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RESEARCH ARTICLE

SITE–SPECIFIC INTEGRATED NUTRIENT MANAGEMENT FOR SUSTAINABLE CROP PRODUCTION AND GROWTH: A REVIEW

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Abstract: Initially after green revolution the food grain production boosted up tremendously, but sign of fatigueness emerged after 1980 with sharp decline in factor productivity, stagnation in crop yields with unstable and marginal farm incomes; all of which are now posing a serious threat to food security, agricultural sustainability, soil and environmental health and rural agricultural economy in the developing world. Growing concerns about impaired soil health, declining productivity growth and decreasing factor productivity or nutrient-use efficiency (NUE) are compelling the farmers to use higher levels of fertilizers during the last two decades. Excessive use of fertilizers in imbalanced ratios leading to low nutrient use efficiency and associated environmental problems has raised serious concerns about the existing nutrient management practices. It is high time to develop site-specific nutrient management (SSNM) technologies which are able to make synergy with crop–soil nutrient dynamics. The SSNM is need-based feeding of crops with nutrients in right rate and right time while, recognizing the inherent spatial variability which enhances crop productivity, profitability, NUE and avoids nutrient wastage. This paper deals with the SSNM technologies approaches and tools which are able to enhance NUE, crop productivity and profitability.

Keywords: Site-specific nutrient management, Nutrient-use efficiency, Crop productivity

INTRODUCTION

Precision agriculture has created scope of transforming the traditional agriculture through proper resource utilization and management practices to sustainable agriculture with rapid socio-economic changes in some developing countries (Mondal and Basu, 2009). The revolution in management of crop nutrients and fertilizers has become very apparent for both environmental and economic reasons in developed countries. These concerns and issues are even more pressing in developing countries of the tropics, where nutrient mining and impoverishment are widespread (Smaling and Braun, 1996). Clearly, there is a need to manage nutrients in food production systems more precisely, to ensure increased food production, but also to ensure reduced environmental degradation. The concepts of Precision Agriculture were developed out of such needs, but as applied in developed nations have come to imply a high level of technology. Fertilizer application recommendations are often based on crop response data averaged over large areas, though farmers' fields show large variability in terms of nutrient-supplying capacity and crop response to nutrients. Thus, blanket fertilizer application recommendations may lead farmers to over-fertilize in some areas and under-fertilize in others, or apply an improper balance of nutrients for their soil or crop. An alternative to blanket guidance, Site-Specific Nutrient Management (SSNM) aims to optimize the supply of soil nutrients over time and space.

Table 1. Examples of key scientific principles and associated practices of 4R nutrient stewardship

SSNM principle	Scientific basis	Associated practices
Product	Ensure balanced supply of nutrients	Commercial fertilizer Livestock manure Compost Crop residue
Rate	Assess nutrient supply from all sources Assess plant demand	Test soil for nutrients Balance crop removal

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Time	Assess dynamics of crop uptake and soil supply Determine timing of loss risk	Apply nutrients: Pre-planting At planting At flowering At fruiting
Place	Recognize crop rooting patterns Manage spatial variability	Broadcast Band/drill/inject Variable-rate application

Where can SSNM are implemented?

In principle, SSNM can be used anywhere fertilizers are applied. The terms "Site-Specific Nutrient Management" and "precision farming" are sometimes used to describe the use of geo-referenced technology to manage within-field variability. However, applying the principles of SSNM does not require such technology, and can be done by farmers lacking machinery.

Challenges to adoption of SSNM

Technology and knowledge requirements-SSNM requires knowledge of underlying soil properties and the ability to monitor crops' nutrient status and adjust fertilizer inputs accordingly. While the need to conduct on-farm nutrient trials and soil tests has historically been a barrier to implementation of SSNM, the development of decision support systems and farmer-friendly tools and techniques that use proxy information to calculate nutrient requirements make SSNM more accessible to farmers and farm advisors.

Availability of fertilizers- Cost and access to fertilizers whether synthetic or organic is not universal. Development of input markets or identification of on-farm nutrient sources may be a necessary precursor to adoption of SSNM, though SSNM can help farmers make best use of limited nutrient resources.

How does SSNM increase productivity, farm livelihoods and food security?

SSNM generally maintains or increases crop yields. In a 2014 study of 13 sites in Southeast Asia, SSNM led to grain yield increases of 13% over a three-year period, although yields declined slightly in the first year (Pasuquin *et al*. 2014). In recent studies across large numbers of locations in wheat systems in South Asia, SSNM led to 18- 27% increases in grain yield of wheat, when compared to farmers' standard fertilizer practices. An average of 107 on-farm experiments in Chinese rice fields found 5% higher grain yields under SSNM than under farmers' practice, attributed to a reduction in insect and disease damage caused by optimal N inputs (Peng *et al*. 2010).

Principles of SSNM

The fertilization required for optimally 'feeding the needs' of crops can vary greatly from field-to-field depending on crop and soil management, historical use of fertilizers, management of crop residues and organic materials and crop cultivar. For increasing the productivity, profitability and efficiency of fertilizer use in rice wheat farming necessitates the uptake by farmers of nutrient management practices tailored to their specific field and farm conditions. The LCC is an effective tool for adjusting fertilizer N use to field-specific needs of rice wheat for supplemental N. Farmers' historical use of fertilizer P and their attainable crop yields can be used to estimate field-specific fertilizer P needs. Straw management, soil K-supplying properties and attainable crop yields can be used to estimate field specific fertilizer K needs. The application and management of nutrients are dynamically adjusted to crop needs of the location and season.

The SSNM approach aims to increase farmers profit through:

- Increased yield of crops per unit of applied fertilizer.
- Higher crop yields, and
- Reduced disease and insect damage.

Important features of SSNM

Site-specific N management (SSNM) was developed to increase fertilizer N use efficiency of irrigated rice (Dobermann *et al*., 2002). In SSNM, N application is based on the crop demand for N. Climatic factors (solar radiation and temperature) and indigenous N supply largely affect crop N demand. The measurement of grain yield in N-omission plots is used to obtain field-specific estimates of the indigenous N supply (Cassman *et al*., 1996). During the growing season, leaf N status measured with a chlorophyll meter (SPAD) or leaf color chart is a good indicator of crop N demand. Both the SPAD and leaf color chart provide a good estimation of leaf N content on a leaf-area basis (Peng *et al*., 1996).

SSNM APPROACHES

The approach of nutrient recommendations under SSNM is mainly based on the indigenous nutrient supply from the soil and nutrient demand of the crop for achieving targeted yield. The SSNM recommendations could be made on the basis of either plant analysis or soil cum plant analysis.

Plant based SSNM

It is considered that the nutrient status of the crop is the best indicator of soil nutrient supplies as well as, nutrient demand of the crops. Initially, SSNM was tried for lowland rice, but subsequently, it has proved beneficial to several contemporary approaches of fertilizer recommendations in rice, wheat and other rice-based production systems prevalent in Asian countries (Dobermann *et al*., 1999). Witt and Dobermann (2002) proposed five key steps for developing site specific fertilizer NPK recommendations for rice and through the basic principles remain the same for other crops as well.

Selection of the yield goal

A yield goal exceeding 70 to 80% of the variety-specific potential yield (Ymax) has to be chosen. Ymax is defined as the maximum possible grain yield limited only by climatic conditions of the site, when there are no other limiting factors for crop growth. The reason behind selection of the yield goal to the extent of 70 to 80% of the Ymax is that the internal NUEs decrease at very high yield levels near Ymax. Crop growth models like DSSAT can be used to work out Ymax of crop variety of a site under a particular climatic condition.

Assessment of crop nutrient

The nutrient uptake estimation of a crop depends both on yield goal and Ymax. The nutrient requirements for a particular yield goal of a crop variety may be smaller in a high yielding season than in a low yielding one.

Apply fertilizer to fill the crop need and indigenous nutrient supply indigenous nutrient supply - INS may be defined as the total amount of a particular nutrient that is available to the crop from the soil during the cropping cycle, when other nutrients are non-limiting. The INS is derived from soil incorporated crop residues, water and atmospheric deposition. It is estimated by measuring plant nutrient uptake in an omission plot, wherein all other nutrients except the one (N, P or K) in question are applied in sufficient amounts.

Table 2. Grain yield response to SSNM and state recommended fertilizer doses over farmer nutrient management practice.

	Rice			Wheat			Rice-wheat system		
	Yield, t/ha	Response		Yield, t/ha	Response		Yield, t/ha	Response	
Treatment		t/ha	%		t/ha	%		t/ha	%
Sabour									
SSNM	8.23	3.27	66	5.18	1.92	59	13.40	5.19	63
SR	6.03	1.07	22	4.55	1.30	40	10.58	2.37	29
FP	4.96	–	–	3.25		–	–	8.21	–
Palampur									
SSNM	5.28	1.14	28	3.41	1.26	59	8.70	2.41	38
SR	4.70	5.58	14	2.99	0.84	39	7.68	1.39	22
FP	4.14	–	–	2.15		–	–	6.29	–
Ranchi									
SSNM	6.76	2.56	61	4.05	1.47	57	10.80	4.03	60
SR	5.96	1.76	42	3.40	0.82	32	9.36	2.58	38
FP	4.20	–	–	2.58		–	–	6.77	–
R.S. Pura									
SSNM	8.40	1.71	26	4.64	1.35	41	13.04	3.06	31
SR	7.38	0.69	10	4.07	0.78	24	11.46	1.47	15
FP	6.69	–	–	3.29		–	–	9.99	–
Ludhiana									
SSNM	10.43	1.30	14	6.02	0.39	7	16.45	1.69	11
SR	9.81	0.67	7	5.79	0.16	3	15.60	0.83	6
FP	9.13	–	–	5.63		–	–	14.77	–
Faizabad									
SSNM	8.28	3.08	59	4.43	1.75	65	12.71	4.83	61
SR	6.13	0.93	18	3.42	0.74	28	9.55	1.67	21
FP	9.13	–	–	5.63		–	–	14.77	–
Faizabad									
SSNM	8.28	3.08	59	4.43	1.75	65	12.71	4.83	61
SR	6.13	0.93	18	3.42	0.74	28	9.55	1.67	21
FP	5.20	–	–	2.68		–	–	7.88	–
Kanpur									
SSNM	9.23	2.34	34	5.69	1.15	25	14.91	3.48	30
SR	8.28	1.39	20	5.26	0.73	16	13.55	2.12	19
FP	6.89	–	–	4.54		–	–	11.43	–

Modipuram									
SSNM	10.18	3.16	45	6.10	1.55	34	16.28	4.71	41
SR	7.73	0.70	10	5.41	0.86	19	13.14	1.56	14
FP	7.03	–	–	4.55		–	–	11.58	–
Varanasi									
SSNM	7.03	1.00	17	4.19	0.81	24	12.46	1.93	
SR	6.53	0.50	8	3.85	0.47	14	11.61	1.08	10
FP	6.02	–	–	3.39		–	–	10.53	–
Mean over location									
SSNM	8.20	2.17	36	4.86	1.30	41	12.79	3.30	35
SR	6.13	0.93	18	3.42	0.74	28	9.55	1.67	21
FP	6.03	–	–	3.56		–	–	9.49	–
CD at 5%	**0.59**	**–**	**–**	**0.25**		**–**	**–**	**0.71**	–
CD = critical difference									
Source-Singh, et.al.,2008									

Dynamic adjustment of N rates

Fertilizer P and K, as computed earlier are applied basally that is, at the time of sowing/planting; the N rates and application schedules can be further adjusted as per the crop demand using chlorophyll meter (popularly known as SPAD) or leaf color chart (LCC). Recent on-farm studies in India and abroad have revealed a significant advantage of SPAD/LCC-based N management schedules in rice and wheat in terms of grain yield, N use efficiency and economic returns over the conventionally recommended N application involving 2 or 3 splits during crop growth irrespective of N supplying capacity of the soils. In wheat, timing of N application at SPAD value ≤42 resulted in 9% higher wheat yield along with 20 kg/ha N saving than the recommended soil based N supply (Dass *et al*., 2012).

Soil-cum-plant analysis based SSNM- In soil cum plant analysis based SSNM, nutrient availability in the soil, plant nutrient demands for a higher yield target (not less than 80% of Ymax), and recovery efficiency (RE) of applied nutrients are considered for developing fertilizer use schedule to achieve maximum economic yield of a crop variety. In order to ascertain desired crop growth not limited by apparent or hidden hunger of nutrients, soil is analyzed for all macro and micronutrients before sowing. Field-specific fertilizer rates are then recommended to meet the nutrient demand of the crop (variety) without depleting soil reserves. These soil–test crop responses (STCR) based recommendations are now in practice to achieve desired yield targets in many crops (Suri *et al*., 2011). Thus, recent studies with intensive cropping systems have shown that fertilizer recommendations with the aforementioned approach offer greater economic gains as compared with NPK fertilizer schedules conventionally prescribed by soil testing laboratories (Shukla *et al*., 2004).

Nutrient decision support systems

Nutrient expert® (http://software.ipni.net/article/nutrient-expert)

Nutrient Expert® (NE) is an easy-to-use, interactive and computer-based decision support tool that can rapidly provide nutrient recommendations for an individual farmer field in the presence or absence of soil testing data. NE is nutrient decision support software that uses the principles of SSNM and enables farm advisors to develop fertilizer recommendations tailored to a specific field or growing environment. NE allows users to draw required information from their own experience, farmers' knowledge of the local region and farmers' fertilizer practices. NE can use experimental data but it can also estimate the required SSNM parameters using existing site information.

The algorithm for calculating fertilizer requirements in NE is determined from a set of on-farm trial data using SSNM guidelines. The parameters needed in SSNM are usually measured in nutrient omission trials conducted in farmers' fields, which require at least one crop season. With NE, parameters can be estimated using proxy information, which allows farm advisors to develop fertilizer guidelines for a location without data from field trials (http://software.ipni.net/article/nutrientexpert).

Site-specific nutrient management parameters in nutrient efficiency

NE estimates the attainable yield and yield response to fertilizer from site information using decision rules developed from on-farm trials. Specifically, NE uses characteristics of the growing environment to water availability (irrigated, fully rain-fed and rain-fed with supplemental irrigation) and any occurrence of flooding or drought; soil fertility indicators including soil texture, soil color and organic matter content, soil test for P or K historical use of organic materials (if any) and problem soils (if any); crop sequence in farmer's cropping pattern; crop residue management and fertilizer inputs for the previous crop; and farmers' current yields. Data for specific crops and specific geographic regions are required in developing the decision rules for NE. The datasets must represent diverse conditions in the growing environment characterized by variations in the amount and distribution of rainfall, crop cultivars and growth durations, soils and cropping systems.

CONCLUSION

Site specific nutrient management (SSNM) is a new and useful concept. This concept is fundamental to precision nutrient applications in different crops. SSNM provides an approach for need based feeding of crops with nutrients while recognizing the inherent spatial variability. This makes the efficient utilization of nutrients by crop plants and avoids the wastages of fertilizers. The environmental footprints of chemical fertilizers are also reduced. Crop yields increase by over 15%, while amount of nutrients applied mostly decrease. Farm profitability and NUE increase convincingly by using this novel concept. For efficient and effective SSNM, the use of soil and plant nutrient status sensing devices, remote sensing, GIS, decision support systems, simulation models and machines for variable application of nutrients play an important role.

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RESEARCH ARTICLE

STUDIES ON AERIAL BLIGHT OF SOYBEAN CAUSED BY *RHIZOCTONIA SOLANI* KUHN

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Abstracts: Soybean (*Glycine max* (L.) Merrill) is one of the most important oil seed crop of India. It was wonder of the twentinth century. Soybean rank first among world oilseed with an annual production of about 105 mt. Among the different growing countries of the world, USA, China, Brazil, Argentina and India are main which accounts more than 90% of the world's acreage (Taware *et al.,* 2007). Soybean (*Glycine max* (L.) Merill.) a grain legume is widely crop due to its high quality protein (40%) and edible oil (20%). Aerial blight caused by *Rhizoctonia solani* is one of the most soil borne diseases of soybean particularly in the northern zone comprising the states of Haryana, Punjab, Uttar Pradesh and Uttarkhand.

