed shoots having at least two sets of leaves. These cuttings were inserted to a depth of 0.5-1 inch in a moist medium such as cocopeat+ sand (1:1) ratio. The experiment was laid out in a randomized

block design with three replications with a plant spacing 40 cm × 40 cm. Data were collected on plant height (cm), plant spread (cm), days to flower, flower size (cm), stem sturdiness (mm), flower duration (days) and flower colour.

RESULTS AND DISCUSSION

Plant height was maximum (141.90 cm) in Giani Zail Singh and minimum (58.70 cm) in Maa Sharda. Maximum plant spread was noticed in SP Srimati (85.90 cm) and minimum in Arthur Humbley (41.32 cm). Cultivar Kenya Yellow took minimum number of days (100 days) to flower, whereas maximum number of days (135.73 days) were taken by cv. SP Srimati. Beura and Maharana (1990) evaluated fifteen cultivars with 15 characters. Analysis of variance revealed that all cultivars showed highly significant differences for each character. Largest flowers were observed in Arthur Humbley (15.90 cm). It was minimum in Maa Sharda (9.5 cm) which was found to be at par with Red Army (9.64 cm) and Kelvin (9.58 cm). Sturdy stems were found in Maa Sharda (8.73 mm), followed by Giani Zail Singh (8.04 mm), Kelvin (7.58 mm) and Red Army (7.50 mm). Feng *et al*. (2012) studied genetic diversity of eighty four elite cultivars of dahlia. Results indicated that differences of stem diameter were significant among different flower type population. The duration of flowering was maximum in Giani Zail Singh and Maa Sharda (26.80 and 25.53 days) and minimum in Kenya

Table 1. Performance of dahlia cultivars under sub-montane, subtropical and low hill zone

Cultivar	Plant height (cm)	Plant spread (cm)	Days to flower	Flower size (cm)	Stem sturdiness (mm)	Flower duration (days)	Flower colour	Potential uses
Arthur Humbley	75.46	41.32	133.33	15.90	7.16	16.93	Light pink	Beds and borders
Bhikhu's Mother	95.48	54.72	106.00	11.88	6.70	15.33	Pink and white	Pots, beds and borders
Bhikhu's Red	94.00	56.50	103.07	11.43	6.56	15.67	Red and white	Pots, beds and borders
Cooch Behar	121.40	66.42	113.67	11.20	5.65	19.26	Orange	Garden display
Eternity	87.30	48.80	114.33	12.39	6.76	14.73	Light Pink	Pots, beds and borders
Giani Zail Singh	141.90	67.17	124.20	11.90	8.04	26.80	Red and white	Cut flower
Kelvin	135.93	75.40	133.00	9.58	7.58	14.20	Maroonish red	Beds and borders Kenya Dark
Pink	133.13	60.10	108.67	10.66	7.16	14.60	Dark Pink	Pure and mixed borders
Kenya Light Pink	136.13	64.96	103.67	10.70	6.78	12.00	Light Pink	Pure and mixed borders
Kenya Orange	132.00	72.62	110.00	10.30	7.00	16.33	Orange	Pure and mixed borders
Kenya Pink	140.00	60.40	106.67	10.50	7.16	15.00	Pink	Pure and mixed borders
Kenya White	90.80	50.50	105.00	10.00	6.50	17.00	White	Pure and mixed borders
Kenya Yellow	103.60	70.20	100.00	10.00	6.46	18.00	Yellow	Beds and borders
Maa Sharda	58.70	65.00	122.00	9.50	8.73	25.53	Creamish white	Cut flower
Piyushuna	134.66	83.13	125.80	10.20	7.04	20.00	Dark pink	Pure and mixed borders
Red Army	80.38	49.43	135.40	9.64	7.50	20.26	Blood red with yellow centre	Mixed borders
Romeo	94.56	73.92	130.00	10.50	6.86	16.93	Red with yellow centre	In pots
SP Srimati	105.53	85.90	135.73	10.50	7.18	13.06	Dark purple	Beds and borders
CD 0.05	0.92	0.81	1.44	0.24	0.32	0.63	-	-

Light Pink (12.00 days) (Table 1).

