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REVIEW ARTICLE

ANDROGRAPHIS PANICULATA: A REVIEW ON ETHNOMEDICINAL POTENTIAL AND BIOLOGICAL ACTIVITIES

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Abstract: *Andrographis paniculata*Nees (Acanthaceae) the 'Kalmegh' of Ayurveda is an erect annual herb extremely bitter in taste. It is also known as 'BhuiNeem', since the plant though much smaller in size shows similar appearance and has bitter taste as that of Neem. Present review reflects its ethnomedicinal uses. Since ancient times. *A.paniculata* is used as a wonder drug in traditional Siddha, ayurvedic systems of medicine as well as in tribal medicine in India. The plant extract exhibits antityphoid and antifungal activities. Kalmegh is also reported to possess antihepatotoxic, antibiotic, antimalarial, antithrombogenic, antiinflammatory, antisnakevenom and antipyretic, anti HIV activity. As the dependance on herbal medication is increasing day by day, this review may be helpful for further research on this wonderful medicinal plant.

Keywords: *Andrographis*, Kalmegh, Antihepatotoxic, Antithrombogenic, Antiinflamatory

INTRODUCTION

Andrographis paniculata Nees, the kalmegh of Ayurveda belongs to family Acanthaceae is also known as king of bitters. It is also known as Bhui Neem since the plant shows similar appearance and has bitter taste as that of neem (*Azadirachta indica*). *Andrographis paniculata* is an erect annual herb extremely bitter in taste in each and every part of plant body. *Andrographis paniculata* plant extract is known to possess a variety of pharmacological activities it has been used in no. of disease as herbal ailment. The herb is well known for drugs as 'green chiretta' and forms the principle ingredient of a reputed house hold medicine 'alui'. *Andrographis paniculata* has immense potential for treating various diseases. This review present information about botanical description, distribution ethnomedicinal and pharmacological aspects of *Andrographis paniculata* which may be used as wonder full herbal drug. Since ancient time *A. paniculata* is used as wonder drug in traditional siddha in ayurvedic system as well as in tribal medicine in India and some other countries for multiple clinical applications. The therapeutic value of kalmegh is due to its mechanism of action which is by enzyme induction. The plant extract exhibit antityphoid, antifungal, antihepatotoxic, antibiotic, antimalarial, antithrobmogenic, anti-inflammatory, anti snake venom, anti-HIV activity. Recent studies confirm anti HIV activity of andrographolide, the main alkaloid found in *Andrographis paniculata*.

Distribution

Andrographis paniculata is distributed in tropical Asian countries in isolated patches it can be found in a variety of habitats viz plains, hills slope, waste land, farms, dry or wets lands, sea shore and even roads sides. Native populations of *A.paniculata* are spread throughout South India. It prefers a sunny location the seeds are sown during May to June. The seedlings are transplanted at a distance of 60 cm X 30 cm. (Zhou *et al.*, 1987)

Botanical Description

Andrographis paniculata grows erect to a height of 32 to 100 cm in moist shady places with glabrous leaves and white flowers with rose-purple spots on the petals. Stem is dark green 0.3 to 1.0 m in height, 2 to 6mm in diameter, quadrangular with longitudinal furrows and wings on the angle younger parts, slightly enlarged at the nodes: Leaves glabrous up to 8.0 cm long and 2.5 cm broad lanceolate, pinnate. Flowers are small, possess calyx with five sepals which are small and linear, corolla tubes are narrow, about 6mm long, bilabiate upper lip oblong, lower tips are broad , three lobed, white with violet markings. Stamens 2, inserted in the throat. Flower is hypogynous.Fruit is a capsule, compressed longitudinally furrowed with thin glandular hairs. Seeds are very small.

According to karyomorphological studies chromosome number is 2n= 50 (Govindarajan *et al*., 1983).

*Corresponding Author

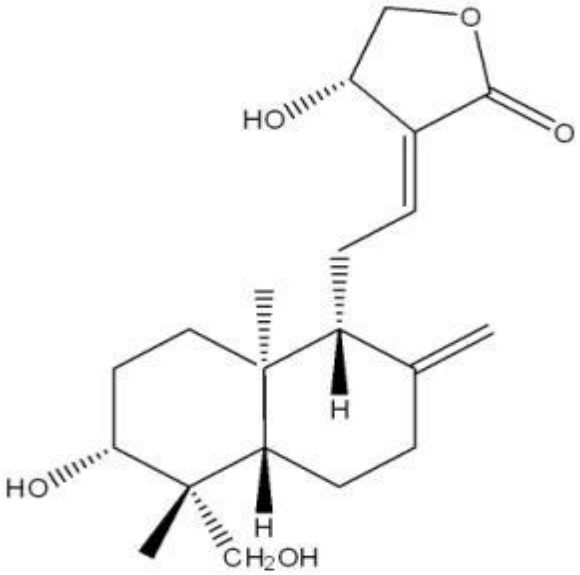
A Plant

Flowering Twig

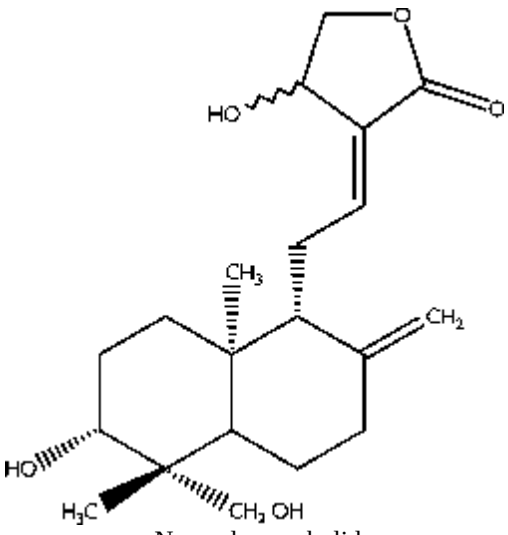
Andrographis paniculata

Chemical Composition of *Andrographis Paniculata*

It contains bitter diterpenoid lactones such as 14deoxyandrographolide (Sangalunkarn *et al.* and Garcia *et al*), andrographolide. Neoandrographolide (a non bitter derivative 14-deoxy11,12didehydroandrographolide identified by Dhammaupakorn *et al.* Du *et al*, separated andrographolide and neoandrographolide from the leaves of *Andrographis paniculata* using HPLC. Andrographolide content depends on collection time and growing region. Leaves of A.paniculata may contain more than 2% andrographolide before the plant blooms and less than 0.5% after blooming. The stem contains 0.1% to 0.4% of andrographolide . The best harvesting time is early autumn (Zhu *et al*). The other active chemical constituents include diterpene (Sharma *et al*) and flavonoids



Andrographolide



Neoandrographolide

Pharmacognosy

Andrographolide, chief constituent extracted from the leaves of the plant exhibited protective effects in carbon tetrachloride induced hepatopathy in rats (Handa and, 1990).This bitter principle was isolated in pure form by Gorter, 1911. Sharma, 1992. Andrographolide is also attributed with such other activities like liver protection under various conditions of treatment with galactosamine (Saraswati *et al*). paracetamol (Visen *et al* 1993) etc. The hepatoprotective action of andrographolide is related to activity of certain metabolic enzymes (Choudhury and Poddar 1984, 1985 ; Choudhury *et al*, 1987)

Several studies have been conducted on cellular processes and targets modulated by andrographolide treatment in human cancer and immune cells. andrographolide treatment inhibited the in vitro proliferation of different tumor cell lines representing various types of cancers. The compound exerts direct

anti cancer activity on cancer cells by cell cycle arrest at G0/G1 phase through induction of ell cycle inhibitory protein and decreased expression of cyclin dependent kinase 4 (CDK 4) . Immunostimulatory activity of andrographolide is evidenced by increased proliferation of lymphocytes and production of interleuk in 2. Andrographolide also enhance the tumor necrosis factor production resulting increased cytotoxic activity of lymphocytes against cancer cells which may contribute for its indirect anti cancer activity. These results suggest that andrographolide is an interesting phytochemical constituent with anti cancer and immunomodulator activity and hence has the potential for being developed as a cancer therapeutic agent. (Rajagopal *et al* 2003).

The herb is the well known drug kalmegh 'green chiretta' , and forms the principal ingredient of a reputed house hold medicine (alui) used as a bitter tonic and febrifuge. The herb is reported to possess astringent, and is helpful in arresting dysentery, cholera, diabetes, influenza, bronchitis, swellings and itches, piles and gonorrhea. A decoction of the plant is a blood purifier. It is used as a cure is for jaundice. It forms the major constituents of the Ayurvedic drug SG-1 Switradilepa which is effective for treating vitilago- a dermatological disease. The macerated leaves and juice together with certain spices, such as cardamom, clove and cinnamon, are made into pills and prescribed for relief from stomach ache other stomach ailments in infants. A decoction or infusion of the leaves Is useful in general debility and dyspepsia. The leaves and roots are also used as febrifuge, tonic, stomachic, cholagogue and anthelmintic.

Andrographis improves non specific immune response. The immune response maybe specific, directed at a microbial invader already present in the body or strengthening the immune system in preparation against future infections. *Andrographis* strongly stimulates phagocytosis and the production of specific antibodies. Following list shows various biological activities of *A. paniculata* Nees

Biological activities of *A. paniculata*

No	Biological Activity	References
1.	Anti allergic activity	Gupta et al., 1994
2.	Antibiotic activity	Gupta *et al*., 1993
3.	Anti fertility effects	Akbarsha *et*., 1990; Akbarsha and Murugan 2000
4.	Anti filarial activity	Dutta and Sukul, 1982
5.	Antifungal activity	Anonymous, 1982
6.	Anti hepatitis activity	Jayaram *et al.*, 1989; Ramfi *et al*., 1992
7.	Antihepatotoxic activity	Rana and Avadhoot, 1991, Honda *et al*, 1990
8.	Anti HIV activity	Shukla et al., 1992; Otake *et al*., 1995; Calabrese *et al* ., 2000, S. Rajagopal, 2003
9.	Antiinflammatory activity	Tajuddin *et al*., 1983; Shen *et al*., 2000
10.	Antimalarial activity	Misra *et al*., 1992
11.	Antisnakevenom effects	Selvanayagam *et al*., 1994, Samy *et a*l, 2008
12.	Antityphoid activity	Anonymous, 1985, Mishra *et al*, 2009
13.	Antiulcer activity	Viswanathan *et al* ., 1981
14.	Asthma	Rao, 1914
15.	Blood purification effects	Vohora, 1985
16.	Colic	Rao, 1914
17.	Diabetes	Ahmad and Asmawi, 1992; Zhag and Tan, 2000
18.	Diarrhea	Gupta e*t al*., 1990
19.	Fever	Ahmed and Asmawi, 1992
20.	Gonorrhea	Rao, 1914
21.	Hepatostimulation effect	Tripathi and Tripathi, 1991
22.	Immunostimul;ation effects	Sutarjadi *et al*., 1991; Puri *et al*., 1993
23.	Influenza	Dey, 1983
24.	Jaundice	Tomar *et al* ., 1983
25.	Loss of scalp hair	Home *et al*., 1992
26.	Piles	Rao, 1914
27.	Stomachic effect	Chaudhury and Poddar, 1985
28.	Leshmaniasis	Sinha *et al*., 2000

List of ethnomedicinal uses of *A. paniculata* nees

No.	Ethnonobotanical use	Reference
1.	Blood purification	Rao, 1914
2.	Cancer	Mathew and Unnithan, 1992
3.	Colic	Jain *et al., 1973*
4.	Diarrhoea	Aminuddin and Girach, 1991
5.	Dysentry and Dyspepsia	Sudhakar and Rao, 1985 Bhalla *et al*., 1982
6.	Fever	Gupta, 1990; Jain 1963; Bhalla *et al*., 1982
7.	Filariasis	Sudhakar and Rao, 1985
8.	Gastric complaints	Gupta, 1990
9.	Jaundice	Hemadri and Rao, 1984; Hemadri and Rao. 1989
10.	Malaria	Reddy, 1988; Aminuddin *et al*., 1993
11.	Snake bite	Gupta and Srivastava, 1994, Samy *et al*, 2008
12.	Stomach complaints	Kiritikar and Basu, 1918; Goel and Mudgal, 1988
13.	Vermifuge	Gupta and Srivastava, 1994
14.	Whooping cough	Goel and Mudgal, 1988
15.	Wounds and itches	Jain, 1963; Jain *et al*., 1973

CONCLUSION

After reviewing the available literature it can be concluded that *A. Paniculata* has great potential as antiallergic, antimicrobial, antihepatotoxic, antifever remedy. The plant may be a constituent in various immunological applications for cancer. It is also beneficial for treating snake bites, abdominal problems. *Andrographis paniculata* can be advocated as herbal remedy for different human diseases. Further research would be helpful in assessment of more medicinal uses and possible adverse effects on human health

REFERENCES

Bhat, V.S., Nanavati, D.D. (1978) *Andrographis paniculata* (Burm) Wall ex Nees. *Indian Drugs* **15**: 187-190.

Cáceres, D.D., Hancke, J.L., Burgos, R.A., Wikman, G.K. (1997) Prevention of common colds with Andrographis paniculata dried extract. A Pilot double blind trial. Phytomedicine **4**: 101-104.

Calabrese, C, Berman, S.H, Babish, J.G, Ma, X, Shinto, L, *et al.* (2000) A phase I trial of andrographolide in HIV positive patients and normal voluntreers. Phytother Res **14**: 333-338.

Choudhury, R.B, Haque, S.J. and Poddar, M.K. (1987). In vitro and in vivo effects of kalmegh (*Andrographis paniculata*) extract and andropholide on hepatic microsomal drug metabolizing enzymes. *Planta Medica* **53**: 135-140.

Deng, W.L., R.J., Nie and J.Y., Liu (1982) Comparison of pharmacologicval effect of four andrographolidess. Chines Pharmacecutical Bulletin **17** : 195-198.

Dhamma-Upakorn, P., Chaichantipyuth, C., Pongjunyakul, P., Sangalungkarn, V., Chaimong Kol, S. (1992) Pharmocological active Substances from Andrographis paniculata Faculty of Pharmacy, Chulalongkon University, Bankok,21.

Dua, V.K, Verma, G, Dash, A.P. (2009) In vitro antiprotozoal activity of some xanthones isolated from the roots of Andrographis paniculata. Phytother Res **23**: 126-128.

Duke, J.A, Ayensu, E.S. (1985) Medicinal plants of China Algonac: Reference Publication; Inc., Michigan, **1**: 705.

Dutta, A., Sukul, N.C. (1982) Filaricidal properties of a wild herb, Andrographis paniculata. J Helminthol **56**: 81-84.

Govindarajan, T. and Subramanian, D. (1983) Karyomorphological studies in South India Acanthaceae. 491-504.

Gorter, M.K. (1911). The bitter constituent of *Andrographis paniculata* Nees. Rec Trav Chim **30**: 151-160.

Goel, S.R., Madan, V.K., Verma, K.K., Nandal, S.N. (2009) Nematicidal activity of various medicinal and aromatic plants under in vitro conditions. Indian Journal of Nematology **39**: 218-220.