Keywords: Soyabean, Rhizoctonia solani, Disease, Chemical, Fungicide

INTRODUCTION

Soybean is mainly grown during Kharif season in sandy loam to clay loam soil in Chhattisgarh. In Chhattisgarh, area, production and productivity of soybean are 0.82 m ha, 0.73 mt and 891 kg/ha, respectively which are much lower than national average (Anonymous, 2006b). The disease appears July-August and is characterized by sudden and complete death of the plants. This disease is considered to be one of the most destructive and causes heavy losses in the yield particularly in warm and humid parts of the countries (Anwar *et al*., 1995). Yield losses can exceed 35-60 per cent and the disease is considered as economically important (Patel *et al.,* 1998). The use of resistant varieties is the cheapest, easiest, safest and most effective method to manage the aerial blight disease. Few tolerant cultivars were reported against aerial blight disease (Thind,1998 and Palat *et al*., 2004). Although various fungicides have shown promising results in controlling the aerial blight of soybean but the phytotoxicity and fungicidal residue problems leading to the environmental pollution are the major constraints in disease management. Substancial emphasis is being given these days on using eco-friendly approaches for controlling plant diseases. Plant products are the best alternatives available today. Several; medicinal plant species have not been screened against plant pathogens. The literature pertaining to the aerial blight of soybean caused by *Rhizoctonia solani* Kühn*"* has been reviewed under following heads:

The Disease

Aerial blight is an important disease of soybean (*Glycine max* (L.) Merrill). It was first reported from Philippines in 1980. Later it was reported from Malaysia, Mexico, Puerto Rico, China, Taiwan, Lousiana (Sinclair, 1982), North America, South America, Brazil, Argentina (Ram and Trikha, 1997). It has been reported on soybean in subtropical and tropical areas. In India, it was first reported from Pantnagar (Uttarakhand) in 1967 (Mukhopadhyay and Singh, 1984). Since then it has spread to other soybean growing state like Rajasthan (Goyal and Ahmad, 1988), Sikkim (Srivastava, 1988), Haryana, Punjab, Uttar Pradesh, Bihar (Sharma and Tripathi, 2001, and Ray *et al*., 2007), Madhya Pradesh and Chhattisgargh (Anonymous, 2007). Now it has been reported from most of the soybean growing state of India. In Chhattisgarh aerial blight becoming an important disease Aerial blight disease is also known as sudden death syndrome (Nakajima *et al.* 1996).

Economic importance

Aerial blight is an important disease of soybean, in USA and other soybean growing countries including India and causes substantial losses in yield. Several estimates of yield losses due to disease have been estimated. Sharma and Sohi (1980) reported 8.45 to 64.68 percent yield losses of green pods due to web blight of French bean caused by *R. solani* in commercially susceptible cultivars. 35% yield losses have been attributed from Louisiana by web blight of soybean (Sinclair, 1982). Patel and Bhargava (1998) reported that yield losses can exceed 35 to 60% due to aerial blight soybean caused by *R. solani* in warm and humid part of country. Sharma and Tripathi (2002) reported 30% yield losses in web blight of Urdbean caused by *R. solani* in Tarai region of Uttarakhand. Sharma and Gupta (2003) reported 60% yield losses due to web blight of French bean caused by *R. solani* in Himachal Pradesh. Stetina *et al.* (2006) assessed disease severity in the moderately resistant and susceptible cultivars of soybean in field plots corresponding to 0-100% of tissue affected. Based on result on regression analysis, pod number, seed number and seed weight per plot decreased as disease severity increased, whereas the proportion of partially filled pods and the weight of 100 seed were

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not affected. Yield loss appeared to be due to loss of entire pods.

Symptoms

Kucharek (1981) described the symptoms as lesion in leaflets can range in size from a single pinpoint to coverage of entire leaflets. Usually the lesion is brown to pale green in colour. If the lesion is fresh it may have a greasy appearance. Lesions do not have a distinct shape; lesion shape is determined by tissue colonized by the fungus. Fungal hyphae can be seen on infected tissue, it appear as a brown spider like web and is apt to be seen early in the day or when the canopy is still moist. Infected pods and stem tissues looks greasy, brown and shriveled. Happerly *et al*. (1982) reported aerial and web blight like symptoms commonly formed in most tropical and subtropical parts of the world. Sinclair (1982) also described the symptoms and categorized in foliage and aerial blight. Foliar blight symptoms appear on leaves, stem and pods, beginning on the lower or middle parts of the plant and moving up. Infected leaves are water soaked at first but soon take on a greenish brown to reddish brown appearance and later become tan, brown, or black. Lesion may be small spots, or whole leaf may be blighted. Severely infected plants lose their leaves. In the aerial blight phase, infected leaves droop and adhere to the pods and stem beneath them, thus becoming sources of infection for the pods and seeds. Brownish lesions form on petioles and stems. Lesions on pods may be small, brownish spots or may blight the whole pod. Seed infection is associated with pod infection. High humidity enhance mycelial growth and sclerotial formation in the lesion and blighted areas. Mukhopadhyay and Singh (1984) reported that symptoms of the disease depend on varieties of soybean. They also reported that the brown spot found on petioles and stems. Necrotic brown spot also formed on green leaves or complete leaves may be blighted. Web like mycelium of the pathogen also seen on diseased parts and their adjoining area of leaves. Thapliyal and Dubey (1987) reported that the pathogen produces two type of sclerotia viz micro and macro sclerotia both can infect six week old plants. Yang *et al*. (1990b) reported that diseased seedlings become source of inoculum's by producing mycelium that grew to and infected neighboring plants and concluded that seedling infection at an early stage can have significant effect on subsequent disease development. Ram and Trikha (1997) reported main symptoms of disease start as blight from base of the leaf and increase towards the tip of the leaf. Fully affected leaf become dry and petiole attached with the plant. They also observed root rot under high moisture in the soil. They reported reddish brown colour dead tissue seem on the outer surface of the root and basal portion of the stem. Disease appears in all stage of plants in heavy rains. Prasad (2005) reported the symptoms of aerial blight generally appear on leaves, stems and pods when plants are 45-60 days, infection start from lowest leaves, touching the ground. Infected leaves are water soaked brown to reddish brown and later on become tan to black. Complete leaf may be blighted slowly. Symptoms on leaves first start from the side of leaflets joined to petiole. Infected leaves droop and may adhere to stem and pods. Small oval to irregular brown to dark coloured sclerotia are present on infected surface of plant. Thind (2005) reported the symptoms as reddening of leaves. Williamson and Muller (2006) reported severe foliar blight which started at the base of the plant, then moved upward and downward, often causing complete defoliation. The disease was found in scattered areas in the field and disease incidence ranged from 25-30%.

The Pathogen

The anamorph or imperfect stage of pathogen causing aerial blight in soybean is *Rhizoctonia solani* Kühn. The detailed classification of the fungus is as follows.

Subdivision	:	Deuteromycotina
Form class	:	Deuteromycetes
Form subclass	:	Hyphomycetidae
Form order	:	Aganomycetales
Genus	:	*Rhizoctonia*
Species	:	*solani*

The teleomorph or perfect stage of the *R. solani* has been described as *Thanatephorus cucumeris* (Frank) Donk.

Subdivision	:	Basidiomycotina
Class	:	Basidiomycetes
Sub class	:	Holobasidiomycetidae
Order	:	Tulasnellales
Family	:	Caratobasidiaceae
Genus	:	*Thanatephorus*
Species	:	*cucumeris*

(Alexopoulos *et al*., 2002)

The genus, Rhizoctonia first described by De Candole (1815), possesses the following characteristics: (a) branching near the distal septum of cells in young vegetative hyphae, (b) formation of a septum in the branch near the point of origin, (c) constriction of the branch, (d) dolipore septum, (e) no clamp connection, (f) no conidium, except moniloid cells, (g) sclerotium not differentiated into rind and medulla and (h) no rhizomorph (Ogoshi, 1975). Tiwari and Khare (1998) reported variation rate and type of growth, colony colour, time taken for sclerotial production and nuclear status *in vitro* in isolates of *R. solani* from *Vigna radiata*.

MORPHOLOGY

Young mycelium of *R. solani* is silvery becoming yellow or brown at maturity, 8-12 µm in diameter having frequent septation and branched. Sclerotia are dark brown to black, 99.9 to 166.5µ in diameter. Sometime they unite to form a large mass in linear shape, which can be as long as 300µ. They are roughly, spherical or somewhat flattened or irregular.

Shape of microsclerotia is oval to irregular (Mukhopadhyay and Singh, 1984).

Isolation, purification and pathogenicity

Cardoso *et al* (1982) reported that the *R. solani* isolated from perennial soybean was highly pathogenic to cowpea, while cowpea root isolates attacked underground cowpea tissues only. Ploetz *et al.* (1985) studied in green house and reported that isolates from soybean were highly pathogenic to soybean seedlings. Anderson (1987) isolated the 13 genera of plant pathogens viz *Rhizoctonia solani, Corynespora cassiicola, Fusarium oxysporum, Pythium spp* and other spp. were isolated more frequently than other fungi. Some fungi such as *C. cassiicola* common on roots while others such as *Phomopsis spp*. were common on stems. The incidence of isolation of most fungi was influenced by sample date. Naito and Kanematsu (1994) reported the symptoms appeared as primary lesions consisting of small circular necrotic spots, followed by secondary lesions under humid condition and isolated *Rhizoctonia solani* from leaves with the primary and secondary lesion. Inoculation test revealed that the leaf spot isolates were highly pathogenic to soybean, *Vigna vulgaris* and *Phaseolus vulgaris* and caused severe pre-emergence and post emergence damping off. Nelson *et al.* (1996) reported *Rhizoctonia solani* was virulent on soybean seedlings and adult plants and when inoculum's was placed in direct contact with seeds caused high level of pre-and post emergence of damping off. It is suggested that *R. solani* could be an important soybean pathogen and that other rotational crops are host to *R. solani* recovered from soybean. Bhattacharyya (1998) described the disease symptoms found in all parts of potted soybeans cv. Bragg plants grown in soil infested with *R. solani*. The *R. solani* isolate from soybean was also found to infect 23 of the 26 crop and weed species tested as alternative host. Khan *et al.* (2002) assessed pathogenicity of *R. solani* isolates by tooth pick tuber inoculation and direct tuber inoculation revealed that in tooth pick tuber inoculation of *R. solani* isolates were more virulent.

Disease cycle

Rhizoctonia solani pathogen is soil borne and seed borne in nature perpetuates in soil through sclerotia and mycelium. There are report that mycelium in soybean debris can remain viable. Park and Berteus (1932) reported that the sclerotia of *R. solani* remained viable for 130 days in air dried soil kept at room temperature (30^0C). Atkins and Lewis (1954) reported that secondary infection take place through sclerotia and disseminate through air and water and reach to healthy plants from infected plants. Das and Western (1959) observed that *R. solani* can survive in crop debris in natural soil for three months. Ou (1975) found that sclerotia of sheath blight fungus of rice survived in soil for one to two years. Tiwari (1993) reported survival of *R. solani* in infected rice bean crop debris upto 11 months storage at room temperature (10-42 ^{0}C). He also reported viability of sclerotia upto 22 months when placed in sterilized soil at room temperature. Sati (1998) reported that decreased viability of *R. solani* with increase in soil depth and loss of viability of sclerotia after 8 months when placed at 2.5 cm deep in soil. The loss in viability of *R. solani* at depth of 10 and 15 cm may be due to competition with other microorganisms, since activity of soil micro flora remains optimum at the soil depth of 10-15 cm. She also reported the survival of *R. solani* causing sheath blight of rice upto 270 days when infected rice crop debris was exposed at 28C. Sati and Sinha (1999) reported that the *R. solani* survived in infected plant debris up to 150 days and in the form of sclerotia up to the next crop season. The percentage of infected plant pieces/sclerotia yielding colonies decreased with increase in time of storage. Sharma and Tripathi (2002) reported that the survival of the *R. solani* declined sharply over a period of time and also with increase in soil depth. The sclerotia and crop debris buried at 25 and 20 cm deep in natural soil showed significant reduction in survival after 8 months. The survival was lost in infected crop debris buried at 25 cm deep over a period of 9 months. However, highest survival of fungus through sclerotia and crop debris was recorded when placed at 5 cm deep soil followed by 10 cm over a period of 9 months. Rain off water and flood irrigation permit good dispersal of the floating sclerotia and consequently, provide the primary foci of the infection through the stretches of soybean field. Secandary spread take place through direct contact. Sinclair (1982) reported that *R. solani* attacks on common bean (*Phaseolus vulgaris*), lima bean (*P.limensis*), clovers (*Trifolium spp*), cowpeas (*Vigna spp*.), fescue (*festuca spp*.), fig (*Ficus spp*.), lespedezas (*Lespedeza spp*.), rice (*Oryza sativa*), wild soybeans (*Glycine javanica*) and tung (*Aleurites spp*.). Srivastava and Gupta (1989) reported that *Rhizoctonia solani* was found to cause aerial blight on *Vigna mungo*, *V. radiata*, *Phaseolus vulgaris,* groundnut and soybean during a survey in Sikkim in 1987 and 1988. Sinclair (1982) reported that web blight occurs in areas characterized by prolonged periods of high humidity and warm temperature, which enhances mycelial growth and sclerotial formation in the lesion and blighted area. Cultivars with more shorter and more compact growth habit are most severely infected. Thapliyal and Dubey (1987) reported 37 ^{0}C temperature and pH 6 are congenial for disease development. Ram and Trikha (1997) that maximum temperature (26-32 ^{0}C), water holding capacity of soil 70% and more than 6.6 pH are favourable for disease development. Kucharek (1981) also found seedling blight and root rot symptoms caused by *R. solani*. Aerial blight may be present at low levels across the field and when frequent rains occur, disease spread fast. Within one week or less an entire field may appear scorched.

Small field bordered by trees or poorly drained field are more apt to have severe aerial blight. Teo *et al.* (1988) reported that *R. solani* isolates were more virulent with early seeding and at high soil moisture. Early seeding resulted in significantly greater seedling infection and disease rating. Soil moisture had a significant effect on seedling infection. Yang *et al.* (1990a) also studied the effect of free moisture and plant growth stage on focus expansion of soybean aerial blight, caused by *R. solani* and reported that disease severity increased when free moisture is increased and showed positive correlation between each other. Patel and Bhargava (1998) investigated that disease reduced shoot length and pod at flowering, and increased with crop canopy and age. Rain was a significant factor in increasing disease development. Application of N, P and K fertilizers and herbicides reduced disease incidence, although application of 20kg N/ha as urea resulted in the maximum disease incidence. Torres *et al.* (2004) reported higher incidence of death of soybean seedlings (DSS) when the crop was planted in shallow soils and when these soils were originated from basalt. Approximately 70% of the death of soybean seedlings occurred in excess soil moisture. Only 30% of the deaths of soybean seedlings were in "latossols", which are well developed soils, deep and with good permeability. Upmanyu and Gupta (2005) reported that high soil moisture (80%) and 25 ^{0}C temperature were the most favourable for root rot development while web blight was best favoured at >85% relative humidity coupled with 25 ^{0}C temperature. Continuous leaf wetness for at least 6 hrs was essential for disease initiation, while increase in leaf wetness duration for 6-12 hrs showed corresponding disease incubation period observed with further increase in leaf wetness.