All cultivars were found suitable for beds, borders, pots and garden display purposes except, Giani Zail Singh and Maa Sharda which had rigid stems and can be used as a cut flowers. Kumar *et al.* (2009) evaluated nine cultivars of Dahlia at Udaipur and on the basis of data recorded for vegetative, floral and relative economics parameters, NT Pompon for cut flowers and Jyotsana were found best for exhibition purposes. Ahmed and Gul (2002) also observed variations in vegetative, floral and tuber characteristics under Haryana and Rawalkot conditions.

Mishra *et al.* (1990) observed that cultivars Kenya and Vigour were superior in plant height and flower size, while flower longevity was best 13.3-15.5 days, in Kenya followed by Kelvin Rose, Black Out and Vigour. Vikas *et al.* (2015) observed that accession No. 16 recorded significantly highest values in terms of plant height, duration of flowering, longevity and number of flowers/plant. Syamal and Kumar(2002) also indicated the presence of substantial variation among dahlia cultivars for their future exploitation. Thus, it was concluded that Giani Zail Singh and Maa Sharda were found suitable for cut flower production. Other cultivars were found suitable for planting in pure and mixed borders, beds, garden display, in pots etc.

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Short Note

Current Horticulture **5**(2): 59–60, July–December 2017 ISSN: 2347-7377; RNI No.: UPENG03865/24/1/2013-TC

Effect of mycorrhizal inoculation on P and Zn uptake in Citrus (*Citrus* spp.)

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Received: January 2017; **Revised:** May 2017

Since mycorrhizal hyphe and roots are food for other organisms and become part of nutrient cycling in rhizosphere, some other organisms are also involved in root growth. Under sterile soil conditions, plant growth is significantly affected. Since Citrus (*Citrus* spp.) plants strongly depend on mycorrhizae, with the soil sterilization, as viable organisms are eliminated, Citrus plants do not grow, but plant grown in non-sterile soil grow in normal stages. Nutrient deficiency, especially of P and Zn, is a common nutritional problem for some crops in Turkey. This results in the application of increasing amounts of several fertilizers. Since fertilizer sources are limited and expensive for developing countries, it is sound to use plant rhizosphere mechanisms.

Mycorrhizae is one of the largest symbiosis in between plant roots and fungi. Mycorrhizal inoculation or indigenous potential of mycorrhizae in soil is a critical factor in crop production under low supply of Zn and P. Mycorrhizal dependency for a representative plant species is a key factor for horticultural crops (Ortas *et al.,* 2002). Mycorrhizal dependencies are high when plants are grown in low P soils than those grown in ill soil with P levels typical of highly productive agricultural soils (Gemma *et al.,* 2002). Mycorrhizal inoculation in soil with P and Zn deficiency is a critical factor for MD in crop production as well as in P and Zn uptake (Ortas and Akpinar 2006).

Under semi-arid conditions, mycorrhizae contributes to overcoming mineral nutrient deficiencies seems to be a suitable agricultural strategy. Citrus crops are strongly mycorrhizal dependent on P nutrition, but less is known about the mycorrhizal dependency on Zn nutrition. Since mycorrhizae inoculated plants have high Zn content compared to non-inoculated ones, it is not clear whether mycorrhizal inoculation helps plants to have more Zn uptake or just as a result of higher plant growth (Ortas *et al.,* 2002). Therefore, we attempted to study the role of mycorrhizal inoculation on growth of several plant species on a calcareous soil having both Zn and P deficiency.

Mycorrhizal dependency (MD) was determined by expressing the difference between dry weight of mycorrhizal plants and dry weight of non-mycorrhizal plants as a percentage of dry weight of mycorrhizal plants (Plenchette *et al.,* 1981).