Govindarajan, M. (2011) Evaluation of Andrographis paniculata Burm.f. (Family:Acanthaceae) extracts against Culex quinquefasciatus (Say.) and Aedes aegypti (Linn.) (Diptera:Culicidae). Asian Pac J Trop Med **4**: 176-181.

Gracia, L.L. Kintanar, Q.L., Fojus, F.R., Sison, F.M., Chua, N.G, *et al.* (1980) Pharmacologic studies on the leaves of Andrographis paniculata Nees plant grown in the Philipines Acta Medica Philippina **16**: 59-68.

Gupta, S., Choudhry, M.A, Yadava, J.N.S. (1990) Antidiarrioeal activity diterpenes of *Andrographis paniculata* (Kal-Megh) agent Escherichia coli enterotoxin in vivo models. International Journal of Crude Drug Research 283-284.

Gupta, V., Srivastava, V.K. (1995) Evaluation studies on kalmegh (*Andrographis paniculata* Nees) *Ind J Pl Resources Genet* **8**: 141-143.

Handa, S.S., Sharma, A. (1990) Hepatoprotective activity of andrographolide against galactosamine & paracetamol intoxication in rats.Indian J Med Res **92**: 284-292.

Handa, S.S. and Sharma, A. 1990. Hepatoprotective activity of andrographolide from *Andrographis paniculata* against carbontetrachloride. *JMed Res Ind* 92B: 276-283.

Joselin, J., Jeeva, S. (2014) Andrographis paniculata: A Review of its traditional uses, Phytochemistry and Pharmacology. *Med Aromatic Plants* 3: 169.

Jada, S.R., Matthews, C., Saad, M.S., Hamzah, A.S., Lajis, N.H., *et al.* (2008) Benzylidene derivatives of andrographolide inhibit growth of breast and colon cancer cells in vitro by inducing G(1) arrest and apoptosis. Br J Pharmacol **155**: 641-654.

Kligler, B.K., Ulbricht, C., Basech, E. et al. (2006) *Andrographis paniculata* for the treatment of upper respiratory infection: a systematic review by the natural standard research collaboration. **2**(1): 25-29.

Koteswara, Rao, Y., *et al.* (2004) Flavonoids and andrographolide from Andrographis paniculata. Phytocemistry **65**: 2317-2321.

Kumar, N.P., Vijayan, S.K., Dharsana, J.N., Seena, K.X., Anjana, A.K. (2012) Comparing the effect of antidiabeic activity of Andrographis paniculata, Salacia reticulate and Ocimum sanctum by in vitro screening. Asian J Pharm Clin Res **5**: 146-149.

Kumar, R.A., *et al.* (2004) Anticancer and immunostimulatory compounds from *Andrographis paniculata*. J Ethnopharmacol **92**: 291-295.

Li, W., Xu, X., Zhang, H., Ma, C., Fong, H., et al. (2007) Secondary metabolites from *Andrographis paniculata*. Chem Pharm Bull (Tokyo) **55**: 455-458.

Mishra, U.S. *et al.* (2009) Antibacterial activity of Ethanol Extract of *Andrographis paniculata, Indian J Pharm sci* **71***: 436-438.*

Mishra, P.K., Singh, R.K., Gupta, A., Chaturvedi, A., Pandey, R. *et al.* (2013) Antibacterial activity of *Andrographis paniculata* (Burm. F.)Wall ex Nees leaves against clinical pathogens. JPR **7**: 459-462.

Niranjan, A., Tewari, S.K., Lehri, A. (2010) Biological activities of Kalmegh (*Andrographis paniculata* Nees) and its active principles-A review. Ind J Nat Prod Resour **1**: 125-135.

Premanath, R., Devi, N.L. (2011) Antibacterial, antifungal and antioxidant activities of *Andrographis paniculata* Nees, leaves. International Journal of Pharmaceutical Sciences **2**: 2091-2099.

Puri, A., Saxena, R., Saxena, R.P., Saxena, K.C., Srivastava, V. *et al.* (1993) Immunostimulant agents from Andrographis paniculata. J Nat Prod **56**: 995-999.

Parvataneni, R. Koduru, R.L. (2010)Antimicrobial activity of the chloroform extracts of the root and the stem of Andrographis paniculata Nees Int Res. Microb **1**: 037-039.

Rajagopal, S., Kumar, R.A., Deevi, D.S., Satyanarayana, C., Rajagopalan, R. (2003) Andrographolide, a potential cancer therapeutic agent isolated from *Andrographis paniculata* .J Exp Ther Oncol **3**: 147-158.

Ramesh, P.M., Farooqui, A.A., Vasundhara, M. and Gowada, H.R. (1997). Influence of nutrients on the growth, yield and active principle content in kalmegh (*Andrographis paniculata* Nees). Souvenir-*National Conference on Health Care & Developement of Herbal Medicines. I.G.U, Raipur. 29-30.*

Roy, S., Rao, K., Bhuvaneswari, C., Giri, A., Mangamoori, L.N. (2010) Phytochemical analysis of Andrographis paniculata extract and its antimicrobial activity world J Microb Biotech **26**. 85-91.

Sharma, M., Joshi, S. (2011) Comparison of Anti-oxidant activity of *Andrographis paniculata* and Tinospora cordifolia leaves. J. Curr. Chem. Pharm. Sci **1**: 1-8.

Sivananthan, M., Elamaran, M. (2013) Medicinal and Pharmacological properties of *Andrographis paniculata*. International Journal of Biomolecules and Biomedicine **3**: 1-12.

Saggoo, M.I. (1983) Cytomorphological studies on plants of economic importance of bicarpellatea from India pp.259.

Sharma, A., Krishan, L., Hands, S.S. (1992) Stadardization of the Indian crude drug Kalmegh by high pressure liquid chromatographic determination of androgrpholide, Phytochemical Analysis **3**:129-131.

Sangalungkarn, V., Thummauppakorn, P., Kittiyanee, U., Chahantipyuth, C. (1990) The effect of andrographolide neoandrographolide and 14-deoxy-11, 12-dedehydro-andrographolide on the intestinal motility of white rat. Journal of Pharmaceutical Science **15**:5-7.

Shukla, B., Visen, P.K., Patnaik, G.K., Dhawan, B.N. (1992) Choleretic effect of andrographolide in rats and guinea pigs. Planta Med **58**: 146-149.

SCHRI (1973) Sichuan Chines Herbs Research Institute . Review of Chemical studies on A. Paniculata. Journal of New Medicinal and New Drugs 23-30

Sirisha, Mulukuri, N.V.L., Mondal, N.B., Raghu, Prasad, M., Renuka, S., Ramakrishna, K. (2011) Isolation of Diterpenoid Lactones from the Leaves of *Andrographis Paniculata* and Its Anticancer Activity. International Journal of Pharmacognosy and Phytochemical Research **3**:39-42.

Singha, P.K., Roy, S., Day, S. (2003) Antimicrobial activity of *Andrographis paniculata Fitoterapia* **74**: 692-694.

Samy, R.P., Thwin, M.M., Gopala, Krishnakone, P., Ignacimuthu, S. (2008) Ethnobotanical survey of folk plants for the treatment of snakebites in Southern part of Tamilnadu, *India. J Ethnopharmacol*. **115**: 302-312.

Sriram, Rajagopal, R., Ajaya, Kumar, Dhanvanthri, S., Deevi, Chitkala, Satyanarayana, R., Rajagopalan (2003). Andrographolide, a potential cancer therapeutic agent isolated from *Andrographis paniculata. Journal of Experimental Therapeutics and Oncology* **3**, *147.*

Tang, W., Eisenbrand, G. (1992) Chinese drugs of plant origin: chemistry, pharmacology and use in traditional and modern medicine. Springer-Vertag Germany.

Triphathi, K.D. (1999) Textbook of Pharmacology and experimental therapeutics.India: Vallabh Prakashan, First Edition.

Visen, P.K.S., Visen, G.K., Patnai and B.N., Dhawan (1993). Andrographolide protects rat hepatocytes against paracetamol- induced damage. *J Etopharhnmacology* **40**: 131-136.

Wen, W.C., Yueh, K.H., Fong, L.B. (2010) Antiinflammaorty activity of new compounds from *Andrographis paniculata* by NF-kB transactivation inhibition. J *Agric food Chem* **58**: 2505-2512.

Zhou, Z. (1987). Cultivation of Andrographis paniculata. Chung Yao Tung Pao 12: 15-18.

Zhang, CY., Tan, B.K. (1996) Hypotensive activity of aqueous extract of *Andrographis paniculata* in rats. Clin Exp Pharmacol Physiol **23**: 675-678.

Zhang, X.F., Tan, B.K. (2000) Antihyperglycemic and anti-oxidant properties of *Andrographis paniculata* in normal and diabetic rats. Clin Exp Pharmacol Physiol **27**: 358-363.

Zhao, H.Y., Fang, W.Y. (1991) Antithrombotic effects of Andrographis paniculata nees in preventing myocardial infarction. Chin Med J (*Engl*). **104**: 770-775.

Zhu, Peng, N.B., Jiang, W.J. (1984) TLC-UV spectrophotometric determination of andrographolide in the leaves and stem of Andrographis paniculata. Chinese journal of Pharmaceutical Analysis **4**: 34-36.

RESEARCH ARTICLE

SEASONAL PROFILE OF SOIL SPORE BANK OF FERNS IN A SEMI-NATURAL FOREST OF HOOGHLY DISTRICT, WEST BENGAL, INDIA AND ITS IMPLICATION IN CONSERVATION

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Abstract: The vertical structures of live and total fern spore banks were studied during summer, rainy, and winter seasons in a semi-natural forest situated at Mankundu region (22.885877, 88.391903 and 22.848333, 88.342603) of Hooghly District, West Bengal, India. A reservoir of vertically distributed live fern spore bank (LFSB) is established in the region. However, not all the spores present in soil samples could retain their viability for germination to establish gametophytic generation and subsequently sporophyte formation. The best reservoirs are 0-5 cm soil depth in summer and rainy seasons; while, 5-10 cm in winter. The sporophytic plants developed from gametophytes through *in vitro* soil culturing have adapted successfully in natural environment, and fulfilled the objective for establishing fern conservation through natural soil spore bank study.

Keywords: Mankundu, Spore germination, Prothallial development, Sporophytic generation, *Ex situ* conservation

INTRODUCTION

Natural spore bank of ferns is a biotic component having potentiality for *in situ* conservation and regeneration processes of the fern community (Dyer 1992, 1994; Dyer and Lindsay 1996; Simabukuro *et al.* 1998, 1999; Ranal 2003; Ramirez-Trezo *et al.* 2004). The bank can be enriched each year by adding new spores in the soil or can also be worn out by spore depletion from the soil due to predation, loss of spore viability, anthropogenic activities, among others. The major advantages of such conservation technique are easy way for soil collection throughout the year and cost effective culturing method in suitable growing conditions. The collected soil samples can be stored for several years and used later on for raising sporophytic plants through germination of viable spores present in the soil. Besides conservation aspects, the soil spore bank has significant role in the natural life cycle of a fern by maximizing the scope for spore germination time and minimizing the risk for extinction of population, if any. Even it can enhance or modify the fern breeding system as a soil spore bank has chance to contain more than one type of spores mostly. The objective of the work is to establish the natural soil spore bank of ferns in West Bengal. Such endeavour is vital for fern conservation in India (Gupta *et al.* 2014) and from available literatures it seems that such reports are lacking. Present investigation is an attempt to explore soil spore bank of ferns seasonally in a semi-natural forest of Hooghly district of West Bengal, India.

MATERIAL AND METHODS

Sampling

Sampling was carried out in two sites (I and II) of a semi-natural forest situated at Mankundu region (22.885877, 88.391903 and 22.848333, 88.342603) of Hooghly District, West Bengal, India (Fig. 1a). Sampling was done in three seasons namely summer, rainy, and winter by soil coring method up to the depth of 25 cm from surface at regular interval of 5 cm. Physical and chemical analyses of soil revealed sandy soil with pH ranging from 6.82 to 8.15 and per cent of total organic matter (OM) from 2.76 to 4.82.
Three replicates from each sample were made to obtain result up to the level of specificity. Precautions were taken to minimize contamination of the soil by airborne spores at all the stages. The soil collected from each depth was analyzed in two ways for getting total fern spore count (TFSC) and live fern spore count (LFSC) in the soil by palynological and soil culturing techniques, respectively.

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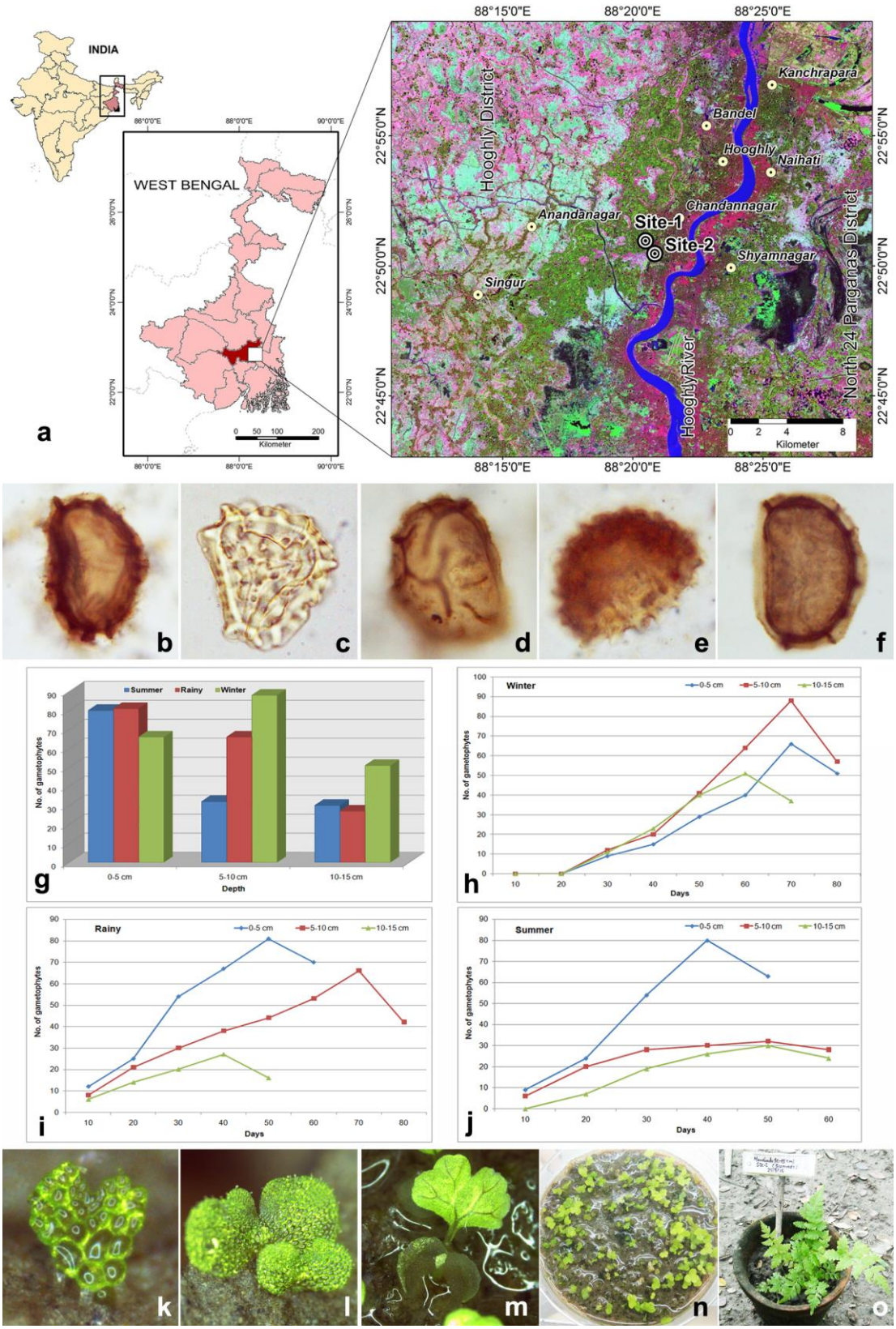

Figure Legends

Fig. 1 (a) Map of West Bengal depicting study area (*marked in black and white circles*); **(1b-f)** recovered spores in soil samples: **(b)** *Diplazium esculentum*, **(c)** *Pteris vittata*, **(d)** *Christella dentata*, **(e)** *Tectaria* sp. **(f)** *Pyrossia lanceolata*; **(1g)** depth wise seasonal variation in LFSB profile; **(1h-j)** number of gametophytes developed at different soil depths in three seasons; **(1k-o)** stages of gametophytic (*in vitro*) and sporophytic (*ex situ*) development from laboratory to field conditions.