Disease management

Host resistance

The use of resistant varieties is the cheapest, easiest, safest and most effective method to manage the aerial blight disease. The efforts through conventional breeding so far made in developing commercial cultivars resistant to aerial blight. However few tolerant cultivars such as PK-262, PK-416, PK-472 and PUSA 16 (Thind, 1998), PS 564, PS 1024 and PS 1042 were reported against aerial blight (Anonymous, 2006c). Palat *et al*. (2004) screened soybean germplasm for their resistance to web blight. They found 8 cultivars free from the disease, 11 cultivars as resistant and 9 cultivars as moderate resistant. The remaining cultivars categorized in moderately susceptible (6 cultivars), susceptible (9 cultivars) or highly susceptible (6 cultivars), groups. A total of 13 entries, which were promoted to AVT-1 across the zone have been evaluated against major disease of soybean at 7 centers along with checks. At Pantnagar severity of Rhizoctonia aerial blight was upto desirable level in susceptible check Punjab 1 and Bragg. No entry was absolute resistant but 5 entries viz., DS 2207, Dsb 8, MACS 1038, SL 688 and SL 751 were observed to be highly resistant. In coordinated trial held at Pantnagar, out of 35, 15 soybean entries were also observed as highly resistant to Rhizoctonia aerial blight during study of performance of previous year resistant entries (Anonymous, 2007).

Cultural

Cultural management practices are simple agricultural or farm practices that man has learn by his long experience as a farmer in order to reduce inoculum potential. However, the methods at least act as prophylaxis rather than a complete cure. Destruction or burning of crop residues could not eliminate sclerotia from a soil but has been suggested to be a part of integrated management practices (Lee and Courtney, 1982). Thind (1998) and Prasad (2005) reported that disease can be minimizing by summer ploughing and crop rotation. Teo *et al.* (1988) reported that early seeding and at high soil moisture significantly increased seedling infection and disease severity. Split application of potassium in a NPK combination of 40:20:20 kg/ha reduced the incidence of sheath blight and increased grain yield of rice (Baruah, 1995). Wide spacing reduced sheath blight and could even counter the effect of high nitrogen, but the yield was not consistent (Gangopadhyay and Chakrabarti, 1982). Incorporation of oil cake and some green manuring crop particularly sunhemp and green gram reduced survivals of *R. solani* (Rajan and Menon, 1975). Sharma and Gupta (2003) reported that Single polyethylene mulch along with soil amendment (mustard cake) resulted in increased temperature in soil lethal to the *Rhizoctonia solani*. They also reported that mulching for 30 and 50 days eliminate the *R. solani* from 5 and 10 cm soil depth, respectively.

Chemical

Many fungicides plant extracts, including oils and animal waste etc have been tested for toxicity against aerial blight.

Fungicide

Cardoso *et al.* (1978) tested the efficacy of five fungicides against *Rhizoctonia solani* among them Benlate (Benomyl) showed most effective to control infection. Ram and Trikha (1997) recommended Benomyl (0.5 kg/ha) and Moncozeb (2.5 kg/ha) 60 days after sowing for control of aerial blight of soybean. Seed treatment with Thiram reduced the initial inoculums (Thind, 1998). Sharma and Tripathi (2001) reported that seed treatment and two foliar spray of tilt (0.1%) at 15 days interval was most effective in reducing disease severity (30-32%) and increased grain yield (950-1012 kg/ha) as well as 1000 grain weight followed by Contaf, Bavistin and Indofil M-45 sprayed plots. Nassreen (2003) reported that the growth of *Rhizoctonia solani* was significantly reduced on PDA medium amended with 0.1% of Benomyl, Captan (Captan), Vitavax

(Carboxin), Dithane M-45 (Mancozeb) and Thiram and found that Benomyl was the most effective. Surulirajan and Kandhari (2003) tested five fungicides, Hexaconazole (Contaf), Thiram, Propiconoazole, Tebuconazole and Carbendazim on radial growth of *R. solani* by poisoned food technique on PDA and stated that the mean radial growth of *R. solani* was 1.0, 1.4 and 2.5 cm in Hexaconazole (Contaf), Propiconazole and Thiram respectively. Rai *et al*. (2007) screened the twelve fungicides/antifungal antibiotics, possessing either systemic or non-systemic activity were screened against *Rhizoctonia solani* pathogen, causing aerial blight of soybean, in *vitro* conditions. Among these, Contaf Hexathir, Dhanustin and Rovral showed almost complete inhibition of the test fungus at all the concentration tested (i.e. 25, 50, 100 and 500 ppm).

Leaf extracts of medicinal plants

Singh *et al.* (1980) reported that fruit pulp of *Azadirachta indica* (Neem) suppressed the formation of sclerotia by *R. solani*. Reddy *et al.* (2002) reported that extract of, *Eucalyptus globulus, Allium sativam* and *Zingiber officinale* caused 61 to 100 percent inhibition of the mycelial growth of *Rhizoctonia solani* causing root rot of chickpea. Bhamare *et al*. (2003) reported that plant extracts of *Datura stramonium* reduced seed borne mycoflora (including species of *Rhizoctonia, Fusarium* and *Sclerotium*) significantly and increase seed germination over untreated control. Sharma *et al.* (2005) tested the efficacy of eight plant extracts against *Rhizoctonia solani in vitro* and reported that *Eucalyptus globules* inhibited 85% mycelial growth at 10% concentration. Kandhari and Devkumar (2006) tested the four plant extracts (*Calotropis procera Allium sativum* C., *Piper betle* L., *Vitex negundo* L.) and one phytochemical (Geranio) against *Rhizoctonia solani* causing sheath blight disease of rice exhibited fungi-toxic properties. Among these, *Calotropis procera* (Madar) emerged as most effective, showing highest reduction closely followed by *Piper betle* at 1500 ppm. Tiwari *et al.* (2007) tested the efficacy of medicinal plant extracts *in vitro* against *Rhizoctonia solani* and reported that out of 950 extracts, *Acorus calamus* (Butch) was highly effective against *R. solani* at all concentration (1%, 5% and 10%).

Medicinal oil

Singh and Dwivedi (1987) observed the fungitoxic activity of the oils of *Eucalyptus globules* against the sclerotial production of *S. rolfci*. Madhukar and Reddy (1989) reported that Eucalyptus oil completely checked the fruit rot diseases of guava caused by *Rhizoctonia solani* and anthracnose caused by *Pestalotiopsis versicolor*. Coconut oil, castor oil and groundnut oil also effective in reducing the fruit rot of guava. Singh *et al.* (1989) evaluated 6 oils of medicinal plants for their antifungal activity against *Sclerotium rolfsii* and 10 soil inhabiting fungi. Out of these, the oil of *Azadirachta indica* was most effective followed by *Eucalyptus globulus* and *Ocimum canum* against *S. rolfsii*.

Animal waste

Raja and Kurucheve (1997) tested the efficacy of animal products (dung, urine and milk) *in vitro* against *Rhizoctonia solani* and reported that urine of cow, bull and buffalo at 20% concentration totally inhibited the mycelial growth and sclerotial production of *R. solani*. More than 80% inhibition of the mycelial growth was recorded with dung of cow and buffalo. Animal milk stimulates the mycelial growth of the fungus, but interestingly the sclerotial production was totally inhibited. Such control measures would be more practicable and economical, and safer for both consumers and the natural environment due to the readily biodegradable nature. The cow urine and its combination were used for control of several soybean diseases like aerial blight, rust, target leaf spot and bacterial pustule of soybean and found that cow urine and its combination reducing the disease incidence over control and get more yield then control (Anonymous, 2004-05). Seed soaking in cow urine + asafetida followed by two spray of cow urine at 30 and 40 DAS reduced disease severity over control of aerial blight of soybean at Pantnagar (Anonymous, 2007).

Biological

Baker and Cook (1974) illustrated the concept of biological control as "the reduction of inoculums density or disease producing activities of a pathogen or a parasite in its active or dormant state by one are more organism, accomplished naturally or through manipulation of environment, host or antagonist or by introduction of one or more antagonist". Biological control means reducing the amount or effect of pathogens that relies on biological mechanism or organism other than man (Campbell, 1989). In other words, biological control practices for direct protection of plants from pathogen involved the development of antagonistic microorganisms at the infection court before are infection take place (Agrios, 2004). Reports in respect to effectiveness of fungi and bacteria as antagonist from soybean field are available for control of aerial blight. Elad *et al.* (1983) reported that hyphae of *T. viride* and *T. harzianum* penetrated into host hyphae and caused lysis of *R. solani*. Beagle and Papavizas (1985) reported that successful disease control using fungal antagonist like *G. virens* and *T. harzianum* against *Rhizoctonia solani*. Das and Dutta (1999) assessed the efficacy of *Trichoderma harzianum* as a seed treatment along with 4 different carrier and sublethal doses of Thiram against stem rot of soybean caused by *Rhizoctonia solani* in sterilized soil. The lowest disease index was observed when seeds were treated with *T. harzianum* + methyl cellulose with a significant increase in dry weight of root and shoots and yield over the inoculated control. Cundom *et al*. (2003) evaluated the antagonistic activity of nine isolates of

Trichoderma spp. in dual culture. All isolates significantly diminished the mycelial growth of *R. solani* in dual culture. Jash and Pan (2004) reported that *Trichoderma virens* was most effective in inhibiting mycelial growth of *R. solani* in dual culture. The highest inhibition of mycelial growth of *R. solani* through production of non-volatile antibiotics at 10% concentration of culture filtrate. Ray *et al.* (2007) tested the efficacy of bio-agents under in *vitro* condition. Among the bio-agents, *T. harzianum* found most effective as it inhibited the mycelial growth of *R. solani* after 96 hr of incubation followed by *T. viride* and *P. flurescens* where 82.43 and 80.36 mm growth were observed, respectively. Sarojaini and Nagmani, (2007) tested the antagonistic potential of *Trichoderma* isolates against rice sheath blight pathogen, *Rhizoctonia solani* Kühn. *In vitro* assessment were made on the mode of antagonism against mycelial growth and sclerotial formation of *R. solani*. All the isolates inhibited the mycelial growth of *R.solani* in dual cultures. Singh *et al*. (2007) reported that three components of integrated disease management of black scurf of potato (*Rhizoctonia solani*) were identified by conducting in *vitro* study. Soil isolates of *T.viride* (Tv-1), *T.harzianum* (Th-1), amendment of Ranunculus muricatus powder, Thiophanate methyl, Carbendazim and boric acid in PDA medium resulted in maximum inhibition of mycelial growth of *R. solani*. Dantre and Rathi (2008) reported that severity of rice sheath blight reduced by integration of non-conventional chemicals and Fluorescent pseudomonads.

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RESEARCH ARTICLE

OXIDATIVE STRESS RESPONSES IN LEGUMINOUS CROPS IN RESPONSE TO SULPHUR DIOXIDE: A MAJOR AIR POLLUTANT

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Abstract: Present study is an attempt to evaluate and compare the oxidative stress response in *Vigna mungo* L. cv.T-9, *Pisum sativum* L. cv. Arkil, *Cajanus cajan* L. cv. UPAS – 120 and *Cicer arietinum* L. cv. Avrodhi on exposure to four different concentrations of sulphur dioxide, viz. 653, 1306, 2612 and 3918 µg m^{-3} at different plant ages. Observations were made and results incurred at 40 and 80 d of plant age. Oxidative stress was observed in the form of Ascorbic acid content which was evaluated, tabulated and statistically analysed. An initial enhancement in the ascorbic acid content was observed upon fumigation with SO_2in the four cultivarswhich was followed by a gradual reduction in the ascorbic acid level with increasing age. Increased level of ascorbic acid has been related with the tolerance of plant to the pollutant. *Cajanus cajan* exhibited highest degree of tolerance.

Keywords: Air pollution, Sulphur dioxide, Oxidative stress, Ascorbic acid, Legumes

INTRODUCTION

In India, pollution has become a great topic of debate at all levels and especially the air pollution because of the enhanced anthropogenic activities such as burning fossil fuels, i.e. natural gas, coal and oil-to power industrial processes and motor vehicles(Khan and Khan, 2011).Among the most common and poisonous air pollutants is sulphur dioxide (SO_2) which is formed when fossil fuels such as coal, gas and oil are used for power generation (Ahmed, 1999). In addition to the health impacts, SO_2 leads to acid deposition in the environment. This deposition causes acidification of lakes and streams and damage to tree foliage and agricultural crops(Alias *et al*., 2007).

Sulphur dioxide is a colourless, non-flammable gas with a penetrating odour that irritates the eyes and air passages and is noticeable at 3-5ppm. It is soluble in water and can be oxidised within air borne water droplets. It is the gas released from burning of coal, high sulphur coal and diesel fuel.In dry, unpolluted atmospheric conditions, it is estimated that the average SO_2 concentration ranges from 0.03 to 0.3µg/cu-m (0.01 to 0.1 parts per billion or ppb). In remote areas, itrangesfrom 0.13 to 0.31µg/cu-m (0.05 to 0.12 ppb). In urban and industrialized areas, SO_2 concentrations range from 2.6 to 2600 µg/cu-m (1 to 1000 ppb). A survey by the World Health Organization (WHO) of urban areas showed annual mean SO_2 concentrations ranging from 20 to 60 µg/cu-m (7 to 21 ppb) and daily means rarely exceeding 125µg/cu-m (44 ppb) (WHO, 2003). IARC (1992) presents data for ambient air concentrations of SO_2 in different parts of the world (WBK and Associates, 2003).

At low concentration, sulphur dioxide can stimulate physiology and growth of plants, especially in plants growing in sulphur deficient soil (Darrall, 1989) where the sulphate might be metabolized to fulfil the demand for sulphur as nutrient (DeKok, 1990). Increased uptake of SO_2 can cause toxicity and reduce growth and productivity of plants due to accumulation of sulphite and sulphate ions in excess (Agarwal *et al*., 2003). The work focuses on the relationship between SO_2 exposures and physiological effects in the plantsin relation to ascorbic acidand impact of SO_2 pollution on it.Ascorbic acid maintains the stability of cell membrane during pollution stress (Dhindsa *et al*., 1982)

MATERIAL AND METHOD

The undertaken research was carried out on four widely grown leguminous crops in western UP, viz.*Vigna mungo* L. cv.T-9, *Pisum sativum* L. cv. Arkil,*Cajanus cajan* L. cv. UPAS – 120 and *Cicer arietinum* L. cv. Avrodhi. The plants were fumigated with four different concentrations of sulphur dioxide, viz. 653, 1306, 2612 and 3918 µg m^{-3}daily for 2hrs. The fumigation was carried out in covered portable aluminium chambers of size $1m^3$. Ascorbic acid content was analysed for oxidative stress response (Keller and Schwager, 1977). The effect was studied at 40d and 80d of the plant age. Observations were tabulated and statistically analysed.

OBSERVATION AND RESULT

Ascorbic acid is a biochemical component indicative of stress. It was found to increase initially at 40d age for all doses of SO_2 while at later age of 80d a considerable decrease was observed in all the four plant species(Table 1 and 2). The increase was 8.55, 41.31, 25.67 and 12.61 % in *Vigna mungo*, *Pisum sativum*, *Cajanus cajan and Cicer arietinum* respectively at 40d age under 3918 µg m^{-3}.

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Maximum increase was found in *Pisum sativum* followed by *Cajanus cajan*, *Cicer arietinum* and *Vigna mungo*. A reduction was observed later with an increase in the age of the plant for higher SO_2 concentrations (Table 2). Maximum reduction was observed at 3918µg m^{-3} of SO_2 by 30.33, 30.88, 19.17 and 20.87 % in *Vigna mungo, Pisum sativum, Cajanus cajan* and *Cicer arietinum* respectively at 80d, indicating the sensitivity of the plant to higher concentrations of SO_2. Maximum decline in the level of ascorbic acid was found in *Pisum sativum* and *Vigna mungo* followed by *Cicer arietinum* and *Cajanus cajan*. Plants under control exhibited a regular increasing trend.