Soil was sterilized by autoclaving and plants were grown under greenhouse conditions. Under greenhouse conditions mycorrhizal dependence was searched in terms of P and Zn requirements. The effects of selected mycorrhizal inoculation and Zn applications on soure orang seedlings were investigated in several Zn deficient soils. Compared to non-inoculated control plants, mycorrhizal inoculation increased dry matter of plants (Fig. 1).

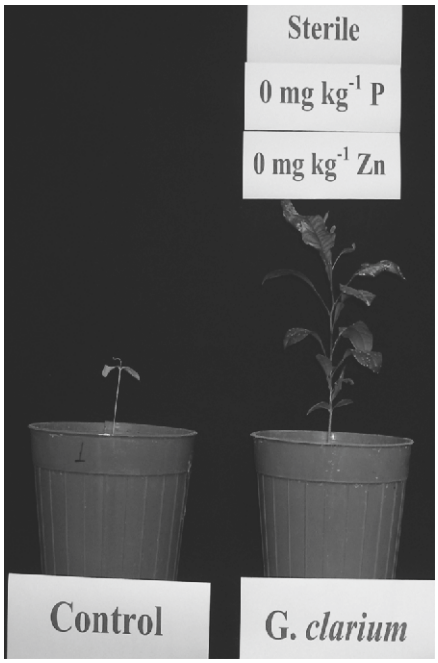

Fig. 1. Comparision between mycorrhizal inoculated plant growing significantly under sterile soil condition and the control

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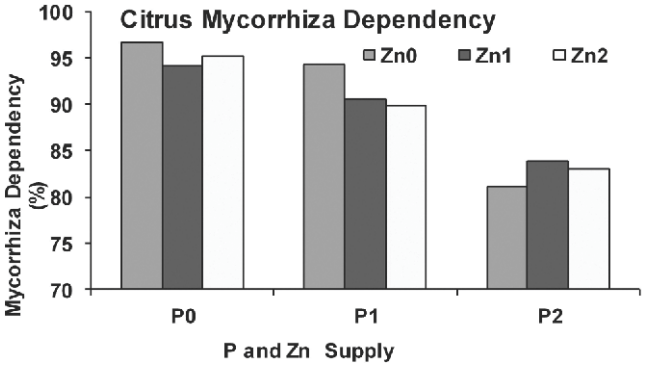

Fig. 2. Effect of P and Zn interaction on mycorrhizal dependency on Citrus plant

In the present experiment, although mycorrhizal inoculation increased plant Zn uptake, yet the plant was found to be much more mycorrhizal dependent on P nutrition. So far, all the experiments conducted have shown similar results (Ortas *et al.*, 2002). Phosphorus treatments generally reduced mycorrhizal dependency, but Zn application did not lead to any difference. From the present results (Fig. 1), it seems MD was less affected by Zn supply than P supply and since non-inoculated plants did not respond to P and Zn supply, it can be said that citrus plants strongly depended on mycorrhizal infection.

It seems that mycorrhizal dependence is an inherent characteristic for which plant nutrient requirement and uptake efficiency are important parameters, especially for P requirement. Considering the importance of mycorrhiza dependence for plant survival, it is of great interest to categorize species according to this characteristic. The effect of mycorrhizal inoculation on plant growth is changed by the effectiveness of inoculum. The results revealed that plants are strongly dependent on mycorrhizal infection.

CONCULUTON

Thus, it is concluded that mycorrhizal inoculated plants have high P and Zn content compared to the non-inoculated ones. It is clear that mycorrhizal inoculation helps plants to have more P and Zn uptake, especially of Citrus plants. The mycorrhizal inoculated seedlings fully depend on P nutrition and partly on Zn nutrition. Although addition of Zn increased plant growth, but mycorrhizal dependence much more depends on P nutrition.

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Editor: Dr Amar Singh Kashyap