Table 1. TFSC profile from different soil depths in studied area

Study area	Type of spores	Frequency distribution of spores (%) (depth wise in cm)				
		0-5	5-10	10-15	15-20	20-25
Site-I	*Pteris vittata*	20	-	-	-	-
	Diplazium esculentum	10	44.48	23.08	-	-
	Pyrossia lanceolata	5	11.12	38.46	80	-
	Lygodium flexuosum	20	-	-	-	-
	Polypodium sp.	5	-	-	-	-
	Christella dentata	25	16.68	30.77	20	100
	Asplenium sp.	5	27.8	-	-	-
	Dryopteris sp.	5	-	-	-	-
	Tectaria sp.	5	-	-	-	-
	Chilanthes sp.	-	-	7.69	-	-
Site-II	*Pyrossia lanceolata*	87.5	57.14	-	-	-
	Christella dentata	12.5	42.86	100	-	-

Table 2. Depth wise seasonal variations in LFSB profile

Seasons	No. of gametophytes scored at different depths (in cm)		
	0-5	5-10	10-15
Summer	80	32	30
Rainy	81	66	27
Winter	66	88	51
χ^2 value of heterogeneity	11.34	140.50	68.77
Probability level at 2 DF	< 0.01	<0.001	<0.001

Palynological Technique

Aliquots of 10 g of each sample were treated for two hours with hydrochloric acid (HCl) to remove the carbonate present in the soil samples. HCl treated samples were washed thoroughly by distilled water by discarding the supernatant by centrifugation at 3000 rpm for 10 minutes. The residue was kept for six days in hydrofluoric acid for removal of silica. The hydrofluoric acid was eliminated by dilution in water (1:2::acid:water) and then centrifuged (10 minutes at 3000 rpm each time) till the acid was removed from the sample. Then the samples were treated with KOH to remove the clay particles. To eradicate base from the samples completely, further centrifugation was done with distilled water for 10 minutes at 3000 rpm. Acetolysis technique (Erdtman 1952, 1960) was applied to the precipitated sample for recovery of pteridophytic spores from the soil. Finally, permanent slides from acetolysed samples were prepared by using polyvinyl alcohol and Canada balsam and observed under Leitz Laborlux S compound microscope.

Soil Culturing Technique

Soil culture was done by breaking up aggregation of soil particles, removing stones, roots, invertebrates, if present. Each sub sample was mixed thoroughly to make a homogeneous sample. Approximately, 10 cm^3 of soil from each core was placed on top of 3 cm^3 of sterile sand (in each of 3 replicates) in 5 cm diameter sterile Petri plates for culturing. About 8-10 ml of water was added to the Petri plates. Wet sand acts as a reservoir preventing small samples of soil from flooding or desiccation. The Petri plates were placed in gametophyte culture room (8-10 weeks; temperature 15-17°C; light 1800-2000 lx; relative humidity around 65-70 %) of Pteridology-Palaeobotany Section of Botany Department, University of Kalyani to promote germination and gametophyte development of pteridophytic spores present in soil samples. At regular interval the Petri dishes containing the cultured soils were observed under Leica S8 APO StereoZoom Microscope.

RESULT

The fern vegetation of two explored sites are recorded by the occurrence of *Adiantum caudatum, A. philippense, Ampelopteris prolifera, Christella dentata, Diplazium esculentum*, along with rich epiphytic flora (mostly growing on mango trees) namely, *Asplenium* sp., *Drynaria quercifolia*, *Microsorium punctatum*, *Pyrossia lanceolata*.

Palynological analysis reveals total fern spore assemblage at site I by the recovery of spores of *Pteris vittata*, *Diplazium esculentum*, *Pyrossia lanceolata*, *Lygodium flexuosum*, *Polypodium* sp., *Christella dentata*, *Asplenium* sp., *Dryopteris* sp., *Tectaria* sp., and *Chilanthes* sp. The fern spore assemblage at site II encompasses *Christella dentata*, and *Pyrossia lanceolata* only (Table 1; Figs. 1b-f).

LFSB of sampled soils is established through soil culture. Among the total fern spore assemblages, spores of *Christella dentata* only remain viable. A similar trend of germination of live spores in cultured is observed at both the sites. However, χ^2 test of heterogeneity reveals considerable seasonal variability in the prothallial frequency emerging from soil samples at different depths (0-5 cm to 10-15 cm) (Table 2; Fig. 1g). Cultured soils from remaining two depths (15-20 cm and 20-25 cm) have given negative results for prothallial development. Spore germination time is relatively lower in winter than summer and rainy seasons. The prothallial development started after 30 days in winter; while, it was only after 10 days in other two seasons. Time taken for prothallial maturation and subsequent initiation of sporophytic generation varied markedly as evinced from gradual decrease in number of emerging prothallia after 60 (10-15 cm), and 70 (0-5 cm; 5-10 cm) days in winter; 40 (10-15 cm), 60 (0-5 cm), and 70 (5-10 cm) days in rainy; 40 (0-5 cm), and 50 (5-10 cm; 10-15 cm) days in summer (Figs. 1h-j). The growing sporophytic plants are relocated from laboratory to field condition (Figs. 1k-o) for the purpose of *ex situ* conservation by adapting themselves in natural environment.

DISCUSSION

The pteridoflora in the studied area is covered by about 10 taxa of ferns though all the taxa (*Adiantum caudatum*, *A. philippense*, *Ampelopteris prolifera*, and *Microsorium punctatum*) represented in TFSC profile in soil. On the contrary, species namely, *Polypodium*, *Dryopteris*, *Tectaria*, and *Chilanthes* are not present in the studied flora but represented well in soil samples which may be the consequence of their presence in distant or nearby areas.

LFSB profile reveals that all spores present in the soil samples are not viable. For spore viability the vertical length of soil profile is recorded up to 15 cm, below which, the spores could not retain their viability. Gametophyte development has demonstrated seasonal variations at different depths of soils. Soil depth of 0-5 cm is found as best reservoir in summer and rainy; while, 5-10 cm depth is significant in winter.

CONCLUSION

The present study clearly established a reservoir of vertically distributed LFSB in the soil of Mankundu region of Hooghly district, West Bengal for conserving the fern flora. The emerging sporophytes from prothalli growing in *in vitro* conditions are brought to natural habitat with the objective for *ex situ* conservation. The sporophytic plants survived and enriched fern community, and highlight the significance of the work.

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REFERENCES

Dyer, A.F. (1992). Natural soil spore banks—can they be used to retrieve lost ferns? *In: Proceedings of the Kew conservation conference*, September 1991.

Dyer, A.F. (1994). Natural soil spore banks—can they be used to retrieve lost ferns? *Biodiversity and Conservation*, **3:** 160–175.

Dyer, A.F. and Lindsay, S. (1992). Soil spore banks of temperate ferns. *American Fern Journal*, **82:** 89–122.

Simabukuro, E.A.; Esteves, L.M. and Felippe, G.M. (1998). Analysis of a fern spore bank in Southeast, Brazil. *Hoehnea*, **25:** 45–57.

Simabukuro, E.A.; Begovacz, A.; Esteves, L.M. and Felippe, G.M. (1999). Fern spore bank at Pedregulho (Itirapina, Sao Paulo, Brazil). *Revista Brasileira de Biologia*, **59:** 131–139.

Ranal, M.A. (2003). Soil spore bank of ferns in a gallery forest of the Ecological Station of Pangg, Uberlandia, MG, Brazil. *American Fern Journal*, **93:** 97–115.

Ramirez-Trezo, M.D.R.; Perez-Garcia, B. and Orozco-Segovia, A. (2004). Analysis of fern spore banks from the soil of three vegetation types in the central region of Mexico. *American Fern Journal*, **91:** 682–688.

Gupta, S.; Hore, M. and Biswas, S. (2014). An overview of the study of soil spore bank of ferns: need for suitable exploitation in India. *Proceedings of the National Academy of Sciences, India Section B: Biological Sciences*, **84:** 779–798.

Erdtman, G. (1952). *Pollen Morphology and Plant Taxonomy: Angiosperms*. Almqvist and Wiksell, Stockholm.

Erdtman, G. (1960). The acetolysis method, revised description. *Svensk Botanisk Tidskrskrift*, **54:** 561–564.

RESEARCH ARTICLE

SCREENING OF SUGARCANE GERMPLASM FOR TRAITS RELATED TO DIVERSIFIED USES

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Abstract: Sugarcane has diversified uses; apart from sugar and jaggery extraction, it is being used for cogeneration and ethanol production. Germplasm is the basic raw material with repository of beneficial traits. Constant evaluation and characterization of the existent, yet uncharacterized germplasm is useful and is the cornerstone for the development of new and better varieties. A systematic study was conducted to evaluate one hundred and thirty one germplasm accessions including four checks for quality and yield attributes. All the varieties varied greatly for different traits. Germplasm accessions possessing traits related to diversified uses were grouped and elucidated. The accessions; 2003T129, 2005T16, 2005T50, 86V96, 2003T123, 95V74, 2006T36 and 2006T3 were found to possess characters that are considered for promotion of varieties for improving cane and CCS production and the accessions; 85R186, 97R383, BO91, 93R113, 97R7, 83V288, 97R424, 2000A213, 2002V2, 94A73, and 2005T89 were observed as reservoirs for production of promising sugarcane varieties suitable for cogeneration and paper making purpose. The genotypes, 2006T3, 2005T50, 93A145, 97R272, Co1148, 87A298, 2005T52 and 2004T68 can be exploited in breeding programmes for production of ethanol efficient varieties.

Keywords: Sugarcane, Germplasm, Cogeneration, Paper making, Ethanol

INTRODUCTION

Sugarcane (*Saccharum spp*.) is an important food crop of the tropics and subtropics accounting for 62 per cent of world sugar production. It is a major source of byproducts which provide raw material for cogeneration, ethanol, pulp and paper production. Approximately 70% of the world's sugar supply in the form of sucrose comes from sugarcane. Sugarcane bagasse (fibrous residue) is the primary fuel source used in boilers, making most sugarcane mills energy self-sufficient. Some mills also generate electricity (referred to as co-generation) and sell the excess to public utilities. It is estimated that about 5000 MW of power can be generated from sugar mills in India as against 2200 MW with the use of energy canes with high fiber. The production of biofuel from sugarcane is seen as one of the best currently available options because it has a significantly higher energy conversion ratio than most other biofuel feed stocks, up to 1:8. National policy to scale up blending of ethanol from current 5% to 20% by 2017 requires about 4400 million liters ethanol as against the current production of 2170 million liters. Hence breeding programmes should integrate traits such as high fiber, high biomass and high total sugars in addition to cane yield and sucrose yield. Germplasm is the basic raw material where diversity of traits prevails and can be exploited for production of superior lines suitable for diversified uses. The present study focused on screening and grouping of sugarcane germplasm accessions for diversified uses and using them as parents in breeding programmes.

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MATERIAL AND METHOD

One hundred and thirty one germplasm accessions including four checks viz., 2003V46, Co6907, Co7219 and Co86032 were evaluated during 2012-13 at Agricultural Research Station, Perumallapalle, with plot size of 6m× 2R × 0.9m = 10.8 m^2 in augmented design II. Recommended package of practices were adopted to raise a healthy crop. Necessary prophylactic measures were taken to safeguard the crop from pests and diseases. The germplasm accessions were evaluated for quality and yield attributes viz., single cane weight, percentage of flowering, sucrose %, brix %, Commercial Cane Sugar %, fibre %, juice extraction %, cane yield and Commercial Cane Sugar yield. Single cane weight was derived by averaging the weight of 10 canes harvested randomly from each accession in the plot at the time of maturity. Brix per cent in juice was estimated by taking a sample of 100 ml of crushed juice for each entry after straining through a fine muslin cloth followed by measuring with brix hydrometer. Sucrose percentage was obtained by direct polarisation of the undiluted juice after clarification with 3 to 4 gm of dry lead subacetate with the help of polariscope. The polarisation reading was then converted into per cent of sucrose using Schmitz's tables (Hawaiian Sug. Tech. Association, 1931).

The Commercial cane sugar (%) was estimated from the following formula:

CCS% = 1.05 (S) – 0.3 (B), Where S = Sucrose % and B = Corrected Brix in juice

Fibre content was estimated from six randomly selected canes harvested at 360 DAP. They were

further sub-sampled to include top, middle and bottom portion from each cane. Cane was split vertically and the split cane was cut into small bits of 1cm length. All the bits of cane were pooled and 250g of fresh cut cane sample was taken for analysis. The sample was transferred to the bowl of the Rapipol extractor and 2 litres of water was added to the bowl. The motor was run for 5 minutes so that the cane bits were sheared into fibre. The contents of the bowl were then transferred to a muslin cloth filter and the fibrous material was washed in running water under the tap till the material was free from juice and dissolved solids. Then the fibre from the filter was transferred to a previously weighed cloth bag and the water was squeezed out. The contents of the bag were dried in an oven at 100^0C and then dry weight of the sample with bag was recorded. Fibre content was calculated as per the formula given by Thangavelu and Rao (1982).