Table 1. Ascorbic acid content (mg/g f.wt.) in SO_2fumigated leavesof leguminous crops at 40d plant

PLANT NAME	SO_2Concentration (µg m^{-3})						
	0	653	1306	2612	3918	CD 5%	CD 1%
Vigna mungo L.	3.273	3.060	3.236	3.673	3.553	0.781	1.111
Pisum sativum L.	4.236	4.973**	4.426	5.890**	5.986**	0.672	0.956
Cajanus cajan L.	2.586	2.511	2.656	3.106	3.250*	0.615	0.875
Cicer arietinum L.	3.733	3.810	4.723**	4.773**	4.187*	0.384	0.547

* Significant at 5% level, **Significant at 1% level

Table 2. Ascorbic acid content (mg/g f.wt.) in SO_2 fumigated leaves of leguminous crops at 80d plant

PLANT NAME	SO_2Concentration (µg m^{-3})						
	0	653	1306	2612	3918	CD 5%	CD 1%
Vigna mungo L.	5.473	4.170**	3.043**	3.240**	3.813**	0.781	1.111
Pisum sativum L.	6.993	5.613**	4.853**	5.573**	4.833**	0.390	0.554
Cajanus cajan L.	4.680	5.100	5.446	4.346	3.796	1.192	1.696
Cicer arietinum L.	6.580	6.446	5.846*	5.710**	5.310**	0.524	0.745

* Significant at 5% level,** Significant at 1% level

DISCUSSION

Ascorbic acid was identified as the antiscorbutic factor, Vitamin C (Davis *et al.*, 1991) and act as an antioxidant (Halliwell, 1994; Podomore *et al.*, 1998). Being a powerful reductant, it maintains the stability of cell membrane during pollution stress (Dhindsa *et al.*, 1982) and scavenges cytotoxic free radicals (Halliwell and Gutteridge,1989). A direct relationship between endogenous level of ascorbic acid and plant susceptibility to pollutant has been established by Lee *et al*. (1984). Shahare (1995) explained that SO2 pollution stress even for comparatively shorter duration and low concentrations affect the ascorbic acid content.

In the above study, the ascorbic acid content was found to slightly enhance initially for all doses of SO_2, but reduced later in all four plant species.*Pisum sativum* showed maximum tolerance initially but later succumbed to the fumigation stress. A high value of decrease in *Pisum sativum* and *Vigna mungo* at 80d might be attributed to relatively short life span and early senescence under the effect of SO_2 fumigation.Untreated plants exhibited a regular increasing trend throughout the life span. Varshney and Varshney (1984) established a correlation between ascorbic acid content and resistance of plants. Heath (1994) reported that SO_2 dissolves in extracellular fluid and reacts with biological compounds producing free radicals. These free radicals interact with protein and lipids in the cell wall and cell membrane leading to production of more free radicals which increase the cell permeability (Pell and Dann, 1991). These antioxidants are developed by plants as a defence against the free radical formation. Chaudhary and

Rao (1977) related pollution tolerance of plants with ascorbic acid levels and concluded that resistant plants contain high amount of ascorbic acid while sensitive plants possess low levels of ascorbic acid. The results are in accordance to Dalmia and Sawhney (2004) and Falus *et al.* (2016). In the present case, ascorbic acid was reduced to a greater extent in *Vigna mungo* at 3918 µg m^{-3}. In the present study, the regeneration of ascorbic acid might be low compared to its utilization for scavenging cytotoxic oxy-radicals. A positive correlation has been reported between ascorbic acid content and cell division and expansion.

CONCLUSION

The results obtained from this study revealed that there was an enhanced reduction in the ascorbic acid contents whichis indicative of stress. It was found to increase initially at an early age, but lowers later, close to senescence. The reductions following the enhanced level of ascorbic acidcontent observed could be attributed to the deposition of air pollutant on the four plant species and its penetration through the stomatal openings and surface of leaves. Maximum decline in the level of ascorbic acid was found in *Pisum sativum* and *Vigna mungo* followed by *Cicer arietinum* and *Cajanus cajan*.

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RESEARCH ARTICLE

CUMULATIVE AND RESIDUAL EFFECTS OF PHOSPHORUS AND ZINC NUTRIENTS UNDER GERANIUM– RICE *(ORYZA SATIVA)* CROPPING SEQUENCE

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Abstract: A field experiment was conducted at Central Institute of Medicinal and Aromatic Plants (CIMAP), Lucknow to evaluate the cumulative and residual effects of phosphorus and zinc sources of nutrients under geranium– rice cropping sequence. The treatment involved three cropping system viz geranium paired sole, garlic sole and geranium paired + garlic, three level of phosphorus (0, 40 & 80 Kg P_2O_5/ha) and two levels of zinc (0 and 30 kg $ZnSo_4$ /ha). Results reveled that application of Phosphorus at 40 Kg P_2O_5 ha^{-1} proved significantly better than control (No Phosphorus) in respect of production of geranium oil and garlic bulbs, further application of 30 kg $ZnSO_4$ ha^{-1} significant increased the herb and oil yields of the crop over the no zinc application (control). Residual effects of P and Zn on the grain yield of succeeding rice crop that geranium crop followed by rice, 40 Kg P_2O_5 ha^{-1} was desirable, particularly in rabi crop season. However application of 30 Kg P_2O_5 ha^{-1} and 25 kg $ZnSO_4$ ha^{-1} to rice grown after geranium was more beneficial.

Keywords: Geranium-rice sequence, Phosphorus & Zinc sources & levels, Cumulative and residual effects

INTRODUCTION

Phosphorus and zinc fertilizers have a carry over effects on the succeeding crops. The utilization efficiency of applied phosphatic fertilizers seldom exceeds 15% by the first crop, but a substantial amount of them is left as residue for the next crop (Roy *et al.*, 1978 and Mahala *et al.*, 2006). Geranium - rice is one of the important cropping systems in northern Indian plains, where the poor tribal farming community is not using phosphorus. Hence it become necessary to findout some low-priced indigenous alternative. Further more, in the north Indian plains, rice is grown as a major food crop during Kharif season. In the rice growing belt of the north Indian plains, geranium and upland rice can be grown in sequential cropping system. The recommendation for phosphorus and zinc are made crop based. Such recommendation does not take into account the carry over effect of quantity of nutrient applied to the preceding crop. Hence, rice though in sequence after the geranium cropping is fertilized with full dose of P and Zn. It is, therefore, imperative to study the residual effect of P and Zn on the grain yield of succeeding rice crop and also to workout, the requirement of nutrient for this crop when grown in sequential cropping system. So for, no research work has been carried out to study the nutritional requirement of the geranium – rice based cropping systems, hence, the aim of the present study was to stabilize the production of geranium and garlic in intercropping system and also the succeeding upland rice crop of the geranium based cropping systems.

MATERIAL AND METHOD

The experiment was conducted during 1998-1999 at Central Institute of Medicinal and Aromatic Plants Lucknow. The soil was sandy loam in texture and alkaline (pH 8.3) in reaction. The nutrients in the 0-15 cm soil layer were; Low (168.9 kg ha-^{1}) in N (Subbiah and Asija, 1956), Medium (21.6 kg ha^{-1}) in P_2O_5 (Olsen *et al.*, 1954) and K_2O 82.7 kg ha^{-1} (Jackson, 1967). The available Zn was 0.4 ppm, estimated by DTPA $CaCl_2$ TEA method. Three cropping systems (geranium paired sole, garlic sole and geranium paired + garlic), three levels of P (0, 40 and 80 kg P_2O_5 ha^{-1}) and two levels of zinc (0 and 30 kg Zn SO_4 ha^{-1}) were evaluate in experiment No. 2 during rabi season. The same layout was used to observe the residual and cumulative effects of the treatment on succeeding rice crop. An uniform dose of 120 kg. N and 60 kg. K_2O ha^{-1} was applied to the paddy crop. Phosphorus and Zinc fertilizers were applied basally as per the treatment at the time of planting. The potassium fertilizer was also applied basally at the time of planting. Nitrogen was top dressed in three equal proportions at 20, 40 and 60 days after planting. The cumulative effect was examined over the direct application of P (0, 30 and 60 kg P_2O_5 ha^{-1}) and Zn (0 and 25 kg $ZnSO_4$ ha^{-1}) were evaluated in a factorial randomized block design with three applications. The seeds of the variety pant – 12 were obtained from G.B. Pant University of Agriculture and technology Pantnagar. 25 days old seedlings were transplanted at a spacing of 20 × 10 cm using 2-3 seedlings per hill on 2 July 1999 and harvested at 100 days after transplanting. Observation on yield attribute and yield were recorded.

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RESULT AND DISCUSSION

Effect on geranium and garlic

Herb and oil yield of Main Crop

The first harvest, the decrease in the oil yield of geranium intercrop combination was about 7.6% in comparison to paired sole crop of geranium. (Table-1)

The herb and oil yields of geranium recorded from first, second and total of both harvests were significantly increased due to 40 kg P_2O_5 ha^{-1} over control. Further increase in phosphorus level did not influence the herb yield of the crop significantly. Application of 30 kg $ZnSO_4$ ha^{-1} significantly increased in the herb and oil yield over control. A significant response to application of Zn was also observed by Armungam and Kumar (1979) in geranium (Singh *et al.,* 2012 & Singh *et al.,* 2014).

Intercrop Productivity

Diameter and weight per bulb were significantly improved with sole crop than the intercropped garlic; where as number of cloves per bulb were not influenced significantly. The bulb yield of garlic sole was increased by almost two times than the bulb yield of intercrop garlic (Table-2). This reduction in yield of intercrop may be due to low plant population in the mixture. The diameter per bulb and weight per bulb was enhanced up to 80Kg P_2O_5 ha^{-1} indicating that garlic is quite responsive crop to phosphorus fertilizer. Similar findings of higher rates of P application for enhancing garlic bulb yield have been reported by several workers, Wankhade *et al* (1996), Singh *et al.,* 2012 & Singh *et al.* 2014. Panchal *et el,* (1992) observed the largest bulb diameter (3.67 cm) with highest bulb yield of 7.9t ha^{-1} in garlic by receiving a does of 100 kg N+50 kg P_2O_5+50 kg K_2O ha^{-1}. Higher rates of P application helped in improving the diameter of bulb and percentage of 'A' grade garlic. Singh *et al;* (2000) also reported a does of 75 P_2O_5 ha^{-1} for the better survival of seedling and increase weight per bulb in garlic as compared to control and higher/or lower levels of P.

Cloves per bulb and weight per bulb in garlic were improved with 30 kg $ZnSO_4$ ha^{-1} over control. Higher doses of Zinc (5 kg $ZnCl_2$ ha^{-1}) increased the number of leaves, weight of bulb and yield of garlic under subtropical condition of the north Indian plains (Phor *et al;* 1995). Jawaharlal *et al* (1986) increased bulb yield in garlic with Zn application also reported.

Cumulative and residual effect of P and Zn in rice

Effect of P on yield attributes and yield in rice

Rice crop grown in the field plots after the harvest of geranium sole as well as intercropped geranium did not differ significantly in yield attributing characters. However, the application of P at 30(40) kg P_20_5 ha^{-1} and Zinc at 25(30) kg $ZnS0_4$ ha^{-1} showed an improvement both in development of panicles and grain. In the cumulative effect, the P levels were added both to geranium and rice crops. The significant differences in the yield attributes of rice at lower doses of P were mainly because of the residual effect of P applied (40 Kg P_20_5 ha^{-1}) to previous crop of geranium. But higher doses of P applied to rice directly did not contribute significantly with respect to yield attributes. It is interesting to note that the grain weight per panicle of rice was observed significant at 60(80) kg P_20_5 ha^{-1} which was applied to rice crop directly in the plots of previous crop fertilized with 80 kg P_20_5 ha^{-1} (Table-3) . As a result, the grain yield was found to be significant in the residual fertility soil status. This implies that the added fertilizer to the preceding geranium crop continued to have marginal residual effects in the succeeding rice crop. Present findings are supported by the observation made by other workers in food crops (Dev and Mistry, 1979, Wichmann, 1979, Mahala *et al.,* 2006 and Singh and singh 2006). Dang *et al* (1989) observed the residual effect of P in wheat - rice system and they found that P at 26.4 kg P_20_5 ha"[1] in wheat increase the yield of wheat (674 kg ha^{-1}) as well as the yield of succeeding rice (712 kg ha^{-1}). P at the rate of 26.4 Kgha'[1] used in rice also increased the yield of when the preceding wheat receiving no application, but up to 13.2 kg P ha^{-1} only when the preceding wheat received only 13.2 kg P ha^{-1}. Rathi and Yadav (1992) also reported that residual effect of P applied to pigeon pea crop was positive on grain yield of wheat. It is clear from the findings that the yield of rice grains under residual fertility status of P at 80 kg P_20_5 ha^{-1} supplied to geranium was almost equal to the yield of rice grain recorded with 30 kg P_20_5 ha^{-1} applied in the plot of 40 kg P_20_5 ha^{-1} received by previous crop of geranium. Therefore, it follows from the results that geranium crop followed by rice, 40 kg P_20_5 ha^{-1} is desirable particularly in Rabi crop season. But to grow rice after geranium 30 kg P_20_5 ha^{-1} is suggested (Table-4). On the other hand we can say that neither the higher doses of P (80 kg P_20_5 ha^{-1}) are required neither to geranium nor to rice (60 kg P_2O_5 ha^{-1})

Effect of Zn on yield attributes and yield in rice

Application of 25Kg $ZnS0_4$ ha^{-1} influenced significantly the yield attributing characters and grain yield on cumulative and residual soil fertility status. The requirement of Zinc for rabi crop of geranium is 30 Kg $ZnS0_4$ ha^{-1} and the rice crop grown in sequence after geranium is 25Kg $ZnS0_4$ ha^{-1}. It has been observed that soi application of $ZnS0_4$ at 20 Kg ha^{-1} to rice improve the grain yield in wheat (Prasad and Umar, 1993). Higher levels of P with Zinc may decrease the availability of Zn to the plants. Several workers have reported the P induced zinc deficiency in agricultural crop (Takkar 1989).

CONCLUSION

It may be inferred from these experiment that the results of residual effects of P and Zn on the grain yield of succeeding rice crop that geranium crop followed by rice, 40 kg P_2O_5 ha^{-1} is desirable, particularly in rabi crop season. But to grow rice after geranium 30 kg P_2O_5 ha^{-1} and 25 kg $ZnSO_4$ ha^{-1} is suggested.

Table 1. Fresh biomass and oil yields of geranium as influenced by different cropping systems and rates of phosphorus and zinc

Treatment	Biomass yield (q ha^{-1}) at			Oil yield (kg ha^{-1}) at		
	Ist harvest	IInd harvest	Total	Ist harvest	IInd harvest	Total
Cropping System						
Geranium paired sole (40/80 cm)	236.92	152.50	389.92	48.72	32.98	81.73
Garlic sole (20×10cm)	-	-	-	-	-	-
Geranium paired (40/80 cm) + Garlic	217.77	140.40	358.15	44.98	30.37	75.35
SEm	5.98	4.30	9.72	1.19	0.82	2.02
CD at 5%	17.54	NS	28.50	3.49	2.40	5.92
Phosphorus levels (Kg P_2O_5 ha^{-1})						
0	194.57	123.05	317.62	40.33	27.05	67.38
40	237.81	153.18	391.00	49.05	33.7	82.75
80	249.66	163.08	412.75	51.17	34.28	85.5
SEm	7.32	5.28	11.90	1.46	1.00	2.47
CD at 5%	21.48	15.48	34.92	4.28	2.94	7.25
Zinc levels (kg $ZnSO_4$ ha^{-1})						
0	214.23	137.42	351.65	44.30	29.72	74.00
30	2.40.46	155.45	395.90	49.40	33.63	83.08
SEm	5.98	4.31	9.72	1.19	0.82	2.02
CD at 5%	17.54	12.64	28.51	3.49	2.40	5.92

NS= Non significant

Table 2. Yield attributes & Bulb yield of garlic at harvest as influenced by different cropping systems and rates of phosphorus and zinc

Treatment	Diameter/bulb (cm)	No. of Cloves/bulb	Weight/bulb (gram)	Bulb yield (q ha^{-1})
Cropping System				
Geranium paired sole (40/80 cm)	4.55	15.82	32.11	122.24
Garlic sole (20×10cm)	-	-	-	-
Geranium paired (40/80 cm)+ Garlic	3.79	15.50	26.00	56.27
SEm	0.11	0.46	0.80	2.56
CD at 5%	0.33	NS	2.34	7.27
Phosphorus levels (kg P_2O_5 ha^{-1})				
0	3.90	12.97	22.17	80.02
40	4.19	16.18	29.5	90.78
80	4.42	17.83	35.50	96.96
SEm	0.14	0.57	0.98	3.14
CD at 5%	0.40	1.66	2.86	8.91
Zinc levels (kg $ZnSO_4$ ha^{-1})				
0	4.06	14.61	26.61	85.45
30	4.28	16.71	31.50	93.05
SEm	0.11	0.46	0.80	2.56
CD at 5%	NS	1.35	2.34	7.27

NS= Non significant

Table 3. Yield attributes of rice as influenced by cumulative and residual effect of P and Zn under different cropping systems

Treatment	Cumulative						Residual					
	No. of panicles /m^2	Length of panicle (cm)	No. of rachilla/ panicle	No. of grains/ panicle	grain weight/ panicle (g)	1000 grain weight (g)	No. of panicles /m^2	Length of panicle (cm)	No. of rachilla/ panicle	No. of grains/ panicle	grain weight/ panicle (g)	1000 grain weight (g)
Cropping System												
Geranium paired sole (40/80 cm)	240.78	26.76	13.47	176.19	4.92	32.06	226.28	25.94	12.93	160.86	4.79	31.67
Garlic Sole (20×10 cm)	249.00	26.74	13.38	175.91	4.94	31.83	223.78	26.13	13.03	168.56	4.63	31.06
Geranium paired (40/80 cm)+ Garlic	240.89	26.65	13.13	163.45	4.54	31.95	227.45	25.49	12.88	158.15	4.37	31.05
SEm	5.98	0.77	0.43	5.66	0.12	0.67	5.15	0.70	0.31	4.32	0.13	0.94
CD at 5%	NS	NS	NS	NS	0.34	NS	NS	NS	NS	NS	0.37	NS
Phosphorus levels (kg P_2O_5 ha^{-1})												
0 (0)	226.33	25.89	12.65	155.23	4.32	30.33	216.67	24.83	12.57	149.10	4.17	29.78
30 (40)	246.67	26.75	13.44	175.45	4.82	32.45	224.17	26.10	13.03	162.96	4.61	31.44
60 (80)	257.67	27.51	13.88	184.87	5.27	33.06	236.67	26.62	13.24	175.52	5.01	32.56
SEm	5.98	0.77	0.43	5.66	0.12	0.67	5.15	0.70	0.31	4.32	0.13	0.94
CD at 5%	17.24	NS	NS	16.30	0.34	1.94	14.80	NS	NS	12.44	0.37	2.69
Zinc levels (kg $ZnSO_4$ ha^{-1})												
0 (0)	231.44	26.13	12.90	160.82	4.39	30.89	216.93	25.13	12.62	154.04	4.31	30.37
25 (30)	255.67	27.30	13.75	182.89	5.22	33.00	234.74	26.58	13.28	171.01	4.89	32.15
SEm	4.89	0.63	0.35	4.62	0.10	0.55	4.20	0.57	0.25	3.53	0.10	0.76
CD at 5%	14.07	NS	NS	13.31	0.28	1.58	12.10	NS	NS	10.15	0.30	NS

Table 4. Yield of rice (q ha^{-1}) as influenced by cumulative and residual effect of P and Zn under different cropping systems

Treatment	**Cumulative**		**Residual**	
	Grain Yield	**Straw yield**	**Grain Yield**	**Straw yield**
Cropping System				
Geranium paired sole (40/80 cm)	49.09	60.87	44.32	56.85
Garlic Sole (20×10 cm)	53.88	66.54	45.10	58.17
Geranium paired (40/80 cm) + Garlic	47.14	59.52	41.88	53.72
SEm	1.39	1.73	1.00	1.45
CD at 5%	4.00	5.00	2.89	4.19
Phosphorus levels (kg P_2O_5 ha^{-1})				
0 (0)	42.17	58.33	38.85	54.67
30 (40)	51.57	64.08	43.28	55.56
60 (80)	56.36	64.51	49.16	58.52
SEm	1.39	1.73	1.00	1.45
CD at 5%	4.00	5.00	2.89	NS
Zinc levels (kg $ZnSO_4$ ha^{-1})				
0 (0)	44.46	60.19	40.41	55.87
25 (30)	55.61	64.43	47.12	56.63
SEm	1.13	1.41	0.82	1.18
CD at 5%	3.27	4.08	2.37	NS

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RESEARCH ARTICLE

SELECTION OF IMPORTANT YIELD COMPONENT CHARACTERS BASED ON GENETIC ANALYSIS IN CELERY (*APIUM GRAVEOLENS* L.)

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Abstract: Eleven genotypes (control and ten macromutants- maintained over generations through selfing) of Celery (*Apium graveolens* L.) are assessedbased on eight phenotypic traits (plant height, number of primary branches/plant, total branches/plant, number of compound umbels/plant, number of umbels/plant, number of umbellets of first inflorescence, total seed yield and harvest index) for selection of essential trait(s) maximizing yield through efficient breeding. ANOVA depict variations among the selected traits. Phenotypic and genotypic co-variance, heritability (broad sense) and genetic gain (5% level) performed reveal three important selection indices (total branches, no. of compound umbel and total umbel per plant) in celery.

Keywords: Celery, Germplasms, Quantitative traits, Selection

INTRODUCTION

Celery (*Apium graveolens* L., Family – Umbelliferae; 2n=22), is an important seed spice of India, besides possessing immense therapeutic significance (Ashburn and Stats, 1999; Guerrero, 2005; Praveen, 2011; Fazal and Single, 2012). The spice is providing considerable source in National economy (Khinvasara and Bhushan, 2015) and therefore it should be under sustainable cultivation for enhancement of production in yield and value added products.Ten true breeding mutant lines are raised in celery (total plants screened - 515), which highlights breeding endeavour for improvement. Further, more knowledge of heritability (Rajput and Singh, 2003; Sabesan *et al.*, 2009; Yadava *et al.*, 2011) and genetic gain (Dhayal *et al.*, 1999; Singh *et al.*, 2003; Yadav *et al.*, 2013; Meena *et al.*, 2014) can also shed light on selection of essential traits under study. With the view to it, present investigation estimate genetic variability, heritability and genetic advance for eight yield and yield related traits in eleven (control and macromutants) germplasms of celery.

MATERIAL AND METHOD

In an induced mutagenesis (γ-irradiations and EMS) programme, eleven germplasms that were maintained through selfing are assessed quantitatively based on eight phenotypic traits (plant height, number of primary branches/plant, total branches/plant, number of compound umbels/plant, number of umbels/plant, number of umbellets of first inflorescence, total seedyield and harvest index). ANOVA is performed to estimate variation among the parameters; Phenotypic and genotypic co-variance, heritability (broad sense) and genetic gain (5% level) are determined for each quantitative trait in the germplasms in accordance to Burton and De Vene(1953), Hanson *et al.* (1956) and Johnson *et al.*(1955a) respectively.

RESULT AND DISCUSSION

Analysis of variance (F-test) revealthat mean sum of square due to variance is significant for all the traits (Table 1), suggesting variations among the plant types. The extent of variability measured in terms of grand mean, PCV, GCV, heritability and genetic gain as per cent of mean are given in Table 2. The estimates of genetic parameters show that the difference between genotypic (GCV) and phenotypic (PCV) co-efficient of variation is low only for plant height, indicating that this character is least affected by environment. For other traits, the differences are much inflated, thereby, depicting a positive role of environment on the expression of genotypes.Co-efficient of variability (%) both at phenotypic and genotypic level are high for total branches/plant, number of compound umbels/plant, number of umbels/plant and seed yield.

High estimate of heritability is obtained for all traits excepting for no. of umbellets of first inflorescence and harvest index. Rawat *et al.* (2013) in their experiment with 12 quantitative characters in 13 diverse genotypes of fennel got high heritability for different traits and opinedgenetic influence rather than environmental influence in control of the attributes.

High values of co-efficient of variation accompanied with high heritability do not mean that character

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(seed yield, no. of primary branches per plant and to an extent harvest index) will show always high genetic advance. Johnson *et al.* (1955a), Mishra *et al.* (2006), Meena *et al.* (2013) and many otherssuggested that high heritability in association with high genetic advance is more reliable for selection. In the present investigation, high heritability is coupled with high genetic gain was estimated for total branches, no. of compound umbels and total umbels per plant. These three traits also exhibit high grand mean in the population. Estimates of heritability also give some idea about the gene action involved in the various polygenetic traits (Johnson *et al.*, 1955b). Panes (1957) reported that association of high heritability with high genetic gain is due to additive gene effect. So, it can infer that the said traits are under additive gene effects.

Table 1. Analysis of variance for different characters in control and mutant plant types.

Sources	DF	Mean Sum of Squares (M.S.S) of quantitative traits (T)							
		T-1	T-2	T-3	T-4	T-5	T-6	T-7	T-8
Treatments	10	1237.87**	33.75**	67573.09**	64823.38**	947646.21**	171.01**	22.01**	92.59**
Error	54	75.40	3.27	6653.76	6479.26	90150.74	87.96	2.09	20.07

** = significant at 1% level.

T-1= Plant height (cm), T-2= No. of primary branches/plant, T-3= Total branches/plant, T- 4= No. of compound umbels/plant, T-5= No. of umbels/plant, T-6= No. of umbellets of first inflorescence, T-7= Seed yield (gm) and T-8= Harvest index (%).

Table 2. Analysis of genetic parameters for different traits in 11 germplasms.

Variable	Grand mean	Genotypic variance	Environmental variance	Phenotypic variance	Co-efficient of variability (%)		Heritability	Genetic gain as % of mean
					GCV	PCV		
Plant height (cm)	74.62	211.58	79.13	290.71	19.49	22.85	73.0	25.56
No. of primary branches/plant	8.75	5.56	3.35	8.91	26.95	34.11	62.0	3.84
Total branches/plant	177.14	10888.48	7069.60	17958.08	58.91	75.65	61.0	167.38
No. of compound umbels/plant	169.55	10383.98	6883.63	17267.61	60.10	77.50	60.0	162.79
No. of umbels/plant	692.52	153165.60	96133.10	249298.70	56.51	72.10	61.0	631.93
No. of umbellets of first inflorescence	34.86	16.22	87.71	103.93	11.55	29.24	16.0	3.28
Seed yield (gm)	2.68	3.47	2.25	5.72	69.64	89.41	61.0	2.99
Harvest index (%)	18.24	12.50	19.83	32.33	19.38	31.17	39.0	4.53

CONCLUSION

Traits namely total branches, no. of compound umbels and total umbels per plant showing high heritability coupled with high genetic gain can be considereffective for selection and improvement in celery.

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RESEARCH ARTICLE

STUDIES ON KNOWLEDGE LEVEL OF EXTENSION PERSONNEL REGARDING SUSTAINABILITY IN AGRICULTURE PRODUCTION

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Abstract : In order to enhance food grain production there has been over exploitation of natural resources and due to which land, water and soil have been subjected to great stress resulting in soil degradation, soil erosion, salinity and alkalinity, sifting cultivation and nutrient losses. Hence, the concept of sustainability has emerged as an alternative for long term sustainable production and economic viability of Indian agriculture. The study was conducted in Rampur district with 80 Extension Personnel in order to assess their knowledge on sustainability. Extension Personnel possessed very good knowledge on soil and water conservation, integrated nutrient management, integrated weed management aspects, whereas in case of integrated water management there was low level of knowledge. The overall knowledge analysis shows that majority (56.25%) of extension personnel possessed medium level of knowledge whereas a good number (32.50%) were having higher level of knowledge.

Keywords: Knowledge level, Sustainable agricultural, Nutrient management, Integrated Weed management

INTRODUCTION

India is an agriculture based country where in majority of the population still depends on agriculture as a source of livelihood and lives in rural areas. The development of the country depends on the development of rural areas. Agriculture is a main family occupation which requires capital, seeds, fertilizers and other inputs. Further labor is also an important input in agriculture and their participation in agricultural related activities are also essential.

Conventional agriculture has caused economic problems associated with over production of crops, increased costs of energy-based inputs and decreased farm incomes. It has also produced ecological problems such as poor ecological diversity, soil and water pollution and soil erosion. The adoption of integrated systems of agricultural production involving lower inputs of fertilizer, pesticides and cultivations can alleviate these economic and ecological problems. Such systems are dependent upon a good understanding of the nature of interactions between the four main components of such systems, which are fertilizers, pesticides, cultivations and rotations, and how these interactions influence crop yields and farm income. Alternatives to energy-based inputs include: legume rotations; use of waste organic matter as well as that from animals and crops; integrated pest management; pest and disease forecasting; biological and cultural pest control; living mulches and mechanical weed control; conservation tillage; specialized innovative cultural techniques, including intercropping, strip cropping, under sowing, trap crops, and double-row cropping. It is essential to integrate the components of agricultural systems fully so that their impact of other inputs is taken into account. Our knowledge of the main inputs and how these practices interact must increase before we can design fully integrated farming systems that minimize energy-based chemical inputs, produce good yields, increase farm profits and decrease environmental problems.

Sustainable agriculture is that form of farming which produces sufficient tool to meet the needs of present generation without eroding the ecological assets and the productivity of the life supporting system in future generation." Sustainability has evolved a lot from its original meaning of "ability to continue". Brundtland commission concept of sustainability referred to development that meets the needs of the present without compromising the ability of generations to meet their needs (Yadav et.al, 2008).In the present context, it is of utmost importance that the sustainability dimensions of the developed and transferred technologies should be looked into and each new technology needs to be developed for future should satisfy the concept and dimensions of sustainability (Ram Chand and Gosian, 1998). Further, knowledge is one of the important components of human behavior. Extension workers are like the nervous system in the process of rural development. There is a great responsibility on the shoulder of extension personal that are in the field of extension. Extension personal should have through knowledge on sustainable agricultural practices, which preserve and enhance the environment. A systematic study was undertaken to assess the knowledge level of extension personal about sustainability of scientific agricultural practices.

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METHODOLOGY

The study was undertaken in Rampur district of Uttar Pradesh. The Krishi Vigyan Kendra, Rampur regularly organized training program for extension personnel. All the extension personnel in position from the selected district were taken as the respondents for the study. Therefore, a total of 80 extension personnel were selected for the study. The data were collected by personnel interview method.

RESULT AND DISCUSSION

Table 1. Knowledge item related to soil and water conservation

Sl. No	Statement	known		Unknown	
		F	%	F	%
1.	Formation of dead furrow for soil and water conservation	75	93.95	5	6.25
2.	Stabilization of bund	67	83.75	13	16.25
3.	The field slope at which agronomic measure recommended	65	81.25	15	18.75
4.	Important cover crop for checking soil erosion	72	92.00	8	10.00
5.	Suitable live barriers	70	87.50	10	12.50
6.	Wind break	70	87.50	10	12.50
7.	Meaning of soil conservation	60	75.00	20	25.00
8.	Meaning of water shed	56	70.00	24	30.00
9.	**Mean**	**66.87**	**83.58**	**13.12**	**16.40**

It is revealed from the above table 1 that the items formation of dead furrow for soil and water conservation (93.95%) and important cover crop for checking soil erosion (92.00%) were known by maximum percent of the agricultural other. The Krishi Vigan Kendra, Rampur up is providing in service training of soil and water conservation. The training might have helped the extension personal in acquiring better knowledge. Moreover the trained persons might have shared their views with extension personal had good knowledge about soil and water conservation practices.