Fibre content (%) = $\frac{A-B}{C} \times 100$

where,

A = Dry weight of bag + bagasse after drying (g)

B = Dry weight of bag alone (g)

C = Fresh weight of cane (g)

The juice extraction percentage (%) was obtained by extracting the cane juice by crushing in a three roller power operated crusher and is worked out as given below:

$$\text{Juice extraction per cent} = \frac{\text{Juice weight}}{\text{Cane weight}} \times 100$$

For cane yield (t ha^{-1}) the weight of canes in net plot after detrashing and detopping just below the spindle was recorded utilising the Avery platform balance and the value was converted to tons per hectare. Commercial Cane Sugar yield (t ha^{-1}) was estimated as per the formula,

$$\text{CCS (t ha}^{-1}\text{)} = \frac{\text{CCS \%} \times \text{Cane yield (t ha}^{-1}\text{)}}{100}$$

RESULT AND DISCUSSION

All the germplasm accessions showed significant variation for the traits under study (Table 1). They were evaluated along with checks for the traits under study and an exercise was made for grouping the genotypes based on their per se performance related to diversified uses *viz*., high fibre percentage, low sucrose percentage, low CCS percentage, high juice extraction percentage, high single cane yield and cane yield per hectare.

Single cane weight showed significant variation among the genotypes (Table 1). The range varied from 0.4 to 1.8 kg. Among the genotypes, single cane weight with more than 1.5 kg was recorded in 24 genotypes. The genotypes *viz*., 2002V48, 2003T129, CoA7602, 92A326 and 92A10 recorded the highest single cane weight (1.8 kg) and the lowest single cane weight was observed in genotype SES594 (0.4kg) followed by BO91 and CoS767 with 0.7 kg (Table 2). Ravishankar *et al*. (2004) reported that a high positive association was present between number of tillers per plant and single cane weight and selection of clones based on these traits will be effective in improving the cane yield.

Out of 131 genotypes, 10 showed presence of flowering and 121 genotypes showed absence of flowering (Table 2). The genotypes which showed flowering were CoS8346 (20.93%), Co38436 (26.82%), 2006T33 (16.36%), 2006T23 (18.75%), 2006T19 (37.16%), 95V221 (7.01%), 95V72 (20%), 97R267 (23.52%), 97R424 (28.12%) and 93R217 (35.20%). The highest percentage of flowering was recorded in the genotype 2006T19 (37.16%) followed by 93R217 (35.20%). Singh (1980) reported that sucrose content in cane reduced especially when there was a high percentage of flowering. Miah and Sarkar (1981) observed that the fresh weight of non-flowered stalks was superior over the flowered ones. Hes (1951) reported that flowering reduced the purity of the juice. So in selection of genotypes for high sucrose % and high single cane weight, due importance should be given for non - flowering nature of selections.

Variation for sucrose among genotypes was significant (Table 1) and it ranged from 10.1 to 19.04 per cent (Table 2). The genotypes with <16.5 per cent of sucrose were observed to be 47 and >18% to be 15. Among the genotypes, the highest sucrose percent was recorded in 94V101 and 97R183 with 19.04 per cent followed by 95V74 (18.99%) and 93A145 (18.79%). The least percentage of sucrose was observed in the genotype SES594 (10.1%) followed by 95V303 (13.52%) (Table 2). Genotypes with low sucrose percent are preferred for cogeneration and pulp.

The range for brix per cent was from 14.32 to 20.48 per cent (Table 2) which was a significant variation among the genotypes (Table 1). Among the genotypes more than 20 per cent brix was recorded in 19 genotypes. The genotype 95V74 recorded the highest brix per cent (20.48%) followed by 88A189 (20.38%), 97R272, 86V96, 93A145, 2005T50 each with 20.36 per cent and the lowest brix per cent was observed in genotype SES594 (14.32%) followed by 95V303 (14.88%), 94V108, 94V104 and 95V72 each with 15.88%. Deep *et al.* (2004), Kadian and Mehla (2006) also classified the genotypes by utilising this characteristic. Kadian and Mehla (2006) reported positive and significant association among brix per cent, purity per cent and CCS per cent. Genotypes with high brix per cent are preferred for commercial cane cultivation as it has positive association with commercial cane sugar yield.

Commercial Cane Sugar (CCS) percentage showed significant variation among the genotypes (Table 1). Genotypes ranged from 6.15 to 13.57 percent for CCS percentage (Table 2). Genotypes with <11 percent of commercial cane sugar percentage were 34 and 38

with >12%. Among the genotypes, the highest CCS percent was recorded in 97R183 (13.57%) followed by 95V74 (13.42%) and 93A145 (13.26%). The least percentage of CCS was observed in SES594 (6.15%) followed by 95V303 (9.47%) and 97R395 (9.67%) (Table 2).

Significant variation among the genotypes was observed (Table 1) for fibre percentage which was ranging from 9.0 to 27.80 per cent. A total of 20 genotypes possessed high fibre percentage (>16%). Among the genotypes, the highest fibre percent was recorded in SES594 (27.80%) followed by 94A73 (18.48%) and 2005T89 (17.92%). The least percentage of fibre was observed in 2004A107 (9.0%) followed by CoC671 (10.32%) and 90A278 (10.40%) (Table 2). Kadian and Mehla (2006) used fibre percentage for grouping and classification of genotypes useful for cogeneration. Babu *et al.* (2009) observed a significant positive correlation between rind hardness and fibre content and advocated that it was beneficial for selection of erect and non-lodging canes suitable for mechanical harvesting and feedstock for co-generation. Radhamani *et al.* (2012) opined that high fibre sugarcane clones with optimum sugar and yield could be exploited for co-generation.

Cane yield showed significant variation among the genotypes (Table 1). Genotypes ranged between 62.5 and 173.76 t ha^{-1}. There were 110 genotypes which produced more than 100 t ha^{-1} cane yield. Among them, 93A53 (173.76 t ha^{-1}) followed by 2005T16 (166.4 t ha^{-1}), 2006T33 (165.12 t ha^{-1}) and 81V48 (157.5 t ha^{-1}) showed higher cane yields in comparison to the check varieties *viz*., 2003V46 (153.9 t ha^{-1}), Co6907 (101.64t ha^{-1}), Co7219 (118.83 t ha^{-1}) and Co86032 (128.44 t ha^{-1}) (Table 2). The lowest cane yield was recorded by CoS8346 (62.5 t ha^{-1}) followed by Co364 (75 t ha^{-1}), Co1148 (78 t ha^{-1}), 97R167 (82 t ha^{-1}), 87A298 (82.17t ha^{-1}) and 97R62 (82.42 t ha^{-1}). Rakkiyappan and Pandiyan (1992) opined that a variety meant for cogeneration purpose should contain high cane yield.

Significant variation among the genotypes was observed for juice extraction percentage among 115 genotypes (Table 1). The range for juice extraction percentage was from 31.5 to 72.9 per cent. Among the genotypes, 2004A103 (72.9%) followed by 2004T68 (70%), 95V221 (66.6%) and 97R424 (65.7%) recorded higher juice extraction percentage when compared to check varieties viz., 2003V46 (54.9%), Co6907 (53.3%), Co7219 (53.49%) and Co86032 (51.4%) (Table 2). The lowest juice extraction percentage was recorded by the genotype, SES594 (31.5%) followed by Co975 (37%), 94A73 (40.24%) and 2004A63 (40.7%). Rakkiyappan and Pandiyan (1992) and Radhamani *et al.* (2012) concluded that a variety meant for ethanol production should contain high juice extraction percent. Rao *et al.* (2007) reported that new multipurpose cane varieties with very high fibre content were found to produce more biomass per hectare and a wide range of brix values when compared to the traditional sugarcane varieties. High fibre multipurpose cane varieties with acceptable levels of fermentable sugars would extend the supply of bagasse and contribute to fuel ethanol production. Babu *et al.* (2009) conducted an experiment to ascertain whether the rind hardness of cane can be used as an index for fibre content in sugarcane and concluded that there was a significant positive correlation between rind hardness and fibre content which is beneficial for selection of erect non lodging canes suitable for mechanical harvesting and feedstock for co-generation. In order to support cogeneration and ethanol production there is need for developing varieties capable of high biomass with high fibre content and higher total sugars (Govindaraj, 2009).

Based on the review of literature an exercise was made to identify genotypes showing combination of all these traits useful for diversified uses such as commercial cane cultivation for cane and CCS yield, for cogeneration and for ethanol production (Table 3). Apart from cane and CCS yields, high sucrose percentage, absence of leaf sheath hairiness, easy or medium detrashing, small to medium sized bud, absence of splits, absence of pithiness and absence of flowering are the important characters which decide the acceptance of farmers for commercial cultivation of a variety. The genotypes 2003T129, 2005T16, 2005T50, 86V96, 2003T123, 95V74, 2006T36 and 2006T3 were found to possess all these characters that are considered for promotion of varieties for improving cane and CCS production.

Similarly high fibre percentage, low sucrose percentage, low CCS percentage and high cane yield are the important characters for a genotype suitable for cogeneration, pulp and paper making. It was observed that the genotypes 85R186, 97R383, BO91, 93R113, 97R7, 83V288, 97R424, 2000A213, 2002V2, 94A73 and 2005T89 possess the aforesaid characters and can be considered as high biomass types useful for cogeneration, pulp and paper making.

A variety suitable for production of biofuel, ethanol should have high juice extraction percentage, high cane yield, high sucrose percentage, high CCS yield, absence or sparse leaf sheath hairiness, easy or medium detrashing, small to medium sized bud, absence of pithiness and absence of flowering. The genotypes, 2006T3, 2005T50, 93A145, 97R272, Co1148, 87A298, 2005T52 and 2004T68 can be considered for production of ethanol as they have all the characters contributing to high ethanol production.

CONCLUSION

Identification and development of the canes for ethanol production, cogeneration, pulp and paper making augments economic prosperity of sugar

industries. Canes with traits useful for diversified uses are suitable for allied uses in sugar industry. Among 131 germplasm accessions maintained at Agricultural Research Station, Perumallapalle, 8 accessions showed a combination of traits suitable for commercial cane cultivation, 11 for cogeneration, pulp making purpose and 8 for ethanol production. These genotypes can be better exploited in breeding programmes for generation of new promising lines suitable for commercial cultivation, ethanol production, cogeneration and paper making purposes along with other traits desirable by the farmers and industry.

Table 1. Analysis of variance for traits related to cogeneration and pulp in sugarcane using Augmented design II

S. No.	Character	Mean Squares				Mean	C.D
		Block df = 2	Entries df = 114	Checks df = 3	Error df = 6		
1	Single cane weight (kg)	0.0175	0.069**	0.020	0.017	1.33	0.45(5)
2	Sucrose (%)	0.7252	2.059**	0.048	0.210	16.66	1.58(5)
3	Brix (%)	0.5963	1.960*	1.900	0.367	18.46	2.09(5)
4	CCS (%)	0.1517	1.172**	0.050	0.016	11.62	0.44(5)
5	Fibre (%)	0.2514	4.610**	1.530	0.313	14.04	1.93(5)
6	Juice extraction (%)	4.0674	37.710**	12.130	0.317	54.29	1.94(5)
7	Cane yield (t ha^{-1})	70.4680	507.190**	599.850	51.210	126.13	24.76(5)
8	CCS yield (t ha^{-1})	0.0777	9.736**	21.410	0.211	14.69	1.59(5)

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

Table 2. Characterization of 131 sugarcane germplasm accessions for important characters

S.No.	Clone	Co7508	90A272	93A145	99V30	2000V59	83R23	93R44
1	**Single cane weight (Kg)**	1.72	1.2	1.5	0.9	1.4	1.2	1.2
2	**Percentage of flowering**	ABSENT	ABSENT	ABSENT	ABSENT	ABSENT	ABSENT	ABSENT
3	**Sucrose%**	17.8	15.75	18.79	14.68	16.04	16.35	17.09
4	**Brix %**	20.26	18.56	20.36	16.16	17.76	17.26	20.16
5	**CCS %**	12.28	10.67	13.26	10.28	11.21	11.67	11.57
6	**Fibre %**	12.44	12.56	12.32	13.92	14.2	14.48	15.32
7	**Juice extraction %**	55.94	50.44	60.3	56.56	49.79	51.89	58.89
8	**Cane yield (tha^{-1})**	149.98	125.52	150.6	101.25	131.25	127.3	101.23
9	**CCS yield (tha^{-1})**	18.42	13.39	19.97	10.41	14.71	14.86	11.71
S.No.	**Clone number**	**Co85004**	**Co94008**	**Co2001-13**	**Co2001-15**	**Co7219**	**CoT8201**	**83V15**
1	**Single cane weight (Kg)**	1.7	1.5	1.5	1.6	1.4	1.6	1.4
2	**Percentage of flowering**	ABSENT	ABSENT	ABSENT	ABSENT	ABSENT	ABSENT	ABSENT
3	**Sucrose%**	17	16.95	16.73	15.82	17.61	17.88	16.97
4	**Brix %**	17.96	18.66	18.36	17.36	19.56	19.16	18.36
5	**CCS %**	12.13	11.87	11.73	11.1	12.29	12.68	11.98
6	**Fibre %**	14.36	14.36	13.32	13.68	14.6	13.56	13.68
7	**Juice extraction %**	55.5	49.2	54.9	43.72	53.49	53.96	52.1
8	**Cane yield (tha^{-1})**	147.56	150.15	142.05	144.8	118.83	147.2	129.36
9	**CCS yield (tha^{-1})**	17.9	17.82	16.66	16.07	14.6	18.66	15.5
S.No.	**Clone number**	**2002V48**	**85R186**	**97R401**	**97R272**	**97R129**	**97R383**	**Co86032**
1	**Single cane weight (Kg)**	1.8	1.2	1.6	1.4	1.2	1.6	1.3
2	**Percentage of flowering**	ABSENT	ABSENT	ABSENT	ABSENT	ABSENT	ABSENT	ABSENT
3	**Sucrose%**	16.97	14.68	15.8	18.27	16.99	14.66	17.82
4	**Brix %**	18.36	16.06	17.76	20.36	18.06	16.46	19.96
5	**CCS %**	11.98	10.32	10.96	12.73	12.09	10.18	12.39
6	**Fibre %**	14.36	17.72	14.84	13.84	13.64	17.64	14.72
7	**Juice extraction %**	58.6	50.5	54.85	62	51.25	52.1	51.4
8	**Cane yield (tha^{-1})**	138.24	119.81	111.87	118.16	100.32	128.48	128.44
9	**CCS yield (tha^{-1})**	16.56	12.36	12.26	15.04	12.13	13.08	15.91
S.No.	**Clone number**	**Co99004**	**2003T129**	**81V48**	**2002A192**	**97A44**	**92A355**	**92A38**
1	**Single cane weight (Kg)**	1.5	1.8	1.5	1.4	1.2	1.3	1.3
2	**Percentage of flowering**	ABSENT	ABSENT	ABSENT	ABSENT	ABSENT	ABSENT	ABSENT
3	**Sucrose%**	17.33	18.11	-	-	-	-	-
4	**Brix %**	20.06	20.16	-	-	-	-	-
5	**CCS %**	11.86	12.62	-	-	-	-	-
6	**Fibre %**	12.44	16.56	15.44	14.64	13.72	12.44	11.48

7	**Juice extraction %**	63.72	53.51	-	-	-	-	-
8	**Cane yield (tha^{-1})**	125	131.04	157.5	124.04	122.76	115.44	138.32
9	**CCS yield (tha^{-1})**	14.82	16.54	-	-	-	-	-
S.No.	**Clone number**	**90A278**	**92A54**	**CoS8346**	**BO91**	**BARAGUA**	**KHAKAI**	**81V99**
1	**Single cane weight (Kg)**	1.3	1.4	1	0.7	0.9	1	1.6
2	**Percentage of flowering**	ABSENT	ABSENT	PRESENT	ABSENT	ABSENT	ABSENT	ABSENT
3	**Sucrose%**	-	17	15.32	15.35	17.2	-	16.9
4	**Brix %**	-	18.38	18.12	17.12	18.52	-	19.32
5	**CCS %**	-	12	10.37	10.69	12.17	-	11.64
6	**Fibre %**	10.4	15.32	13.12	16.36	10.84	15.52	12.56
7	**Juice extraction %**	-	45.8	58.2	52	53.26	-	53.75
8	**Cane yield (tha^{-1})**	107.85	140.7	62.5	108	110	-	100
9	**CCS yield (tha^{-1})**	-	16.88	6.48	11.54	13.38	-	11.64
S.No.	**Clone number**	**97A85**	**SES594**	**Co6907**	**84A125**	**CoA7602**	**CoC671**	**Co7717**
1	**Single cane weight (Kg)**	1.5	0.4	1.1	1.2	1.8	1.4	1
2	**Percentage of flowering**	ABSENT	ABSENT	ABSENT	ABSENT	ABSENT	ABSENT	ABSENT
3	**Sucrose%**	17.36	10.1	17.46	16.74	16.72	17.36	15.53
4	**Brix %**	19.72	14.32	18.32	18.12	18.42	19.72	18.12
5	**CCS %**	11.98	6.15	12.49	11.82	11.72	11.98	10.58
6	**Fibre %**	15.04	27.8	13.96	13.6	12.44	10.32	12.36
7	**Juice extraction %**	53.7	31.5	53.3	58.8	58.12	47.9	56.07
8	**Cane yield (tha^{-1})**	93.75	83.3	101.64	114.36	153	110.12	92.4
9	**CCS yield (tha^{-1})**	11.23	5.12	12.69	13.52	17.93	13.19	9.78
S.No.	**Clone number**	**Co975**	**Co1148**	**Co997**	**Co419**	**Co62399**	**Co364**	**Co38436**
1	**Single cane weight (Kg)**	1.4	1.2	1.5	1.6	1.4	0.9	1
2	**Percentage of flowering**	ABSENT	ABSENT	ABSENT	ABSENT	ABSENT	ABSENT	PRESENT
3	**Sucrose%**	15.34	17.21	18.13	15.16	14.46	17.87	17.42
4	**Brix %**	17.32	18.42	19.12	16.72	16.42	19.32	18.82
5	**CCS %**	10.62	12.21	12.94	10.62	10.69	12.62	12.31
6	**Fibre %**	12.84	13.76	15.72	12.08	11.28	15.76	13.6
7	**Juice extraction %**	37	63	58.33	57.1	55	54.6	55.5
8	**Cane yield (tha^{-1})**	87.5	78	97.5	138.4	136.08	75	104.16
9	**CCS yield (tha^{-1})**	9.29	9.52	12.61	14.7	14.54	9.46	12.82
S.No.	**Clone number**	**CoS767**	**2003V46**	**2004A75**	**2004A63**	**2004A55**	**2004A107**	**2004A103**
1	**Single cane weight (Kg)**	0.7	1.5	1.2	1.3	1.3	1.4	1.5
2	**Percentage of flowering**	ABSENT	ABSENT	ABSENT	ABSENT	ABSENT	ABSENT	ABSENT
3	**Sucrose%**	16.04	18.29	-	17.6	15.51	16.54	16.52
4	**Brix %**	17.82	20.12	-	20.12	18.52	17.92	17.92
5	**CCS %**	11.19	12.82	-	12.12	10.44	11.68	11.65
6	**Fibre %**	14.48	12.04	14.6	13.68	14.08	9	12.4
7	**Juice extraction %**	50	54.9	-	40.7	53.8	50	72.9
8	**Cane yield (tha^{-1})**	87.5	153.9	111.6	104.65	136.5	145.88	153.6
9	**CCS yield (tha^{-1})**	9.79	19.73	-	12.68	14.25	17.04	17.89
S.No.	**Clone number**	**2004A82**	**2006T34**	**2006T33**	**2006T10**	**2006T35**	**2006T13**	**2006T18**
1	**Single cane weight (Kg)**	1.4	1.2	1.6	1.2	1	1.5	1.4
2	**Percentage of flowering**	ABSENT	ABSENT	PRESENT	ABSENT	ABSENT	ABSENT	ABSENT
3	**Sucrose%**	15.32	15.83	16.65	18.33	17.89	15.98	14.46
4	**Brix %**	17.62	17.32	19.92	19.62	19.02	18.72	16.32
5	**CCS %**	10.51	11.12	11.2	13.01	12.73	10.86	10.01
6	**Fibre %**	14.2	14.68	10.52	12.84	12.92	12.32	14.32
7	**Juice extraction %**	53.84	54.68	61.4	62.5	53.4	53.3	55.5
8	**Cane yield (tha^{-1})**	151.2	153.6	165.12	146.4	112.03	159.45	151.2
9	**CCS yield (tha^{-1})**	15.89	17.08	18.49	19.05	14.26	17.32	15.14
S.No.	**Clone number**	**2006T36**	**2006T23**	**2006T19**	**2006T8**	**2006T3**	**95V221**	**89V74**
1	**Single cane weight (Kg)**	1.4	1.2	1.4	1.4	1.3	1.6	1.4
2	**Percentage of flowering**	ABSENT	PRESENT	PRESENT	ABSENT	ABSENT	PRESENT	ABSENT
3	**Sucrose%**	18.5	16.11	17.83	17.4	18.3	16.45	16.04
4	**Brix %**	20.4	17.22	19.92	19.12	19.8	18.88	18.18
5	**CCS %**	12.9	11.44	12.4	12.2	13	11.3	11.09
6	**Fibre %**	16.08	11	13.6	12.08	17.2	11.36	12.76
7	**Juice extraction %**	50.7	58.12	53	55.91	63	66.6	54.4
8	**Cane yield (tha^{-1})**	145.6	129.6	145.6	147.98	127.4	153.92	143.92
9	**CCS yield (tha^{-1})**	18.78	14.83	18.05	18.05	16.56	17.39	15.96
S.No.	**Clone number**	**97V178**	**92V225**	**95V48**	**97V118**	**94V101**	**93V297**	**92V104**
1	**Single cane weight (Kg)**	1.2	1.6	1	1.2	1.5	1.1	1
2	**Percentage of flowering**	ABSENT	ABSENT	ABSENT	ABSENT	ABSENT	ABSENT	ABSENT
3	**Sucrose%**	16.54	17.2	16.98	17.14	19.04	17.66	16.5
4	**Brix %**	18.08	18.58	18.28	20.28	20.28	19.38	18.18
5	**CCS %**	11.62	12.15	12.01	11.59	13.53	12.39	11.55
6	**Fibre %**	13.68	14.56	12.48	15.32	12.52	12.6	12.16
7	**Juice extraction %**	49.35	43.04	43.39	55	46.8	57.22	58.8

8	**Cane yield (tha^{-1})**	117.55	156.16	95.46	102.34	124.8	114.4	112.32
9	**CCS yield (tha^{-1})**	13.66	18.97	11.46	11.86	16.89	14.17	12.97
S.No.	**Clone number**	**94V104**	**95V423**	**95V74**	**97V163**	**95V428**	**92V206**	**95V72**
1	**Single cane weight (Kg)**	1.1	1	1.3	0.8	1.1	1.3	1.3
2	**Percentage of flowering**	ABSENT	ABSENT	ABSENT	ABSENT	ABSENT	ABSENT	PRESENT
3	**Sucrose%**	14.69	15.79	18.99	-	16.72	16.29	14.69
4	**Brix %**	15.88	18.38	20.48	-	18.48	17.68	15.88
5	**CCS %**	10.38	10.77	13.42	-	11.69	11.48	10.38
6	**Fibre %**	11.36	12.4	16.12	16.64	15.52	13.48	14.84
7	**Juice extraction %**	53.5	54.54	56.6	-	47.91	51.2	54.54
8	**Cane yield (tha^{-1})**	114.4	94.6	124.41	82.24	109.82	121.68	107.51
9	**CCS yield (tha^{-1})**	11.87	10.19	16.7	-	12.84	13.97	11.16
S.No.	**Clone number**	**94V108**	**97R199**	**97R267**	**97R276**	**93R113**	**97R7**	**97R183**
1	**Single cane weight (Kg)**	1.4	1.5	1.4	1.6	1.3	1.2	1.3
2	**Percentage of flowering**	ABSENT	ABSENT	PRESENT	ABSENT	ABSENT	ABSENT	ABSENT
3	**Sucrose%**	14.69	16.25	15.99	15.84	14.84	-	19.04
4	**Brix %**	15.88	18.28	18.48	17.08	17.58	-	20.18
5	**CCS %**	10.38	11.27	10.95	11.2	10.03	-	13.57
6	**Fibre %**	13	13.84	13.08	15.68	17.84	16.52	14.88
7	**Juice extraction %**	58.46	47.91	65.07	56.15	52.5	-	58.46
8	**Cane yield (tha^{-1})**	143.64	145.05	148.51	123.84	128.31	118.44	143.52
9	**CCS yield (tha^{-1})**	14.91	16.35	16.26	13.87	12.87	-	19.47
S.No.	**Clone number**	**97R15**	**85A146**	**83V288**	**82V12**	**86V96**	**92R62**	**93R129**
1	**Single cane weight (Kg)**	1.4	1.6	1.4	0.8	1.6	1.5	1.4
2	**Percentage of flowering**	ABSENT	ABSENT	ABSENT	ABSENT	ABSENT	ABSENT	ABSENT
3	**Sucrose%**	14.67	16.97	16.07	16.67	18.51	-	14.89
4	**Brix %**	16.28	19.26	17.36	19.26	20.36	-	16.68
5	**CCS %**	10.24	11.72	11.35	11.41	12.98	-	10.35
6	**Fibre %**	15.4	13.24	17.16	14.84	14.24	14.68	15.28
7	**Juice extraction %**	50	53	55.55	50.76	57.5	-	57.5
8	**Cane yield (tha^{-1})**	149.1	144.8	125.33	85.12	145.15	-	126.45
9	**CCS yield (tha^{-1})**	15.27	16.97	14.22	9.71	18.84	-	13.09
S.No.	**Clone number**	**97R134**	**97R123**	**97R163**	**97R424**	**97R395**	**97R217**	**97R6**
1	**Single cane weight (Kg)**	1.4	0.9	0.8	0.8	1.01	1.1	1.6
2	**Percentage of flowering**	ABSENT	ABSENT	ABSENT	PRESENT	ABSENT	ABSENT	ABSENT
3	**Sucrose%**	-	15.34	15.63	16.29	14.57	-	14.63
4	**Brix %**	-	17.88	16.58	18.18	17.88	-	16.96
5	**CCS %**	-	10.45	11.13	11.33	9.67	-	10
6	**Fibre %**	12.6	16.16	13.68	17.52	14.28	15.12	12
7	**Juice extraction %**	-	50	50	65.7	55.55	-	51.54
8	**Cane yield (tha^{-1})**	105.84	92.16	99.84	106.5	95.14	87.78	104.96
9	**CCS yield (tha^{-1})**	-	9.63	11.11	12.07	9.2	-	10.5
S.No.	**Clone number**	**93R217**	**97R174**	**97R167**	**92A326**	**2000A213**	**2000A225**	**2005T16**
1	**Single cane weight (Kg)**	0.8	1.1	0.8	1.8	1.3	1.3	1.6
2	**Percentage of flowering**	PRESENT	ABSENT	ABSENT	ABSENT	ABSENT	ABSENT	ABSENT
3	**Sucrose%**	15.6	16.53	-	15.99	-	16.55	18.08
4	**Brix %**	16.96	17.76	-	18.48	-	17.38	20.16
5	**CCS %**	11	11.7	11.19	10.95	-	11.84	12.59
6	**Fibre %**	15.32	14.8	17.16	12.04	17.72	14.92	13.4
7	**Juice extraction %**	50	60.8	-	58.8	-	46.66	54.16
8	**Cane yield (tha^{-1})**	118.14	125.84	82	149.76	109.46	111.54	166.4
9	**CCS yield (tha^{-1})**	13	14.72	9.18	16.4	-	13.21	20.95
S.No.	**Clone number**	**95V348**	**94V103**	**2002V2**	**95V303**	**92A10**	**88A189**	**94A73**
1	**Single cane weight (Kg)**	1.2	1.6	1.2	1.1	1.8	1.5	1.3
2	**Percentage of flowering**	ABSENT	ABSENT	ABSENT	ABSENT	ABSENT	ABSENT	ABSENT
3	**Sucrose%**	16.03	17.44	16.05	13.52	-	17.82	16.71
4	**Brix %**	17.88	19.48	17.66	14.88	-	20.38	18.68
5	**CCS %**	11.16	12.13	11.24	9.47	-	12.26	11.62
6	**Fibre %**	15.32	12.64	16	13.44	14.16	12.56	18.48
7	**Juice extraction %**	57.27	54.54	57.14	55.5	-	60.7	40.24
8	**Cane yield (tha^{-1})**	104.04	155.65	125.52	113.52	126.7	152.1	149.56
9	**CCS yield (tha^{-1})**	11.61	18.88	14.11	10.75	-	18.65	17.38
S.No.	**Clone number**	**92A374**	**93A53**	**92A126**	**87A298**	**92A130**	**2005T89**	**2005T52**
1	**Single cane weight (Kg)**	1.4	1.6	1.2	1.2	1.1	1.3	1.4
2	**Percentage of flowering**	ABSENT	ABSENT	ABSENT	ABSENT	ABSENT	ABSENT	ABSENT
3	**Sucrose%**	17.89	14.72	14.92	16.98	17.17	15.12	16.92
4	**Brix %**	19.48	15.98	16.68	18.26	19.38	16.96	19.16
5	**CCS %**	12.59	10.37	10.38	12.02	11.89	10.5	11.69
6	**Fibre %**	13.84	12	15.44	10.84	14.88	17.92	13.64
7	**Juice extraction %**	47.7	58.97	51.11	60.7	53	50	60.9
8	**Cane yield (tha^{-1})**	120.67	173.76	137.28	118.75	127.57	140.4	148.4

9	**CCS yield (tha^{-1})**	15.19	18.02	14.25	14.27	15.17	14.74	17.35
S.No.	**Clone number**	**2004T67**	**2003T123**	**2005T50**	**2004T68**	**2003T121**		
1	**Single cane weight (Kg)**	1.4	1.6	1.4	1.1	1.5		
2	**Percentage of flowering**	ABSENT	ABSENT	ABSENT	ABSENT	ABSENT		
3	**Sucrose%**	16.94	18.29	18.27	16.97	17.21		
4	**Brix %**	18.76	20.16	20.36	18.36	18.46		
5	**CCS %**	11.84	12.8	12.73	11.98	12.19		
6	**Fibre %**	14.36	17.64	13.24	13.92	14.64		
7	**Juice extraction %**	58.33	50	61.5	70	46.67		
8	**Cane yield (tha^{-1})**	145.6	150.72	134.4	128.04	156		
9	**CCS yield (tha^{-1})**	17.24	19.29	17.11	15.34	19.02		

Table 3. Grouping of genotypes for combination of economic traits

S. No.	Combination of characters	Genotypes	Diversified uses
1	High yield High sucrose % High CCS yield Absence of leaf sheath hairiness Easy / medium detrashing Small/ medium bud size Absence of splits Absence of pithiness Absence of flowering	2003T129, 2005T16, 2005T50, 86V96, 2003T123, 95V74, 2006T36, 2006T3.	Useful for commercial cane cultivation by farmers for cane and CCS yields.
2	High fibre % Low sucrose % Low CCS % High yield	85R186, 97R383, BO91, 93R113, 97R7, 83V288, 97R424, 2000A213, 2002V2, 94A73, 2005T89.	High biomass types useful for cogeneration and paper making.
3	High juice extraction percentage High cane yield High sucrose % High CCS yield Absence or sparse leaf sheath hairiness Easy/medium detrashing Small/medium bud size Absence of pithiness Absence of flowering	2006T3, 2005T50, 93A145, 97R272, Co1148, 87A298, 2005T52, 2004T68	Useful for ethanol production.