Table 2. Knowledge items related to water management

Sl. No.	Statement	Known		Unknown	
		F	%	F	%
1.	Quality of irrigation water in terms of electrical conductivity	26	32.50	54	67.50
2.	The stage of crop at which irrigation in schedule is scarce	34	42.50	46	57.50
3.	Soil moisture sensitive stage	31	38.75	49	61.25
4.	Efficient method of irrigation	42	52.50	38	47.50
5.	Suitability of soil for broad bed and furrow method of irrigation	48	60.00	32	40.00
6.	Water harvesting in arid zone	53	66.25	27	33.75
7.	**Mean**	**39**	**48.75**	**41**	**51.25**

It is observed from the Table 2 that in case of water management maximum 66.25 percent extension personnel knew the practice like water harvesting in arid zone followed by 60.00, 52.50, 42.50, 38.75 and 32.50 percent of the extension personnel knew the practices like Suitability of soil for broad bed and furrow method of irrigation, efficient method of irrigation, the stage of crop at which irrigation schedule is scarce, soil moisture sensitive stage and quality of irrigation water in terms of electrical conductivity, respectively. However, on quality of water used for irrigation in terms of electrical conductivity a considerable proportion (67.50%) of the extension personnel were not aware. Thus, it can be concluded that the extension personnel did not possess good knowledge on water management.

Table 3. Knowledge items related to integrated nutrient management and cropping system

Sl. No	Statement	Known		Unknown	
		F	%	F	%
1.	BC status of legumes stabilization of bunds.	71	88.75	9	11.25
2.	Content of Ca and P in vermi-compost	74	92.50	6	7.50
3.	Bio-fertilizer recommended for pulse crop	65	81.25	15	18.75
4.	Quantity of bio-fertilizer	25	31.25	55	68.75
5.	Method of inoculation of bio-fertilizer	20	25.00	60	75.00
6.	Time of application of Blue green Algae	42	52.5	38	47.50

7.	Usual close of Blue green	37	46.25	43	53.75
8.	Desirable cost benefit ratio	22	27.5	58	72.50
9.	Objective of mixed farming	39	48.75	41	51.25
10.	**Mean**	**43.88**	**54.85**	**36.11**	**45.13**

It is clear from the table 3 that most of the extension personnel ranging from (25.00 to 92.50) per cent knew the practices like content of Ca and P in vermi-compost, B.C. status of legumes stabilization of bunds, bio-fertilizer recommended for pulse crop, Time of application of Blue green Algae, objective of mixed farming, usual close of blue green algae, objective of mixed farming, quantity of bio-fertilizer, desirable benefit-cost ratio and inoculation method of bio-fertilizers. Over decades, the extension personnel of the Department of Agriculture have been exposed to crop production technologies through their periodical training programmes. Hence, there appears to be strong reason for the personnel knowledge in the above subject. Suresh P. (1995) also found that agricultural officers working in Godavari district of Andhra Pradesh perceived less training need in manures and their effective use. Only more than half of the extension personnel knew the practices like method of inoculation of bio-fertilizer, desirable cost benefit ratio, quantity of bio-fertilizer recommended for treatment of seeds, usual close of blue green algae and objective of mixed farming. Almost fifty percent of the extension personnel under study were lacking in knowledge on these items. Therefore, training programmes should be organized for the extension personnel on integrated nutrient management in order to update their knowledge

Table 4. Knowledge items related to integrated pest management

Sl. No.	Statement	Known		Unknown	
		F	%	F	%
1.	Thuricides used against moth pest	18	22.50	62	77.50
2.	Thuricides mode of action	15	18.75	65	81.25
3.	The load of pest population at which pesticide is recommended	27	33.75	53	66.25
4.	Popular bactericide	10	12.50	70	87.50
5.	Popular egg parasite	13	16.25	67	83.75
6.	Place of parasite breeding station	54	67.50	26	32.50
7.	Meaning of IPM	80	100.00	0	0.00
8.	Parasite use to break pest multiplication	71	88.75	9	11.25
9.	Method of pest control include in IPM	68	85.00	12	15.00
10.	Pheromones mode of action	37	46.25	43	53.75
11.	Number of pheromone traps/ha	32	40.00	48	60.00
12.	Chemical used in rat control	50	62.50	30	37.50
13.	**Mean**	**39.58**	**49.47**	**40.41**	**50.51**

Table 4 the cent percent of extension personnel knew the meaning of IPM. The highest majority (88.75%) extension personnel were also having knowledge about Parasite use to break pest multiplication. This was followed by 85.00, 67.50, 62.50, 46.25, 40.00, 33.75, 22.50, 18.75 and 12.50 per cent extension personnel were having knowledge about method of pest control including IPM, place of parasite breeding station, Chemical used in rat control, pheromones mode of action, number of pheromones traps per hectare, load of pest population at which parasite is recommended, thuricide used against moth pest, thuricide mode of action popular and popular bactericide, respectively. (53.75 to 87.50) per cent of the extension personnel had not known the items like pheromones mode of action, Number of pheromone traps/ha, the load of pest population at which pesticide in recommended, thuricides used against moth pest, thuricide mode of action, Popular egg parasite and Popular bactericide. There is a need to stress on pheromone traps that control the pest population by disrupting the mating which is very economical and environmentally safe.

Table 5. Knowledge items related to integrated weed management

Sl. No.	Statement	Known		Unknown	
		F	%	F	%
1.	Smoothing crops to check weed growth	38	47.50	42	52.50
2.	Biological agent successfully control the Opuntia dillinii	33	41.25	47	58.75
3.	Important methods of control in integrated weed management	72	90.00	8	10.00
4.	Meaning of pre emergence application	54	67.50	26	32.50

5.	extension personnel weed for salinity	45	56.25	35	43.75
6.	Tanslocated herbicides	36	45.00	44	55.00
7.	**Mean**	**46.33**	**57.90**	**33.66**	**42.07**

Table 5 reveals that extension personnel possess varied knowledge on integrated weed management such as important method of integrated weed management (90.00%), meaning of pre-emergence application (67.50%), extension personnel weed for salinity (56.25%), smoothing crop to check weed growth (47.50%), tans located herbicides (45.00%) and biological agent (41.25%). On the other hand, majority of the extension personnel (58.75%) did not know about biological agents successfully to control opuntia dillinsi. Though majority of them knew about some of the aspects integrated weed management still some of the aspects their knowledge was poor. In case of biological agents was only 52.50 percent whereas of smoothening up to check weed growth, trans located herbicide the percentage was to the time of (55.00%), extension personnel weed for salinity (43.75%) and Meaning of pre emergence application (32.05%), respectively. Tran located herbicide and smooth crops check weed growth are an important method of weed control.

Table 6. Overall knowledge levels of agriculture officers

Knowledge level	Frequency	Percentage
0-25 (Low)	9	11.25
26-50 (Medium)	45	56.25
51-75 (High)	26	32.50
Total	80	100.00

A cursory look at table 6 indicated that majority (56.25%) of the extension personnel were having medium level of knowledge while 32.50 per cent and 11.25 per cent had high and low knowledge, respectively. Thus, it is clear from the above findings that overall majority of the extension personnel had either medium or high level of knowledge about sustainable agriculture. Therefore, in future training programme should be organized to up-to-date their knowledge on sustainability of the technologies.

CONCLUSION

Sustainability is the urgent need of Indian agriculture for production and economic viability. The study revealed that state department of extension personnel possessed medium level of knowledge on sustainable agriculture. A good percentage of extension personnel also possessed higher knowledge. Hence, there is a need to update their knowledge regularly to make agriculture sustainable in the state of U.P. It could also be informed during the study that most of extension personnel did not receive trainings regularly by the State Department of Agriculture where appropriate training facilities and infrastructure was not available to training the field level staff on sustainable agriculture. Hence, there is a need to update the knowledge of extension personnel by State Deptt. of Agriculture in every district for the sustainability of agriculture in the district in particular and in the country in general.

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RESEARCH ARTICLE

STUDIES ON INTEGRATED NUTRIENT SUPPLY ON YIELD OF FODDER MAIZE + LEGUMES INTERCROPPING SYSTEM IN INCEPTISOLS

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Abstract : A field experiment was conducted during the winter seasons of 2008 -09 and 2009-10 at Raipur Chhattishgrah, to find out the effect of integrated nutrient supply on yield of fodder Maize + legumes intercropping system in inceptisols. The results of experiment revealed that maize + ber seem (1:1) produced significantly maximum total green fodder yield (662.52 & 680.10 q ha^{-1}), maize equivalent yield (702.37 & 721.34 q ha^{-1}) & relative yield equivalent ratio (162% & 164%) as compared to other treatments during both the years respectively as well as mean basis whereas, significantly higher total dry matter yield (128.54 & 133.88 q ha^{-1}) were recorded with the treatment of maize + lucerne (1:1) during second year. Among integrated nutrient supply, the application of 50% RFD + 10 tonnes FYM + $ZnSO_4$ was recorded significantly higher value of total green fodder yield (626.96 & 648.66 q ha^{-1}), total dry matter yield (125.91 & 129.75 q ha^{-1}) and maize equivalent yield (650.93 & 670.25 q ha^{-1}) during both the years and mean basis. With respect to interaction effect of intercropping and integrated nutrient supply reveals that treatment combination of maize + berseem (1:1) and application of 50% RFD + 10 tonnes FYM + $ZnSO_4$ were recorded significantly higher total green fodder yield than others except treatment combination of maize + ber seem (1:1) and application of 50% RFD + 10 tones MSC + $ZnSO_4$.

Keywords : Integrated nutrient supply, Fodder maize + legumes intercropping, Fodder yield

INTRODUCTION

Livestock is an integral part of Indian Agriculture and plays a vital role in rural economy. India has a huge livestock population of 527 millions (DAH, Ministry of Agriculture, Gol, 2007) however the production of milk and other livestock products are lowest in the world because there is huge gap between demand and supply of all kinds of feed and fodders and on the other hand, there is only 4.4 per cent area of total cultivable land used for growing of fodder and forage crops, therefore, the heavy livestock pressure on the limited land resources in the country calls for increasing the fodder productivity. Intercropping of forage cereals and legumes appears to be technically feasible and economically viable approaches to increase quality herbage yield, utilization of land more efficiently and providing stability of production (Tripathi, 1989) as well as combined use of inorganic fertilizers and organic manures supplied sufficient plant nutrients to the forage maize + legumes crops during the entire crop growth period increases the availability of macro and micro nutrients (Patel *et al.,* 2002) which is not only provide the higher yield but also improves the soil physico-chemical properties. Therefore, the present experiment was conducted to study on integrated nutrient supply on yield of fodder maize + legumes intercropping system in inceptisol.

MATERIAL AND METHOD

The field experiment was carried out at Instructional farm, Indira Gandhi Krishi Vishwavidyalaya, Raipur, during rabi season 2008-09 and 2009-10. The soil of the experimental field was sandy clay loam in texture, locally known as Inceptisols. The soil was neutral in reaction and had low nitrogen, low phosphorus and high potassium contents. Experiment was laid out in Split Plot Design with 3 replications. There were two factor, factor A is intercropping had 4 levels *viz.*, I_1 - sole maize, I_2 - maize + cowpea (1:1), I_3 - maize + berseem (1:1), I_4 and maize + lucerne 1:1 assigned in main plot. Factor B had 5 level of integrated nutrient supply *viz.,* N_0 - Control, N_1 – RFD, N_2 - 50% RFD + 10 tonnes FYM, N_3 - 50% RFD + 10 tonnes MSC, N_4 - 50% RFD + 10 tonnes FYM + $ZnSO_4$, N_5 - 50% RFD + 10 tonnes MSC + $ZnSO_4$ kept in sub plot. Crop was sown on 5th December and 6th December during 2008-09 and 2009-10 respectively at row spacing of 40 cm in case of sole maize and one row of legumes were introduced in between two rows of maize in case of maize + legumes intercropping. The organic manures were applied as per treatments in the experimental plots before sowing. The recommended dose of nutrients for fodder maize was 100, 60 and 40 kg of NPK ha^{-1}. The nitrogen, phosphorus and potash were applied in the form of urea (46%), Single super phosphate (16% P_2O_5) and muriate of potash (60% K_2O).The nutrients dose applied as per treatments through commercial fertilizers. The full dose of phosphorus and potash and 1/3rd dose of the nitrogen was applied as basal. Remaining 1/3rd nitrogen was applied as top dressing after 20 & 45 days of sowing. In case of legumes the recommended dose of nutrients was 20:50:20 kg of NPK ha^{-1} and the entire amount of nutrients were applied as basal dose through commercial fertilizers as per treatments. Crops were raised adopting their recommended package of practices. Crops were harvested after 65 days manually with a sickle.

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RESULT AND DISCUSSION

Green fodder yield (q ha^{-1})

The effect of different treatments on green fodder yield (q ha^{-1}) is presented in table 1. a perusal of mean value from table indicate that the intercropping of maize + lucerne 1:1, (I_4) recorded significantly maximum green fodder yield of maize alone *viz*., 443.94 and 452.83 q ha^{-1} during first and second year, respectively over rest of the treatments, but yield was at par with maize + berseem 1:1 (I_3) whereas, among the legume intercrops berseem produced significantly higher green fodder yield viz., 225.80 and 233.71 q ha^{-1} during first and second year, respectively with maize + berseem intercropping 1:1 (I_3) over other treatments and significantly highest total green fodder yield *viz*., 662.52 and 680.10 q ha^{-1} during first and second year, respectively, was obtained with intercropping of maize + berseem 1:1 (I_3) over rest of the treatments during both the years and mean basis. Singh *et al.* (1983) reported that berseem improves physical conditions of the soil, that helps proper plant growth resulting higher green fodder yield.

Minimum green fodder yield of system was recorded under sole maize (I_1) *viz*., 419.66 and 429.33 q ha^{-1} during first and second year, respectively.

Data in table indicated that application of 50 per cent recommanded dose of fertilizer + 10 tonnes of FYM + $ZnSO_4$, (N_4) recorded significantly maximum green fodder yield of maize alone, green fodder yield of legume intercrops and total green fodder yield of maize + legumes *viz*., 477.00, 149.96 and 626.96 during first year and 489.58, 159.08 and 648.66 q ha^{-1} during second year, respectively over rest of the treatments except 50% RFD + 10 tonnes MSC + $ZnSO_4$, (N_5) during both the years as well as pooled mean basis. This might be due to integration of organic and inorganic source of fertilizer not only made availability of all essential nutrients to the crop plant but also release the nutrients in slow pattern therefore, plant get sufficient quantity of all plant nutrients in time resulted better growth and development ultimately turn in maximum production of green and dry matter yield of crop. Similar results were also reported by various investigators *viz*., Patel and Vihol (1992), Manohar *et al.* (1992).

Dry matter yield (q ha^{-1})

The data on dry matter yield of maize and total dry matter yield of maize + legumes are presented in table 2. It is evident from the results that, in general, the dry matter yield of maize alone and total dry matter yield of maize + legumes were higher when maize intercropped with legumes as compare to sole maize (I_1) and also significant difference among the dry matter yield of legume intercrops in intercropping system during both the years of experimentation and it was also noticed that dry matter yield was higher in second year than first year.