REFERENCES

Babu, C.; Koodalingam, K.; Natarajan, U.S.; Shanthi, R.M and Govindaraj, P. (2009). Assessment of rind hardness in sugarcane (*Sachharum*spp. hybrids) genotypes for development of non lodging erect canes.*Advances in Biological Research.*3(1-2): 48-52.

Deep, G.; Mehla, A.S.; Punia, M.S and Kadian, S.P. (2004).Studies on variability, heritability and genetic gain for yield, its components and quality traits in sugarcane (*Saccharum c*omplex).*Indian Sugar.*54(9):733-737.

Govindaraj, P. (2009). Breeding varieties for cogeneration and ethanol production. *ICAR International Training programme on "Breeding sugarcane for use in sugar-industrial complex",* SBI Coimbatore: 148-162.

Hawaiian Sug.Tech. Association, (1931).Association of Howaiian Sugar Technologists.

Hes, J.W. 1951. The Effect of flowering on the yield of cane.*Sugar* Journal.14(4): 10-17.

Kadian, S.P and Mehla, A.S. (2006).Correlation and path analysis in sugarcane.*Indian Journal of Agricultural Research*. 40(1): 47-51.

Miah, M.A.S and Sarkar, M.A.A. (1981). The effect of flowering on the quality of sugarcane.*Bangladesh Journal of Sugarcane.*3 (24): 25-28.

Radhamani, R.; Rakkiyappan, P.; Kannan, R.; Eyalarasan. K and Karthikeyan, K. (2012). Ethanol Production of Some Promising Commercial Sugarcane Varieties for Eco-friendly use of Ethanol as an Automobile Fuel. *International Journal of Science & Emerging Technologies.*4(5): 18-180.

Rakkiyappan, P and Pandiyan, R. (1992). Evaluation of certain sugarcane varieties for ethanol production.*Journal of Agronomy & Crop Science.* 169:250-253.

Rao, P.S.; Davis, H and Simpson, C. (2007). New sugarcane varieties and year round sugar and ethanol production with bagasse based cogeneration in Barbados and Guyana. *XXVI Congress, International Society of Sugarcane Technologists, ICC, Durban, South Africa*.1169-1176.

Ravishankar, C.R.; Ramappa, H.K.; Prakash, P.; Gowda, S.N.S and Shivakumar, N. (2004). Genetic variability and correlations in sugarcane (*Saccharum* spp.) germplasm for quantitative traits. *Environment and Ecology. 22: spl-3*:569-571.

Singh, S. (1980). Studies on flowering in sugarcane.Ph, D.Thesis, Banaras Hindu University, Varanasi, India.

Thangavelu, S and Rao, K.C. (1982). Comparison of Rapi pol extractor and Cutex cane shredder methods for direct determination of fibre in *Saccharum* clones. *Proc. Ann. Conv. Sug. Tech. Assoc.* India., 46: 15-21.

RESEARCH ARTICLE

RESULT OF DIVERSE STORAGE STRUCTURES ON POTATO TUBER ROTS AND WEIGHT LOSS IN POTATO (*SOLANUM TUBEROSUM* L.) VAR. KUFRI BADSHAH

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Abstract: Four different storage structures were evaluated *viz.*, cold storage, country cold storage, heap method and rustic cum diffuse light storage. After 100 days of storage period, rottage incidence and weight loss were recorded. Minimum rottage incidence and weight loss was found in cold storage that is 16.31 % and 8.30 % followed by rustic cum diffuse light method 33.75 % and 12.35 %, country cold storage having 46.99 % and 20.70 % and maximum rottage incidence and weight loss was found in heap method 62.71 % and 27.45 % respectively.

Keywords: Cold storage, Country cold storage, Heap method, Rustic cum diffuse light storage

INTRODUCTION

Potato (*Solanum tuberosum* L.) is one of the most nutritious sources of food in the world. It has been recognized as a wholesome food and the richest source of energy in most of the countries of the world where, it forms an important part of the human diet. *Fusarium* dry rot is one of the most important diseases of potato, affecting tubers in storage and seed pieces after planting. *Fusarium* dry rot of seed tubers can reduce crop establishment by killing developing potato sprouts, and crop losses can be up to 25%, while more than 60% of tubers can be infected in storage. However, average annual crop losses attributed to dry rot have been estimated at 6 to 25 per cent (Chelkowski, 1989) and found that more than 60 per cent of tubers in storage can be affected (Carnegie *et al*., 1990). *Fusarium* sp. that causes dry rot and spread readily among tubers during handling and planting which results in seed tuber rots and poor plants stand (Hooker, 1981). However, other diseases as charcoal rot (*Macrophomina phaseolina*) may cause 10-70 per cent tuber rottage in eastern plains depending upon the period of harvest and presence of predisposing factors (Thirumalachar, 1955). The first symptoms of *Fusarium* dry rot are usually dark depressions on the surface of the tuber. In large lesions, the skin becomes wrinkled in concentric rings as the underlying dead tissue desiccates. Internal symptoms are characterized by necrotic areas shaded from light to dark brown or black in colour. This necrotic tissue is usually dry (hence the name given as dry rot) and may develop at an injury such as a cut or bruise. The pathogen enters the tuber, often rotting out in the center. *Fusarium* dry rot is caused by several fungal species in the genus *Fusarium*. *Fusarium sambucinum* (teleomorph *Giberella pulicaris*) is the most common pathogen causing dry rot of stored tubers, but other *Fusarium* species are also known to cause dry rot, particularly *F. solani* var. *coeruleum* and *F. avenaceum*. However, *F. sambucinum* is may be the probably the main causal agent of dry rot, but *F. solani* var. *coeruleum* may also be present and affect the potato crop. *Fusarium* dry rot is both seed and soil-borne and is present in most potato growing areas. Spread is associated with damage through seed cutting, grading or harvesting. Wounds created during these processes allow the *Fusarium* fungi to enter the tuber and spread. Temperatures of 15 to 20°C and high relative humidity aid the growth of *Fusarium* dry rot. Lower temperatures and humidity retard the fungus but dry rot development continues even at the lowest storage temperatures (As shown in photograph).

Many storage rots are incited by wound parasites. Therefore, avoidance of mechanical injuries at harvest and post-harvest stages, by improving the technology would go a long way in reducing tuber decay. Hence different storage structures have been evaluated in reducing the rottage incidence and weight loss in potato crop.

MATERIAL AND METHOD

In Gujarat, potato crop is sown in the month of November and harvested in March. The tubers are usually kept in heaps and country storages for one month to three months period. The experiment was conducted at Potato Research Station, Deesa, SDAU. The tubers are heaped covered with dry potato halms of one feet to two feet layers in the field itself under tree shade. Some of the farmers store the tubers in country cold store and rustic cum diffuse light store for a period of three months.

Healthy tubers of Kufri Badshah variety was selected and stored in cold storage, country cold storage, heap method and rustic cum diffuse light method to study

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the storage behaviour against different potato tuber rots. Twenty kg potato tubers of variety Kufri Badshah was kept in the beginning of March. Apparently unbruised and undamaged tubers of uniform sized (40-60 g) were kept under different storage structures. Stored potatoes were examined at 10 days interval for 100 days in respect to dry rot, charcoal rot and soft rot diseases. Here sprouts were not removed, but the tubers showing even the slightest sign of rottage were critically examined and rotted tubers were discarded from stocks in each observation.

Loss estimates

Four random samples were taken from every lot of potatoes. The diseased tubers were sorted out and counted on number and weight basis at 10 days interval. The weight of rotted tubers was done on pan balance. The per cent weight loss and per cent rottage incidence at each date were calculated.

Total percentage weight losses due to all diseases were calculated by formula given by Chester, K.S. (1950).

Percentage loss of individual diseases

$$= \frac{W_3}{W_2} \times 100$$

W_3 = Weight of diseased tubers of particular disease

W_2 = Total weight of the sample

RESULT AND DISCUSSION

A perusal of the data presented in Table-1 and 2 revealed that minimum dry rot incidence of 5.26 per cent was recorded in the cold storage method after 100 days of storage period followed by rustic cum diffuse light storage (10.82 %), country cold storage (14.20 %) and heap method storage (19.77 %). Charcoal rot infection was not observed in cold storage but maximum incidence of charcoal rot was observed in heap method (25.42 %) followed by country cold storage (20.95 %) and rustic cum diffuse light method (10.19 %). Soft rot incidence was minimum in cold storage method (11.05 %) followed by country cold storage (11.84 %), rustic cum diffuse light method (12.74 %) and heap method of storage (17.51 %).

Total rottage incidence ranged from 16.31 to 62.71 per cent (Fig.: 1) depending upon type of storage. The maximum rottage incidence was recorded in heap method of storage (62.71%) followed by country cold storage (46.99%), rustic cum diffuse light storage (33.75%) and cold storage method (16.31%).

Per cent weight loss due to dry rot was minimum in cold storage method (2.35 %) followed by rustic cum diffuse light method (2.92 %), country cold storage method (5.50 %) and heap method storage (7.05 %) while, weight loss due to charcoal rot was 3.82, 10.30 and 12.35 per cent in rustic cum diffuse light storage, country cold storage and heap method of storage, respectively. Weight loss due to soft rot was 4.90, 5.55, 5.95 and 8.05 per cent in country cold storage, rustic diffuse light storage, cold storage and heap method of storage, respectively (Fig.: 2).

Total weight losses due to storage diseases ranged from 8.30 to 27.45 % depending upon the type of storage. The minimum total weight loss was found to occur in cold storage (8.30 %) followed by rustic cum diffuse light storage (12.35 %), country cold storage (20.70 %) and heap method of storage (27.45 %) after 100 days of storage period.

Similarly, Khan *et al.* (1973) estimated weight losses of potato in cold storage at 22 locations amounted to about 2.2 – 9.5% due to dry rot, soft rot, common scab and physiological disorders such as hollow heart and freezing injury. Singh and Verma (1981) studied four storage environment at Patna (a) Kutcha farm store (b) Double walled Kutcha store (c) An under ground cellar (d) A cork insulated precooling room. Of which, rotting was lowest in pre-cooling room and highest in Kutcha store. Mehta and Kaul (1987) found 19.55 per cent weight loss of Kufri Badshah tuber stored at room temperature after 14 weeks (98 days) of storage. Shekhawat *et al.* (1992) reported that potato soft rot incidence ranged from 0.48 – 8.80% in cold storage and it was highest (8.8%) in the cultivar Kufri Badshah. Kang and Gopal (1993) studied ten advance stage hybrids and varieties of potato stored at ambient temperature and estimated per cent weight loss after 100 days in the year 1984 and 1985 was 20.6 and 18.8 per cent respectively in variety Kufri Badshah. The present findings were more or less similar in agreement with the above research workers.

Table 1. Effect of different storage structures on per cent rottage incidence and weight loss in var. Kufri Badshah

Storage period (days)	Cold Storage		Country Cold Storage		Heap Method		Rustic Cum Diffuse Light Method	
	% Rottage incidence	% Weight loss	% Rottage incidence	% Weight loss	% Rottage incidence	% Weight loss	% Rottage incidence	% Weight loss
10	0.000	0.000	2.180	0.900	2.82	0.870	3.821	1.450
20	0.526	0.220	2.190	0.950	9.955	1.700	3.821	0.975
30	1.052	0.550	2.730	1.150	5.084	2.200	3.184	1.075
40	2.105	1.150	1.640	0.650	5.084	2.230	1.910	0.875
50	1.578	0.770	4.920	2.100	5.649	2.600	1.273	0.450
60	2.105	1.140	6.010	2.600	6.215	2.800	3.821	1.375

70	2.105	1.100	6.010	2.700	7.344	3.300	3.184	1.275
80	2.105	1.100	7.650	3.350	8.474	3.700	3.821	1.475
90	1.578	0.700	7.650	3.550	9.040	4.000	3.184	1.180
100	3.157	1.570	6.010	2.750	9.040	4.050	5.732	2.225
Total	**16.31**	**8.30**	**46.99**	**20.70**	**62.71**	**27.45**	**33.75**	**12.35**

Table 2. Effect of different storage structures on per cent rottage incidence and weight loss in var. Kufri Badshah

Storage condition	Storage period (days)	% Rottage incidence			Total rottage incidence (%)	% Weight loss			Total weight loss (%)
		DR	CR	SR		DR	CR	SR	
Cold storage	100	5.26	-	11.05	16.31	2.35	-	5.95	8.30
Country cold storage	100	14.20	20.95	11.84	[illegible]99	5.50	10.30	4.90	20.70
Heap storage	100	19.77	25.42	17.51	62.71	7.05	12.35	8.05	27.45
Rustic cum diffuse light method	100	10.82	10.19	12.74	33.75	2.92	3.82	5.55	12.35

Where, DR = Dry rot, CR = Charcoal rot, SR = Soft rot.

Fig. 1. Indicates the Total Rottage Incidence (%) in different storage structures.

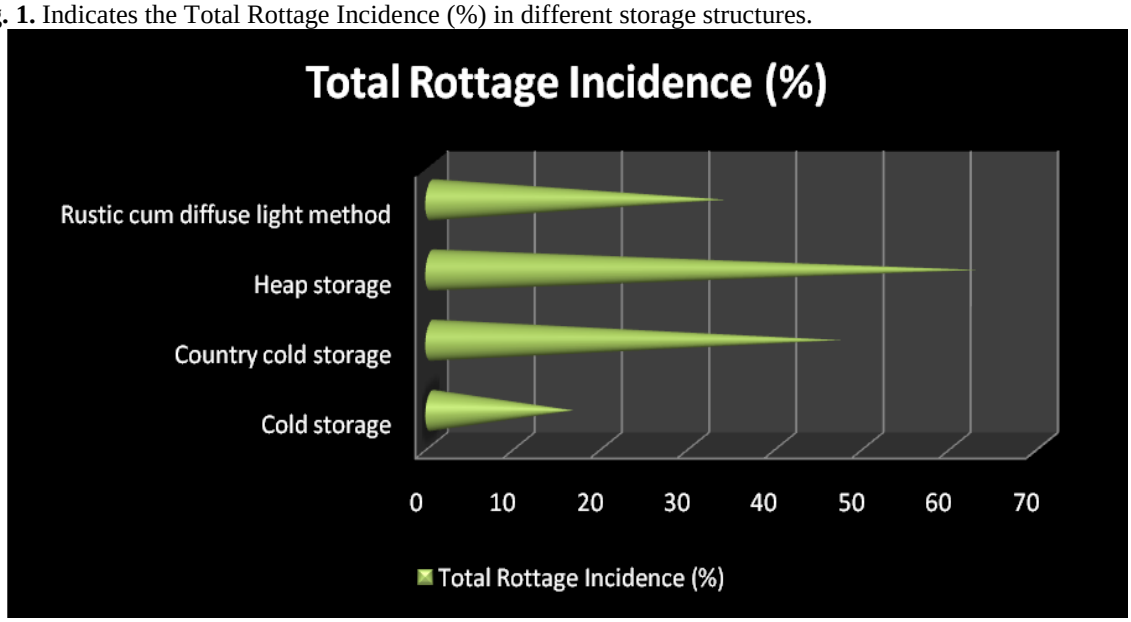
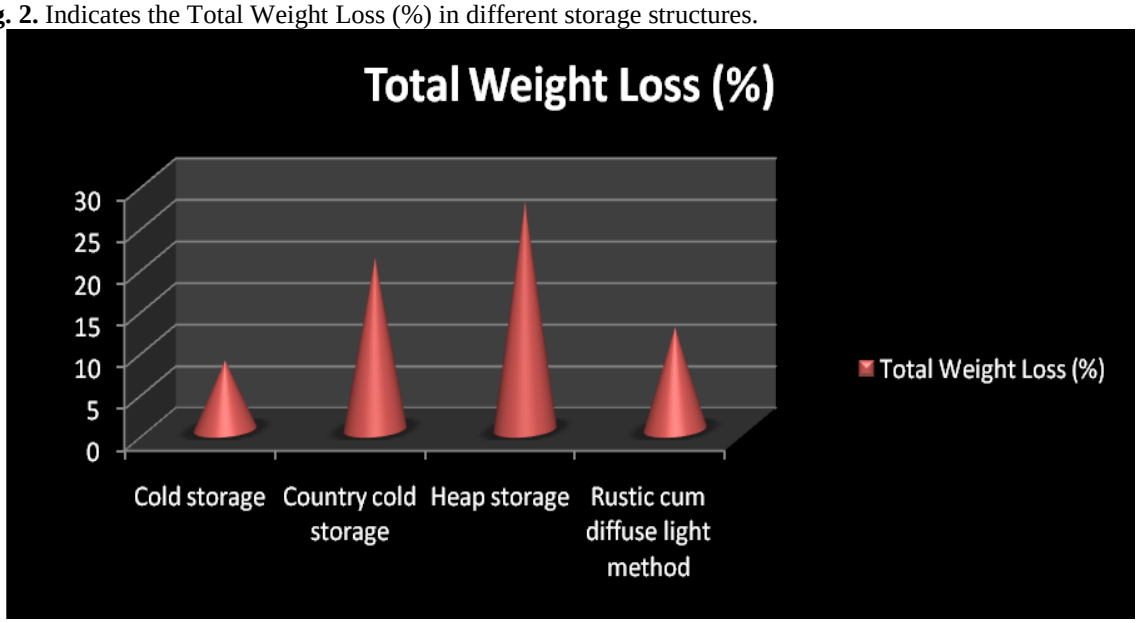


Fig. 2. Indicates the Total Weight Loss (%) in different storage structures.



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REFERENCES

Carnegie, S.F., Ruthven, A.D., Lindsay, D.A. and Hall, T.D. (1990). Effects of fungicides applied to seed potato tubers at harvest after grading on fungal storage diseases and plant development. *Ann. Appl. Biol.*, **116**: 61-72.

Chelkowski, J. (1989). Toxigenicity of *Fusarium* species causing dry rot of potato tubers. Pages 435-440 in: *Fusarium* Mycotoxins, Taxonomy and Pathogenicity. J. Chelkowski, ed. Elsevier Science Publishing Co., Inc., New york.

Chester, K.S. (1950). Plant disease losses: their appraisal and interpretation. *Pl. Dis. Reptr*. (Suppl.) **193:** 190-362.

Hooker, W.J. (1981). Compendium of Potato Diseases. *American Phytopathological Society*, St.Paul, MN.

Khan, A.A., Rahman, S. and Kamaluddin, G. (1973). A preliminary survey of the diseases of potatoes in cold storage in Bangaladesh. *Bangaladesh Journal of Biological and Agricultural Sciences,* **2**: 17-18.

Kang, G.S. and Gopal, Jai. (1993). Differences among potato genotypes in storability at high temperature after different periods of storage. *J. Indian Potato Assoc.*, **20** (2): 105 110.

Mehta, Ashiv. and Kaul, H.N. (1987). Storage behaviour of potato cultivars in evaporatively cooled store. *J. Indian Potato Assoc.*, **14**: 69-71.

Singh, M. and Verma, S.C. (1981). Post harvest technology and utilization of potato. In Hari Kishore Ed. Proceedings of International Symposium, Shimla, New Delhi 1979; International Potato Centre, New Delhi. pp. 1-14.

Shekhawat, G.S., Singh, Rajpal., Gadewar, A.V. and Rai, R.P. (1992). Ecology and management of common scab and soft rot. Annual Scientific Report (1991-92), Central Potato Research Institute, Shimla. pp. 105-106.

Thirumalachar, M. J. (1955). Incidences of charcoal rot of potatoes in Bihar (India) in relation to cultural conditions. *Phytopath*., **45**: 91-93.

Weerasinghe, S.P.R. (1985). In "Research for the potato in the year 2000." Proceedings International Congress, International Potato Centre, Lima, Peru. pp. 199.

RESEARCH ARTICLE

INFLUENCE OF PLANT EXTRACTS ON LARVAL AND PUPAL DEVELOPMENT OF *ELICOVERPA ARMIGERA* (HUBNER)

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Abstract: Fourteen plant extracts namely mango ginger rhizome, bergera leaf, calotropis leaf, tulsi leaf, thusa leaf, dhatura leaf, ipomia leaf, neem leaf, garlic leaf, ginger rhizome, bel leaf, harsingar leaf, neem cake and turmeric rhizome were tested for their toxic effect against the gram pod borer, *Helicoverpa armigera* (Hubner). Each extract was tested in three oncentrations (100, 500 and 1000 ppm) incorporated in the semisynthetic diet. The weight of larval and pupal development were observed on different concentration in different interval.

Keywords: Plant, Extract, Mango, Leaf

INTRODUCTION

In recent past research work on many plant species for their insecticidal properties and their possible utilization for the insect pest control attracted the attention of Entomologists. This is mainly due to awareness towards of the environment, which is being polluted by the use of synthetic organic insecticides. The possibilities of their utilization for the pest control have attracted attention in last two-three decades. The research work on properties like toxicant, antifeedant and growth regulators of various plant species has been initiated on many insect species of economic importance. In the last two decades crude and refined extracts of different plant parts, particularly of neem has been used against the defoliators and sucking insects.

For extracting the active ingredient solvents like water, ethanol, methanol, acetone, hexane, petroleum ether, chloroform etc. has been used. In the present investigation ethanol extract of common plant materials were tested against the larval and pupal development of gram caterpillar, *Helicoverpa armigera* (Hubner).

MATERIAL AND METHOD

The present investigations were undertaken to test the efficacy ethanol extract of plants on the larval and pupal development of *Helicoverpa armigera* (Hubner) under laboratory condition in the Department of Entomology College of Agriculture, Gwalior (M.P.).

Extracts of the following fourteen plants were tested against control.

S.No.	Extracts	Botanical name
1	Mango ginger rhizome	*Curcuma ameda*
2	Bergera leaf	*Murraya koiningi*
3	Calotropis leaf	*Calotropis gigantia*
4	Tulsi leaf	*Ocimum adscendens*
5	Thusa leaf	*Thusa oxidentalis*
6	Dhatura leaf	*Dhatura fastusa*
7	Ipomia leaf	*Ipomia carnia*
8	Neem leaf	*Azadirachta indica*
9	Garlic leaf	*Allium sativum*
10	Ginger leaf	*Zingibar officinale*
11	Bel leaf	*Aegel marmelos*
12	Harsingar leaf	*Nyctanthus*
13	Neem cake	*Azadirachta indica*
14	Turmeric rhizome	*Curcuma longa*

Ethanol extracts were prepared from the dried powders of the plant materials. The extracts were dried in Petri dishes, at room temperatures and were kept in the incubators at 60^{o}C for complete drying till constant weight were obtained. The dried materials were dissolved in known quantity of ethanol for further use. Semi synthetic diet for mass rearing of *Helicoverpa armigera* (Hubner) was prepared with following contents -

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S.No.	Diet constituent	Quantity required (gm)	Purpose
1.	Bengal gram flour	100.00	Basal food
2.	Agar-agar	12.80	Solidification
3.	Yeast tablet	30.00	Digestion of food material
4.	Wessons salt mixture	7.20	All essential nutrients
5.	Sorbic acid	1.00	Preservative
6.	Methyl paraben	2.00	Anti-fungal agent
7.	Choline chloride	0.72	Fat for better growth
8.	Strepomycine (SO_4)	0.04	Antibacterial
9.	Ascorbic acid	3.20	Increased fecundity
10.	Vitamin drops	1.00ml	Better growth
11.	Formalin (40%)	1.00ml	Antiviral
12.	Distilled water	720.00ml	

The plant extracts were mixed thoroughly @ 100, 500 and 1000 ppm of dried power in 50 ml of semi-solid diet and the mixture was poured in ten specimen tubes (5x 3.5 cm) @ 5ml/tube. The specimen tubes were kept open for eight hours to avoid access of moisture. One, two days old larva was released in each specimen tube and was covered with the perforated lid. Ten such larvae were kept for each concentration and for the control. There were three replications for each treatment. Observations on the mortality were recorded 3, 9, 15 and 21 days after released. Data were subjected angular transformation (arc sine), for statistical analysis.

RESULT AND DISCUSSION

The effect of fourteen plant extracts were tested against the larval and pupal development of *Helicoverpa armigera* (Hubner). Three concentrations viz. 100, 500 and 1000 ppm of each plant products were tested by mixing them in the artificial diet. The results are described here with-

Effect on development

There was no marked on variation in larval period due the treatments. Different doses of the extracts also did not influenced the larval developmental period.

Taking into the concentration the plant extracts and their doses together the larval development ranged from 19.1 days in 500ppm of turmeric rhizome extracts to 23.0 days in 1000 ppm of mango ginger rhizome and garlic leaf extracts as against 21.5 days in control (Table 1).

Table 1. Effect of plant extracts and their concentrations on the larval development (in days) of *Helicoverpa armigera*

S.No.	Treatment	Per cent larval development in concentration of			Mean
		100 ppm	500 ppm	1000 ppm	
1.	Mango ginger rhizome	20.3	19.2	23.0	20.8
2.	Bergera leaf	21.0	20.0	20.5	20.5
3.	Calotropis leaf	20.0	21.0	21.0	20.7
4.	Tulsi leaf	20.3	20.0	20.0	20.1
5.	Thusa leaf	20.0	-	-	20.0
6.	Dhatura leaf	20.0	-	-	20.0
7	Ipomia leaf	20.7	20.7	-	20.7
8.	Neem leaf	20.0	21.5	22.0	21.1
9.	Garlic leaf	19.2	19.2	23.0	20.5
10.	Ginger rhizome	21.0	20.7	20.0	20.7
11.	Bel leaf	20.4	20.0	20.0	20.1
12.	Harsingar leaf	19.5	20.0	19.2	19.6
13.	Neem cake	19.3	20.6	-	19.9
14.	Turmeric rhizome	19.7	19.1	20.6	19.8
	Mean	20.1	20.1	20.9	20.3
	Control	-	-	-	18.5

Effect on larval weight

The weight of the larvae were taken 5,10 and 15 days after release the artificial diet treated with different plant extracts.

The table 2. Depicted that the larval weight in the treatments were lower than the control except in thusa, ginger and dhatura leaf. In ipomia leaf extracts the larval weight was the minimum (93.7mg)

followed by tulsi leaf, mango ginger rhizome and neem leaf extracts. In general the highest concentration had the lowest weight while the lowest concentration had the highest weight. Among the different concentrations the minimum larval weight was observed in 500ppm of neem leaf extracts followed by 500ppm of ipomia leaf extracts and in 1000ppm of mango ginger rhizome extracts. The maximum weight was recorded in 500ppm of ginger rhizome extracts.

Ten days after release higher larval weight in comparision to control was recorded in bergera (313.0 mg) and dhatura leaf extracts (385.0mg). The minimum larval weight was observed inneem leaf extracts followed by neem cake extracts and harsingar leaf extracts.The difference in the larval weight due the concentration was negligible. Cosidering the different leaf extracts and their concentrations together, the minimum larval weight was recorded in 100ppm of neem extracts followed by 500ppm of neem leaf extracts and 500ppm of harsingar extracts. The maximum larval weight (420mg) was in 1000ppm of bergera leaf extracts (Table 3).

Fifteen days after the release the larval weight in the treatments were less than in the control. The minimum weight (156.7mg) was recorded in neem leaf extracts followed by harsingar leaf extracts and neem cake leaf extracts.The maximum larval weight (343.3mg) was observed in bergera leaf extracts fooled by bel leaf extracts. Considering the extracts and their concentrations together, the maximum larval weight was recorded in 1000ppm in bergera leaf extracts followed by 100ppm of bel leaf extracts (400mg). the minimum weight was recorded in 500ppm of harsingar leaf extracts and 100 and 500ppm of neem leaf extracts (Table 4).

Weight of pupae

The table 5 indicated that the average pupal weight in the treatments lesser than in the untreated control. The minimum weight was recorded in neem leaf extracts followed by harsingar leaf neem cake leaf extracts and the maximum (274.7mg) in bergera leaf extracts followed by bel leaf extracts and turmeric rhizome powder extracts. Among different concentrations the minimum weight was observed in 500ppm followed 100ppm and 1000ppm. When the plant material and their concentrations were considered the least pupal weight was attended in 100 and 500ppm of neem leaf extracts followed by harsingar leaf extracts.