The dry matter yield of maize and total dry matter yield of maize + legumes were significantly influenced due to various intercropping system. The significantly maximum dry matter yield of maize alone *viz.*, 88.62 and 91.83 q ha^{-1} during first and second year, respectively were recorded with maize + lucerne intercropping over sole maize (I_1) but at par with maize + cowpea 1:1 (I_2) and maize + berseem 1:1, (I_3). Whereas, among the legume intercrops berseem produced significantly higher dry matter yield viz., 40.79 and 42.05 q ha^{-1} during first and second year, respectively with maize + berseem intercropping 1:1 (I_3) over other treatments but at with maize + lucerne intercropping 1:1 (I_4) and total dry matter of maize + lucerne *viz.*,128.54 and 133.88 q ha^{-1} were recorded during first and second year, respectively. Which was significantly higher than other treatments but at par with maize + cowpea 1:1 (I_2) and maize + berseem 1:1, (I_3). during both the years as well as mean basis too this might be due to complimentary effect of lucerne through better symbiotic system which increase quantity and availability of nitrogen. Similar, results were observed by Krishna *et al.* (1998)

It is quite clear from the table that the significantly maximum dry matter yield of maize alone *viz*., 96.61 and 98. 99 q ha^{-1} , dry matter yield of legume intercrops *viz*., 29.30 and 30.76 q ha^{-1} and total dry matter yield of maize + legumes *viz*., 125.91 and 129.75 q ha^{-1} during first and second year, respectively was recorded under the treatment which received 50% RFD + 10 tonnes FYM + $ZnSO_4$, (N_4) over rest of the treatments except 50% RFD + 10 tonnes MSC + $ZnSO_4$, (N_5) during both the years and mean basis. This might be due to plant get sufficient quantity of essential nutrients throughout their crop growth period by combine use of organic and inorganic source of fertilizers Similar results were also reported by Patel *et al.* (2002) and Sudhir *et al.* (2002)

Interaction effect

Intercropping and integrated nutrient supply interacted significantly with respect to total green fodder yield of maize + legumes at harvest are presented in table 2. It is quite clear from the table that significantly maximum total green fodder yield of 742.31 q ha^{-1} on pooled mean basis was recorded when maize intercropped with berseem 1:1, (I_3) and supplemented with 50% RFD + 10 tonnes FYM + $ZnSO_4$, (N_4) as compared to other treatment combinations, however, it was remained statistically at par with treatment combination of I_3 N_5 (I_3 - Maize + berseem, 1:1 and N_5 - 50% RFD + 10 tonnes MSC + $ZnSO_4$,) on pooled mean basis.

Maize equivalent yield

The data on maize equivalent yields as affected by different treatments are presented in table2. It is evident from the data in table that, in general, higher maize equivalent yield was recorded in second year as compared to first year. The maize equivalent yield of intercropping recorded significantly higher value with maize + legumes intercropping as compare to sole maize (I_1). Among the intercropping of maize with legumes the maize + berseem 1:1, (I_3) was recorded maximum maize equivalent yield *viz.*, 702.37 and 721.34 q ha^{-1} during first and second year, respectively were significantly higher over rest of the treatments. The minimum maize equivalent yield *viz.*, 419.66 and 429.33 q ha^{-1} was recorded under sole maize, (I_1) during both the years of experimentation. This might be due to additional green fodder yield obtained from legumes under intercropping system and higher price rate of legumes i.e. Rs. 100 q^{-1} as compared to maize Rs. 85 q^{-1}**.** Similarly, Balyan (1997) reported that significantly higher maize equivalent yield in intercropping as compared to sole maize.

It is quite clear from the table that the trend was similar for all the treatments during both the years of investigation. Significantly maximum maize equivalent yield *viz.,* 650.93 and 670.25 q ha^{-1} were recorded with the application of 50% RFD + 10 tonnes FYM + $ZnSO_4$, (N_4) during first and second year respectively over rest of the treatments except 50% RFD + 10 tonnes MSC + $ZnSO_4$, (N_5). The minimum maize equivalent yield *viz.,* 369.81 and 383.24 q ha^{-1} was noticed under control plot (N_0) during both the years. This might be attributed to increased availability of macro and micro nutrients, favorable soil conditions and better nutrition for entire growth period under this integration leading to higher production of fodder yield of both the crops. Similar results were reported by Skekinath *et al.* (2004) and Deshmukh *et al.* (2009).

Relative yield equivalent ratio

It is quite clear from the table 3 that the maize + legumes intercropping significantly influenced the relative yield equivalent ratio. In general second year of investigation recorded higher relative yield equivalent ratio as compared to first year. The maize + berseem 1:1, (I_3) recorded significantly higher relative yield equivalent ratio *viz.,* 162 (%) and 164 (%) as compared to rest of the treatments during both the years, respectively. This might be due to the compensated yields and best economical usage of land as evidenced by Elexander and Genter *et al.* (1962).

Relative yield equivalent ratio did not significant influence with the treatments of integrated nutrient supply. But maximum relative yield equivalent ratio was recorded with application of 50 % RFD + 10 tonnes FYM + $ZnSO_4$ (N_4).

Table 1. Total green fodder and dry matter yield of fodder maize + legume intercrops as influenced by intercropping and integrated nutrient supply.

Treatment	Total Green Fodder Yield (q/ha)			Total Dry Matter Yield (q/ha)		
	2008-09	**2009-10**	**Mean**	**2008-09**	**2009-10**	**Mean**
Intercropping						
I1 - Maize Sole	419.66	429.33	424.50	80.49	83.94	82.21
I2 - Maize + Cowpea (1:1)	544.70	568.86	556.28	106.12	111.45	108.78
I3 - Maize + Berseem (1:1)	662.52	680.10	671.31	128.07	131.09	129.58
I4 - Maize + Lucerm (1:1)	637.56	656.44	647.00	128.54	133.88	131.21
SEm	**3.80**	**4.07**	**3-93**	**1.90**	**2.56**	**2.23**
CD (P=0.05)	**13.16**	**14.13**	**13.64**	**6.58**	**8.87**	**7.73**
Integrated Nutrient Supply (NPK kg ha^{-1})						
N0 - Control						
N1 - RFD	335.36	367.52	341.44	68.53	73.10	70.82
N2 - 50% RFD + 10 tonnes FYM	583.18	602.61	592.90	114.38	118.40	116.39
N3 - 50% RFD + 10 tonnes MSC	608.69	627.16	617.93	117.89	122.48	120.19
N4 - 50% RFD + 10 tonnes FYM + Znso4	603.94	622.92	613.85	115.50	120.09	117.79
N5 - 50% RFD + 10 tonnes MSC + Znso4	626.96	648.66	635.82	125.91	129.75	127.84
SEm	617.69	638.72	626.71	122.60	126.70	124.65
CD (P=0.05)	**3.97**	**4.03**	**3.99**	**1.67**	**1.75**	**1.71**
Interation (I* N)	**11.34**	**11.50**	**11.42**	**4.78**	**5.0**	**4.89**
	S	**S**	**S**			

Table 2. Interaction effect of integrated nutrient supply and intercropping on total green fodder yield of fodder maize + legumes intercropping system.

Intercropping / Integrated Nutrient Supply	Pooled mean of Total Green fodder yield (q ha^{-1})			
	I1	I2	I3	I4
N0	270.00	357.08	423.30	395.40
N1	440.00	568.78	693.71	669.10
N2	454.50	597.97	720.88	698.38
N3	451.33	592.79	717.37	693.90
N4	469.16	614.73	742.31	717.07
N5	462.00	606.34	730.29	708.29
Interaction (I×N)	N at same level of I		N at same level of I	
SEm	6.64		6.99	
CD (P=0.05)	18.98		21.27	

Table 3. Maize equivalent yield and Relative yield equivalent ratio of fodder maize + legume intercrops as influenced by intercropping and integrated nutrient supply.

Treatment	Maize equivalent yield			Relative yield equivalent ratio		
	2008-09	**2009-10**	**Mean**	**2008-09**	**2009-10**	**Mean**
Intercropping						
I1 - Maize Sole	419.66	429.33	424.50	100.00	100.00	100.00
I2 - Maize + Cowpea (1:1)	564.84	590.22	577.53	135.00	137.00	136.00
I3 - Maize + Berseem (1:1)	702.37	721.34	711.86	162.00	164.00	163.00
I4 - Maize + Lucerm (1:1)	671.74	692.38	682.05	154.00	155.00	154.00
SEm	**4.14**	**4.19**	**4.19**	**0.70**		**0.80**
CD (P=0.05)	**13.35**	**13.72**	**13.53**	**0.70**		
Integrated Nutrient Supply (NPK kg ha^{-1})				**2.30**	**3.00**	**2.70**
N0 - Control						
N1 - RFD	369.81	383.24	376.53			
N2 - 50% RFD + 10 tonnes FYM	607.68	628.34	618.00	136.00	137.00	137.00
N3 - 50% RFD + 10 tonnes MSC	631.24	651.07	641.15	138.00	139.00	139.00
N4 - 50% RFD + 10 tonnes FYM + Znso4	627.13	646.43	636.78	138.00	139.00	138.00
N5 - 50% RFD + 10 tonnes MSC + Znso4	650.93	670.25	660.58	138.00	138.00	138.00
SEm	641.12	660.58	650.85	139.00	140.00	140.00
CD (P=0.05)	**4.25**	**4.47**	**4.36**	138.00	139.00	139.00
	12.15	**12.79**	**12.46**	**1.4**	**1.3**	**1.3**
				NS	**NS**	**NS**

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RESEARCH ARTICLE

YIELD PERFORMANCE OF TIKHUR (*CURCUMA ANGUSTIFOLIA* ROXB.) GENOTYPES IN NARAYANPUR DISTRICT OF CHHATTISGARH

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Abstract : The investigation was undertaken during the year of kharif season 2014-15 and 2015-16 at demonstration farm of KVK, Narayanpur. The experiment was laid out in Randomized Complete Block Design (RCBD) and experiment was conducted for evaluation of six genotypes of Tikhur (IGSJT-10-1, IGSJT-10-2, IGBLT-10-1, IGBT-10-4, IGDMT-10-1 and Local Check) with three replications. The genotypes were grown randomly in each replication/block in a total of 18 plots of 3.0 m x 2.4 m each containing 60 plants per plot and planting spacing was 60 x 20 cm. Observations were recorded from ten randomly selected sample plants in each treatment and observed mean value used for statistical analysis. The result revealed that the maximum rhizome weight (327.5 g plant^{-1}) maximum rhizome yield (27.30 t ha^{-1}) and starch recovery 14.29 per cent was recorded in genotype IGSJT-10-2 and followed by IGSJT-10-1. On the basis of experimental results of two years pooled data the genotype IGSJT-10-2 may be recommended to farmers of Narayanpur district for commercial production.

Keywords: Tikhur, *Curcuma angustifolia* Roxb., Rhizome yield, Starch recovery per cent MLT

INTRODUCTION

Tikhur (*Curcuma angustifolia,* family Zingiberaceae) is a rhizomatous herb also known as white turmeric or East Indian Arrowroot. It's cultivation has now been undertaken by the farmers of Bastar on a large area. Tikhur cultivated as medicinal crop in many parts of the state under moist deciduous mixed and *sal* forest of Madhya Pradesh, Chhattisgarh and Jharkhand. It is generally propagated by rhizomes and good source of starch and fibre (Misra and Dixit, 1983). Tikhur is also found in central province, Bihar, Maharashtra and Southern part of India. In undivided Madhya Pradesh, it is widely distributed in Bastar, Balaghat, Chhindwara, Surguja, Bilaspur, Raipur & Mandla districts (Kirtikar and Basu, 1918). In Chhattisgarh, it is found abundantly in the hilly tracts and forests of Bastar, Dantewada, Bijapur, Narayanpur, Kanker, Rajnandgaon, Kawardha, Dhamtari, Bilaspur, Raipur, Korba, Korea and Surguja districts. The total collection of tikhur rhizome as a minor forest produce in Chhattisgarh is 1,90.00 tonnes. Bastar and Bilashpur divisions are the major potential area of the state for tikhur (Anonymous, 2005).

The farmers of Chhattisgarh reside vicinity to the forest, collect naturally grown tikhur rhizomes as a minor forest produce and some farmers grown commercially in their kitchen garden and *badi* farming system. Farmers grown unidentified locally available genotypes of tikhur for rhizome production and doing processing of rhizomes through traditional method for starch extraction. Farmers yielded less starch due to lack of improved and high starch yielding genotype.Very little information is available regarding this crop especially collection and evaluation under agro-climatic condition of Chhattisgarh. These kinds of work would ensure *ex-situ* conservation of tikhur plants, besides the economical up scaling of farmers and the augmentation of supply of raw material to pharmaceutical industries.

Looking to the importance of the crop for people of the Chhattisgarh an investigation entitled "Yield Performance of Tikhur (*Curcuma angustifolia* Roxb.) genotypes under Multilocational Trial in Narayanpur District of Chhattisgarh" was conducted with the objectives *viz.* to study the performance of different genotypes of tikhur for growth, rhizome and starch yield.

MATERIAL AND METHOD

The present investigation was conducted at Krishi Vigyan Kedra Farm (IGKV), Narayanpur, Bastar, Chhattisgarh during *Kharif* seasons of 2014-15 and 2015-16. Six genotypes of Tikhur were provided from SG CARS, AICRP on Tuber Crops under MLT for evaluation of the genotypes in Narayanpur district of Chhattisgarh.

The experiment was laid out in Randomized Complete Block Design (RCBD) with 6 genotypes of tikhur with three replications. The experimental field was prepared by two ploughing upto a depth of 30 cm and FYM thoroughly mixed with soil as pH of soil was slightly basic in nature. Raised 30 cm planting beds as plot was made to overcome water logging condition and prepared proper drainage channels.

Farm yard manure was applied 20 tones/ha and N: 40 kg/ha, P_2O_5: 20 kg/ha, K_2O: 40 kg/ha during the crop season. Full dose of FYM mixed in plots during field

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preparation. Half dose of N and full dose of P and K was mixed in the plots before planting (basal dose) and remaining half dose was applied 45 days after planting during intercultural operation and earthing-up for better rhizome yield. The genotypes were grown randomly in each replication/block in a total of 18 plots of 3.0 m x 2.4 m each containing 60 plants per plot and spacing was 60 x20 cm. The crop was grown under rainfed conditions for 6 months. All the observations were taken from sprouting of rhizomes and up to maturity. The harvested rhizomes were cleaned up and mother rhizomes and finger rhizomes were separated. Grwoth observations were taken during maturity of the crop and rhizome yield and starch recovery observations were taken after harvesting of the rhizome.

RESULT AND DISCUSSION

The results of Performance of Tikhur (*Curcuma angustifolia* Roxb.) genotypes under Multilocational Trial in Narayanpur District of Chhattisgarh are presented in Table 1 to 3. The mean performance of genotypes for total rhizome yield t/ha, starch recovery (%) and its component characters (Table 1, 2 & 3) for the year 2014-15, 2015-16 and pooled mean of both the years are described below.

Highest plant height (141.67 cm) was observed in genotypes IGDSJT-10-1 followed by IGDMT-10-1 (141.23 cn) and lowest plant height (83.27 cm) was observed in Local Check during the year 2014-15. Highest plant height (75.53 cm) was observed in genotypes IGDSJT-10-1 followed by IGDMT-10-1 (72.80 cm) and ITSJT-10-2 (69.00 cm) lowest plant height (45.07 cm) was observed in IGBLT-10-1 during the year 2015-16. Plant height ranged from 66.60 cm (Local Check) to 108.60 cm (IGSJT-10-1) average of both the years 2014-15 and 2015-16.

Maximum number of leaves per plant (13.53) was recorded in Local Check followed by IGSJT-10-1 (12.87) and minimum was 10.93 in genotype IGSJT-10-2 during the year 2014-15. Maximum number of leaves per plant (8.67) was recorded in Local Check followed by IGSJT-10-1 (7.47) and minimum was 5.33 in genotype IGSJT-10-2 during the year 2015-16. Number of leaves per plant ranged from 8.13 (IGSJT-10-2) to 11.10 (Local check) average of both the years 2014-15 and 2015-16.

The maximum rhizome weight per plant (334 g) was recorded in entry IGSJT-10-2 and lowest rhizome weight per plant (219 g) was recorded in Local Check during the year 2014-15. The maximum rhizome weight per plant (321 g) was recorded in entry IGSJT-10-2 and lowest rhizome weight per plant (206 g) was recorded in Local Check during the year 2015-16. The rhizome weight per plant ranged from 327.50 (IGSJT-10-2) to 212.50 (Local Check) average of both the years 2014-15 and 2015-16.

The highest rhizome yield (27.85 t. ha^{-1}) was recorded in entry IGSJT-10-2 followed by IGSJT-10-1 (26.13 t. ha^{-1}) and lowest rhizome yield (18.26 t. ha^{-1}) was recorded in Local Check during the year 2014-15. The highest rhizome yield (26.75 t. ha^{-1}) was recorded in entry IGSJT-10-2 followed by IGSJT-10-1 (25.44 t. ha^{-1}) and lowest rhizome yield (17.19 t. ha^{-1}) was recorded in Local Check during the year 2015-16. The rhizome yield t. ha^{-1} ranged from 27.30 (IGSJT-10-2) to 17.70 (Local Check) which is average of both the years 2014-15 and 2015-16.

The highest starch recovery per cent (14.38 %) was recorded in entry IGSJT-10-2 followed by IGSJT-10-1 (13.38 %) and lowest was (8.92 %) was recorded in Local Check during the year 2014-15. The highest starch recovery per cent (14.20 %) was recorded in entry IGSJT-10-2 followed by IGSJT-10-1 (12.93 %) and lowest was (8.52 %) was recorded in Local Check during the year 2015-16. The starch recovery per cent ranged from 14.29 % (IGSJT-10-2) to 8.72 % (Local Check) which is average of both the years 2014-15 and 2015-16.

The variation in growth characters like Plant heitht & number of leaves perplant, total rhizome yield tonne per ha and starch recovery per cent might be due to genetic makeup of plant genotype which expresses their own character. Similar results were observed by Dhandar and Varde (1980), Philip and Nair (1983), Pushkaran *et al.* (1985), Pujari *et al.* (1987), Pathania *et al.* (1988), Nandi (1990), Indiresh *et al*. (1990), Maurya (1991), Latha *et al*. (1994), Latha *et al.* (1995), Patil *et al*. (1995), Radhakrishnan *et al*. (1995), Gangadharan *et al*. (1997), Lynrah and Chakrabarty (2000), Sabu (2006) in Curcuma species, Vimala (2002) in starchy curcuma species and Anonymous (2008) in Cassava.

CONCLUSION

The genotypes IGSJT-10-2 and IGSJT-10-1 observed the highest rhizome yield tonne per ha and starch recovery per cent as well as mean performance under yield attributing characters of plant and rhizome for plant height, number of leaves per plant, rhizome weight per plant, total rhizome yield t.ha^{-1} and starch recovery per cent as compared to local check.

Table 1. Performance of Tikhur genotypes under MLT during: 2014-15

S. No.	Name of Genotype/ Variety	Plant height (cm)	No. of leaves $Plant^{-1}$	Rhizome weight $plant^{-1}$ (g)	Rhizome yield $t.ha^{-1}$	Starch Recovery (%)
1.	IGSJT-10-1	141.67	12.87	314	26.13	13.38
2.	IGSJT-10-2	89.21	10.93	334	27.85	14.38
3.	IGBLT-10-1	103.21	11.53	231	19.21	10.39

4.	IGBT-10-4	91.37	11.07	270	22.49	9.58
5.	IGDMT-10-1	141.23	12.33	241	20.06	9.36
6.	Local Check	83.27	13.53	219	18.26	8.92
	CD (at 5 %)	6.022	1.510	5.559	2.231	0.68
	SEm±	1.887	0.473	1.742	0.699	0.213
	CV %	3.017	6.804	1.125	5.442	3.356

Table 2. Performance of Tikhur genotypes under MLT during: 2015-16

S. No.	Name of Genotype/ Variety	Plant height (cm)	No. of leaves Plant^{-1}	Rhizome weight plant^{-1} (g)	Rhizome yield t.ha^{-1}	Starch Recovery (%)
1.	IGSJT-10-1	75.53	7.47	305	25.44	12.93
2.	IGSJT-10-2	69.00	5.33	321	26.75	14.20
3.	IGBLT-10-1	45.07	6.80	318	18.55	10.05
4.	IGBT-10-4	61.37	5.66	257	21.39	9.64
5.	IGDMT-10-1	72.80	6.27	229	19.05	9.13
6.	Local Check	49.60	8.67	206	17.19	8.52
CD (at 5 %)		**5.46**	**1.114**	**5.08**	**3.723**	**2.012**
SEm±		**1.71**	**0.394**	**1.59**	**1.167**	**0.63**
CV %		**4.75**	**9.021**	**2.13**	**9.44**	**10.16**

Table 3. Mean Performance of Tikhur genotypes under MLT (Pooled Mean: 2014-15 & 2015-16)

S. No.	Name of Genotype/ Variety	Plant height (cm)	No. of leaves Plant^{-1}	Rhizome weight plant^{-1} (g)	Rhizome yield t.ha^{-1}	Starch Recovery (%)
1.	IGSJT-10-1	108.60	10.17	309.50	25.79	13.16
2.	IGSJT-10-2	79.11	8.13	327.50	27.30	14.29
3.	IGBLT-10-1	74.14	9.17	274.50	18.88	10.22
4.	IGBT-10-4	76.37	8.37	263.50	21.94	9.61
5.	IGDMT-10-1	107.02	9.30	235.00	19.56	9.25
6.	Local Check	66.44	11.10	212.50	17.73	8.72
Range		**108.60-66.60**	**11.10-8.13**	**327.50-212.50**	**27.30-17.70**	**14.29-8.72**

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SHORT COMMUNICATION

ASSESSMENT OF KNOWLEDGE GAP ABOUT ORGANIC FARMING ASPECT, FACTS AND PRACTICES OF FARMERS OF RAMPUR DISTRICT OF UTTAR PRADESH

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Abstract: The study was undertaken to access the knowledge gap of organic farming practices of farmers of Rampur district. Out of six blocks, three blocks selected purposively for this study. Four villages selected from each block thus, total twelve villages were selected randomly. From these villages five organic practicing farmers were selected by simple random techniques. Thus there were total sixty numbers of farmers were selected. The data were collected with the help of structured interview schedule. From this analysis data, it was concluded that majority (43.34%) of farmers had high knowledge level of organic farming practices. The wide knowledge gap are in the areas of organic farming practices like use of HaNPV (46.66%), use of trichocards (42.50%), use of bio pesticides (37.50%), use of bio fertilizers (34.16%), use of NADEP compost (31.66%) and use of mechanical cultivation (29.16%). The overall knowledge gap of farmers in organic farming practices were 31.95 percent.

Keywords: Knowledge gap, Organic farming practices, Farmers, Rampur district

INTRODUCTION

In India, organic farming has received considerable attention and the Government of India emphasized to give boost to organic farming in rain fed areas and in the area of limited use of agricultural chemicals especially in North- Eastern states. It is estimated that there is around 76,00 ha of certified organic food at the farm level and 2.4 million ha of certified forest area for collection of wild herbs in India, but the actual area under organic is much more. (Kumar and Singh, 2009).

Organic farming is a production system which avoids or largely excludes the use of synthetic compounded fertilizers, pesticides, growth regulators and livestock feed additives. Organic farming does not imply the simple replacement of synthetic fertilizers and other chemical inputs with organic inputs and biologically active formulations. Instead, it envisages a comprehensive management approach to improve the health of underlying productivity of the soil air and water exist in a stage of dynamic equilibrium and regulate the ecosystem processes in mutual harmony by complementing and supplementing each other. Organic farming does not totally exclude the elements of modern agriculture. Present studies were undertaken to assess the knowledge gap of organic farming practices of farmers of Rampur district of Uttarpradesh.

METHODOLOGY

The present study was conducted in Rampur district of Uttar Pradesh. Out of 6 blocks three blocks namely Milak, Swar and Sahabad were selected randomly. Four villages selected from each block for this study. Thus total twelve villages were selected randomly from these villages. Five organic practicing farmers were selected by simple random sampling technique for the study purpose by proportional allocation method. Thus there were total sixty no of farmers were selected. To measure the knowledge gap of farmers they were asked to different question knowledge about concept of organic farming, use of bio fertilizers, vermicompost, use of bio pesticides, use of organic manure and crop residues, use of mechanical cultivation, use of HaNPV, use of NADEP compost and use of trichocards. The following device was developed to measure the knowledge of farmers of on the basis of organic farming practices.

$$\text{Knowledge} = \frac{\text{Total obtained knowledge scores}}{\text{Maximum obtained knowledge scores}} \times 100$$

RESULT AND DISCUSSION

Knowledge level

Knowledge is defined as the set of concepts meanings, skilled and routines developed overtime by individuals and group through processing of information. Once the knowledge is required. It also brings about changes in overt behavior such as adoption, knowledge level of farmers refer to the information they posses in respect of organic farming practices.

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Table 1. Distribution of farmers according to their knowledge level about organic farming Practices.

Sl. No.	Category of Knowledge	Frequency	Percentage
1.	Low	14	23.33
2.	Medium	20	33.33
3.	High	26	43.34

It is clear from table 1 that majority (43.34%) of farmers had high knowledge level of organic farming practices followed by 33.33 percent had medium and 23.33 percent had low knowledge level of organic farming practices. Similar findings were also reported by Sahu (2010) and Naik *et.al.* (2009).

Table 2. Knowledge gap of farmers on the basis of the organic farming practices.

Sl. No.	Organic farming practices	Maximum Knowledge Score	Total obtained Knowledge (Score)	Knowledge Gap (Percentage)	Rank
1.	Knowledge about concept of organic farming	120	99	17.50	IX
2.	Use of bio-pesticides	120	75	37.50	III
3.	Use of organic manure and crop residues	120	89	25.83	VII
4.	Use of mechanical cultivation	120	85	29.16	VI
5.	Use of Vermicompost	120	93	22.50	VIII
6.	Use of bio-fertilizers	120	79	34.16	IV
7.	Use of HaNPV	120	64	46.66	I
8.	Use of NADEP compost	120	82	31.66	V
9.	Use of trichocards	120	69	42.50	II
	Over all knowledge gap	**1080**	**735**	**31.95**	

The data presented in table 2 reveals that overall knowledge gap of the farmers in organic farming practices were 31.95 percent respectively. As reported by the farmers, the major contributing practices for this knowledge gap were use of HaNPV (46.66%) followed by use of trichocards (42.50%), use of bio-pesticides (37.50%), use of bio fertilizers (34.16%), use of NADEP compost (31.66%), use of mechanical cultivation (29.16), use of organic manure and crop residue (25.83%), use of Vermicompost (22.50%) and knowledge about concept of organic farmers (17.50%). These finding were found to be practically supported by reports of Sahu et.al. (2010), Singh (2007) and Kirar and Mehta (2009).

CONCLUSION

It may be concluded that majority of farmers were found in the range of high level of organic farming practices. The wide knowledge gaps are in the areas of organic farming practice like use of HaNPV, use of trichocards, use of bio-pesticides, use of bio-fertilizers, use of NADEP compost and use of mechanical cultivation. The farmers need to be made well aware about the use of such practices, so that the basic concept of organic farming and its application part could be familiar to the farmer.

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SHORT COMMUNICATION

SCREENING OF LINSEED GENOTYPES AGAINST BUD FLY, *DASYNEURA LINI* (BARNES) IN SURGUJA OF CHHATTISGARH

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Abstract : Fifty four linseed genotypes were screened among them one genotype ie RLC-133 was found resistant however other eighteen genotypes viz- R-4226, R-4231, R-4234, R-4236, R-4237, R-4239, R-4240, R-552, RLC-92, RLC-133, R-4230, R-4232, R-4226, R-4233,R-4237,-4238, RLC-92, RLC-133 were found moderately resistant and thirty fives genotypes R-4221, R-4229, R-4230, R-4232, R-4233, R-4235, R-4238, R-RLC-92, TA-32, R-4235, R-4236, R-4237, R-4238, R-4239, R-4240, R -552, IA-32, R-4226, R-4227, R-4229, R-4231, R-4233, R-4234, R-4227, R-4229, R-4230, R-4231, R-4232, R-4234, R-4235, R-4236, R-4239, R-4240, R-552, IA-32 were found susceptible.

Keywords: Linseed genotypes, Bud fly, Crop, Production

INTRODUCTION

Linseed is an important industrial oilseed crops of India. In India, linseed is cultivated in about 4.26 lakh hectares with a total linseed production of 1.67 lakh tonnes and 392 kg/ha productivity. Chhattisgarh is one of the important linseed growing states of India, which accounts for nearly 19.05 per cent area and 16.21 per cent production of the country. In Chhattisgarh, linseed is cultivated over 70 thousand hectare area with a production of 16.19 thousand tonnes and productivity of 231.31 kg/ha. Maximum area of this crop is grown as ‘utera’ during *rabi* season. The important linseed growing districts of Chhattisgarh are Rajnandgaon, Durg, Bilaspur, Kabirdham, Raipur, Dhamtari, Surguja, Kanker and Raigarh(Chhattisgarh). Linseed crop is attacked by a number of insect pests at various phases of its growth. Linseed bud fly *Dasyneura lini* Barnes with 88 per cent grain yield losses, is a key pests of this crop .

MATERIAL AND METHOD

The experiment was undertaken at Rajmohini Devi College of Agriculture & Research Station, Ambikapur of Indira Gandhi Krishi Vishwavidyalaya Raipur (C.G.) during 2015-16 to study the varietal screening for identify the resistance source against linseed bud fly. Fifty four linseed genotypes were screened under natural condition. Two lines of each genotypes were sown line to line 30 cm and plant to plant 15cm. On the basis of calculated data the bud fly infestation, the genotypes were categorized into five reactions *viz.* Resistant up to 10% ,Moderately Resistant (> 10-25%), Susceptible (> 25-50 %), Moderately susceptible (> 50-75 %) and Highly susceptible (> 75 %) . Individual plant was scored for budfly infection. In each plant buds infected by budfly (*Dasyneura lini*) were counted and percentage was taken from the total number of buds as follows (Reddy *et al.* 2013).

$$\text{Budfly infestation (\%)} = \frac{\text{Infested bud}}{\text{Total number of buds}} \times 100$$

RESULT AND DISCUSSION

Table 1 indicated that out of fifty four genotypes only one showed resistance ie RLC-133 however eighteen were showed moderately resistance R-4226, R-4231, R-4234, R-4236, R-4237, R-4239, R-4240, R-552, RLC-92, RLC-133, R-4230, R-4232, R-4226, R-4233,R-4237,-4238, RLC-92, RLC-133 and thirty fives genotypes ie R-4221, R-4229, R-4230, R-4232, R-4233, R-4235, R-4238, R-RLC-92, TA-32, R-4235, R-4236, R-4237, R-4238, R-4239, R-4240, R -552, IA-32, R-4226, R-4227, R-4229, R-4231, R-4233, R-4234, R-4227, R-4229, R-4230, R-4231, R-4232, R-4234, R-4235, R-4236, R-4239, R-4240, R-552, IA-32 showed susceptible against bud fly. However, moderately susceptible and highly susceptible were not found.

Earlier worker Prasad *et al.* (2004), Pal and Singh (2010) reported similar results in linseed. Biradar *et al* (2016) reported in intercrop (Linseed + chick pea) less bud fly infestation and Reddy *et al* (2013) more or less similar result in screening of linseed against bud fly.

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Table 1. Reaction of different linseed genotypes against bud fly

Reaction	**Linseed genotypes**
Resistant up to 10%	RLC-133
Moderately Resistant (> 10-25%)	R-4226, R-4231, R-4234, R-4236, R-4237, R-4239, R-4240, R-552, RLC-92, RLC-133, R-4230, R-4232, R-4226, R-4233,R-4237,-4238, RLC-92, RLC-133
Susceptible (> 25-50 %)	R-4221, R-4229, R-4230, R-4232, R-4233, R-4235, R-4238, R-RLC-92, TA-32, R-4235, R-4236, R-4237, R-4238, R-4239, R-4240, R -552, IA-32, R-4226, R-4227, R-4229, R-4231, R-4233, R-4234, R-4227, R-4229, R-4230, R-4231, R-4232, R-4234, R-4235, R-4236, R-4239, R-4240, R-552, IA-32
Moderately susceptible (> 50-75 %)	-
Highly susceptible (> 75 %)	-

CONCLUSION

It is concluded that the some genotypes of linseed were screened and found resistance and moderately resistance may be used for further screening of varietal trail against bud fly.

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