The present findings are more or less with the earlier workers Breuer and Schmidt **(**1990) who studied the effect of *Melia azadarach* extracts on *Spodoptera frugiperda* and Kulakrni (1998) observed the feeding deterrence of some plant extracts against poplar defoliator *Clostera cupreata.* Prabhakar *et. al* **.** (1986) who evaluated the neem seed extracts against larvae of the cabbage looper and beet army worm. Mesfin Wondafrash *et al.* (2012) who also observed the Neem, *Azadirachta indica* (A. Juss) extracts negatively influenced growth and development of African Bollworm, *Helicoverpa armigera.* Panneerselvam, *et al.* (2013) studied the Biopesticidal Effect of Ethyl Acetate Leaf Extracts of Datura metel L.(Solanaceae) on the larvae of *Helicoverpa armigera.*

Table 2. Effect of different plant extracts on the larval weight (5 days after release)

S.No.	Treatment	Weight of larvae (mg) in concentration of			Mean
		100 ppm	500 ppm	1000 ppm	
1.	Mango ginger rhizome	144	104	082	110.0
2.	Bergera leaf	116	178	206	116.7
3.	Calotropis leaf	245	144	100	163.3
4.	Tulsi leaf	101	112	090	101.0
5.	Thusa leaf	238	-	-	230.0
6.	Dhatura leaf	255	-	-	255.0
7	Ipomia leaf	110	081	090	093.7
8.	Neem leaf	096	065	170	110.3
9.	Garlic leaf	217	252	170	213.0
10.	Ginger rhizome	237	270	255	254.0
11.	Bel leaf	105	196	100	133.7
12.	Harsingar leaf	190	220	100	170.0
13.	Neem cake	125	125	-	125.0
14.	Turmeric rhizome	133	140	125	132.7
	Mean	165.1	157.3	135.3	161.9
	Control	-	-	-	230.0

Table 3. Effect of different plant extracts on the larval weight (10 days after release)

S.No.	Treatment	Weight of larvae (mg) in concentration of			Mean
		100 ppm	500 ppm	1000 ppm	
1.	Mango ginger rhizome	220	301	334	285.0
2.	Bergera leaf	183	336	420	313.0
3.	Calotropis leaf	290	185	160	211.7
4.	Tulsi leaf	224	150	185	186.3
5.	Thusa leaf	253	-	-	253.0
6.	Dhatura leaf	385	-	-	385.0
7	Ipomia leaf	210	207	170	195.7
8.	Neem leaf	080	085	245	136.7
9.	Garlic leaf	240	260	230	243.3
10.	Ginger rhizome	253	250	240	247.7
11.	Bel leaf	370	290	210	290.0
12.	Harsingar leaf	210	090	160	153.3
13.	Neem cake	195	100	-	147.5
14.	Turmeric rhizome	200	310	260	256.7
	Mean	236.7	213.7	237.7	236.0
	Control				310.0

Table 4. Effect of different plant extracts on the larval weight (15 days after release)

S.No.	Treatment	Weight of larvae (mg) in concentration of			Mean
		100 ppm	500 ppm	1000 ppm	
1.	Mango ginger rhizome	-	213	340	276.5
2.	Bergera leaf	255	330	445	343.3
3.	Calotropis leaf	240	200	175	205.0
4.	Tulsi leaf	242	202	220	21.3
5.	Thusa leaf	260	-	-	260.0
6.	Dhatura leaf	250	-	-	250.0
7	Ipomia leaf	250	192	190	210.7
8.	Neem leaf	100	100	270	156.7
9.	Garlic leaf	260	320	-	290.0
10.	Ginger rhizome	265	260	270	265.0
11.	Bel leaf	400	330	280	336.7
12.	Harsingar leaf	240	100	210	183.3
13.	Neem cake	240	150	-	195.0
14.	Turmeric rhizome	260	350	310	306.7
	Mean	250.9	228.9	271.0	250.0
	Control				430.0

Table 5. Effect of different plant extracts on the pupal weight

S.No.	Treatment	Weight of pupal (mg) in concentration of			Mean
		100 ppm	500 ppm	1000 ppm	
1.	Mango ginger rhizome	-	170	272	221.0
2.	Bergera leaf	204	264	356	274.7
3.	Calotropis leaf	192	160	140	164.0
4.	Tulsi leaf	194	162	176	177.3
5.	Thusa leaf	208	-	-	208.0
6.	Dhatura leaf	200	-	-	200.0
7	Ipomia leaf	200	154	152	186.7
8.	Neem leaf	080	080	216	125.3
9.	Garlic leaf	208	256	-	232.0
10.	Ginger rhizome	212	208	216	212.0
11.	Bel leaf	320	264	224	269.3

12.	Harsingar leaf	192	080	168	146.7
13.	Neem cake	192	120	-	156.0
14.	Turmeric rhizome	208	280	248	245.3
	Mean	201.0	183.0	217.0	200.0
	Control				314.0

REFERENCES

Breuer, M. and Schmidt, G.H. (1990). Studies on the effect of *Melia azadarach* extracts on *Spodoptera frugiperda* Mitteilungen-der-Deuschen Gesellschaft-fur-Allgemeine und Angewandte. *Entomologie*, 7:4-6,419-429.

Kulakrni, N. (1998). Feeding deterrence of some plant extracts against poplar defoliator *Clostera cupreata* (Butt). *Insect Environment* 3(4) :98.

Mesfin Wondafrash and Emana Getu and Geremew Terefe 1 (2012). Neem, *Azadirachta indica* (A. Juss) Extracts Negatively Influenced Growth and Development of African Bollworm, *Helicoverpa armigera* (Hubner) (Lepidoptera: Noctuidae) *Academic Journal of Entomology* 5 (1): 22-27,

Panneerselvam, A.; Ramya, S.; Gopinath, K., Periyathambi, N., Jayakumararaj, R., and Aruna Devaraj, (2013). Biopesticidal Effect of Ethyl Acetate Leaf Extracts of Datura metel L.(Solanaceae) on the larvae of *Helicoverpa armigera* (Hübner) *Int. J. Pharm. Sci. Rev. Res*., 18(1), , 150-154.

Prabhakar, N.; coudriet, D.L.; Kishaba, A. N. and Meyerdirk, D.E. (1986). Laboratory evaluation of neem seed extracts against larvae of the cabbage looper and beet army worm. *J. of Econ. Ent.* 79(1) : 39-41.

RESEARCH ARTICLE

GROWTH RESPONSE IN *LYCOPERSICON ESCULENTUM* MILL. ON EXPOSURE TO ENDOSULFAN AND MALATHION

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Abstract: The effect of three different concentrations (0.05%, 0.15% and 0.25%) of endosulfan and malathion was observed on the growth of two varieties of tomato, viz. Pusa Ruby and Pusa Early Dwarf. The length and weight of root and shoot were studied on treatment with the two pesticides. It was observed that at low concentration of malathion the growth was stimulated in both root and shoot of both the varieties. On the other hand growth was reduced at high concentrations with both endosulfan and malathion. Reduction was more in root than shoot. Root weight ratio, shoot weight ratio and root shoot ratio were also analyzed. A significant effect was observed with endosulfan and the effect with malathion were less deleterious.

Keywords: Endosulfan, Malathion, Tomato, Growth, Root, Shoot

INTRODUCTION

India is the second largest producer of fruits and vegetables in the world. Majority of Indians are vegetarians with a per capita consumption of 135g per day as against recommended 300g per day. In near future there is need of around 5-6 million tons of food to feed our 1.3 billion Indian population expected by the year 2020 (Dhaliwal e*t al.*, 2010). There is an increase in severity of insect pest problems on agricultural crops in our country. Food plants are damaged by more than 10,000 species of insects. Hence, use of pesticide became essential for easy and quick control of pest. For better production of crops and aesthetic value, farmers are using a large amount of pesticides during the entire period of growth of vegetables even at fruiting stage unaware of the affect on the plant. In many cases, the treatment influences the crop by changing the morphology, affecting growth rate, physiology and yield of the plant product. Prolonged use of pesticide can cause the pest species to develop genetic resistance to it. Use of pesticides raises toxicological effects on morphological, physiological and genetic factors in non target organisms and environment as well (Kumar and Chaudhary, 2012). Organochlorines and organophosphates are widely used as pesticides all over the world. In the present study, effect of endosulfan, an organochlorine and malathion, an organophosphate is tested on two crop varieties of tomato plant. Tomato fruit borer, *Helicoverpa armigera* is an important insect which cause considerable losses in quantity and quality of the crop. Both endosulfan and malathion are effective insecticides used against it.

MATERIAL AND METHOD

The present study was carried out in the field and laboratory of Department of Botany, D.N. College, Meerut. Tests were conducted on two varieties of tomato (*Lycopersicon esculentum* Mill. var. Pusa Ruby (PR) and Pusa Early Dwarf (PED)). Seeds were procured from certified seed centre of Meerut. The pesticides selected for investigation were Endosulfan 35% EC and Malathion 50% EC. Three different concentrations were made for each chemical insecticide, viz. 0.05%, 0.15% and 0.25% with distilled water by using Pearson's square method (Wagner and Stanton, 2006). Tap water was used as control. Simple randomized block design was followed for growing the crops. The field was divided into six plots for each variety, each being 1x1 meter^2 for different pesticide concentrations. One plot was selected for control. The plots were kept 25cm apart from each other. The plants were treated with different pesticide solutions from 15th day of transplantation to the maturity of the crop. The treatment was given with the help of a sprayer at an interval of 30 days. Observations were made at plant age of 90 day for plant growth parameters and the root shoot ratio. The length of root and shoot were separately measured by means of an ordinary ruler and the total plant length was the sum of their individual lengths. Root and shoot were weighed separately on an electronic balance for their fresh weight and oven dried before weighing for their dry weight. Root shoot ratio was analyzed by using the following formulae –

$$\text{Root weight ratio (RWR)} = \frac{\text{dry weight of root (g)}}{\text{whole plant dry weight (g)}}$$

$$\text{Shoot weight ratio (SWR)} = \frac{\text{dry weight of shoot (g)}}{\text{whole plant dry weight (g)s}}$$

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$$\text{Shoot root ratio (SRR)} = \frac{\text{dry weight of shoot (g)}}{\text{dry weight of root (g)}}$$

RESULT AND DISCUSSION

The increasing dose of pesticide caused reduction in length and weight, both fresh and dry of the plant. High concentration of endosulfan and malathion produced a pronounced reduction in root, shoot and total plant length, however the root length was found to be decreased more than the shoot length. Maximum inhibition in shoot length was recorded at highest concentration of endosulfan (0.25%) and it was 31.98 and 27.07 percent in comparison to control of PR and PED respectively. Similar results were obtained in case of root length where inhibition was 35.92 and 33.38 percent in comparison to control of 90 day old plants of PR and PED respectively (Table 1 and 2). However, at highest concentration of malathion the reduction in shoot length was 10.67 and 10.23 percent and the reduction in root length was 11.67 and 10.85 percent respectively in PR and PED in comparison to control of 90 day old plants. It was also observed that malathion at lowest concentration (0.05%) stimulated the growth of the plant. Maximum stimulation was recorded in PED which was 3.67 percent in root length and 2.15 percent in shoot length followed by PR which was 0.66 percent in root length and 0.37 percent in shoot length.

In PR the percent decrease in fresh weight of shoot was observed to be 3.62, 18.26 and 35.10 at 0.05%, 0.15% and 0.25% concentration of endosulfan respectively. The corresponding loss due to similar concentrations of endosulfan in PED was recorded as 3.54, 17.40 and 34.35 percent. A slightly enhanced values of fresh weight were recorded at 0.05% of malathion although at 0.15% and 0.25% there was a reduction of 3.62 and 8.92 percent in PR and 3.55 and 8.74 percent in PED respectively (Table 1 and 2). The observations revealed that from the commencement of exposure, the pesticide had more influence on root fresh weight than the shoot and it persisted till the end of the experiment. At 0.05%, 0.15% and 0.25%, the root fresh weight decreased by 5.04, 20.09 and 39.66 percent respectively with endosulfan and 4.36 and 17.40 percent with 0.15% and 0.25% of malathion in PR. Similarly, there was 4.36, 5.11 and 9.17 percent reduction with endosulfan and 10.21 and 13.72 percent with malathion in PED.

Dry weights of root and shoot showed appreciable reduction as compared to the fresh weight and the reductions were found to be increased with an increase in the exposure of pesticide. The percent dry weight reduction recorded in the root of PR was 4.62, 25.35 and 39.98 respectively at the three concentrations of endosulfan (Table 1). The corresponding values for PED were 4.43, 24.76 and 38.38 percent (Table 2). In case of malathion, the percent reduction was 8.75 and 13.55 in PR while it was 4.64 and 24.28 in PED respectively at 0.15% and 0.25% concentration. Shoot dry weight in PED showed a percent reduction of 3.78, 21.76 and 36.79 while it was 3.81, 21.92 and 37.06 percent in PR for 0.05%, 0.15% and 0.25% of endosulfan respectively. For malathion, the reduction in dry weight of shoot at 0.15% and 0.25% concentrations was 3.85 and 12.03 percent respectively in PR and 3.82 and 11.94 in PED. On the contrary, with 0.05% malathion a stimulatory effect was observed and a slight increase in root and shoot dry weight was recorded which was 5.89 and 0.70 percent in PR and 24.45 and 4.18 percent in PED (Table 1 and 2).

The above results were also analyzed by calculating the root weight and shoot weight ratio. It was found that there was a slight increase in shoot weight ratio in plant of both the varieties with the enhancement of pesticide dose. Shoot root ratio followed the same trend. On the contrary, the root weight ratio was found to be reduced under high concentration of pesticide suggesting that the roots were more susceptible to pesticide (Figure 1 and 2).

The pesticides when sprayed on plants are translocated to various parts (Sinha, 1985; Enayathullah and Mariappan, 1989). Exposure to pesticide at lower concentration may be responded by the plant as enhanced activity of enzymes, greater resource mobilization and stimulated growth response (Kumar and Khanna, 2006; Trifonova, 2012). With the onset of chemical stress caused by the pesticides, plants initially try to mitigate the effect of chemical exposure by optimal resource utilization, nutrient management, alterations in biomass allocation, etc. At high concentration reduction in growth is observed in shoot and root length which may be the result of reduced tolerance and enhanced phytotoxicity (Raut et al., 2012). Reduction in cell growth might be the cause of reduced shoot and root parameters (Chauhan et al., 2002). Pesticide treatment affect the process of assimilate distribution as observed by altered root weight ratio (RWR) and shoot root ratio (SRR). There occurs a negative correlation between shoot weight ratio (SWR) and root weight ratio (RWR). This may be due to reduced translocation of food material from the leaves to the roots. Hence, there might be greater reduction in root growth (Osborne, 1986; Verma *et al*., 1997; Roberts *et al*., 1997). The decrease in fresh and dry weight are attributed to inhibited growth (Clarkson *et al*., 1982; Breeze and West, 1987; Thorn and Perry, 1987)

Figure 1. Shoot weight ratio (SWR), Root weight ratio (RWR) and Shoot root ratio (SRR) in Pusa Ruby exposed to malathion and endosulfan at 90d of plant age

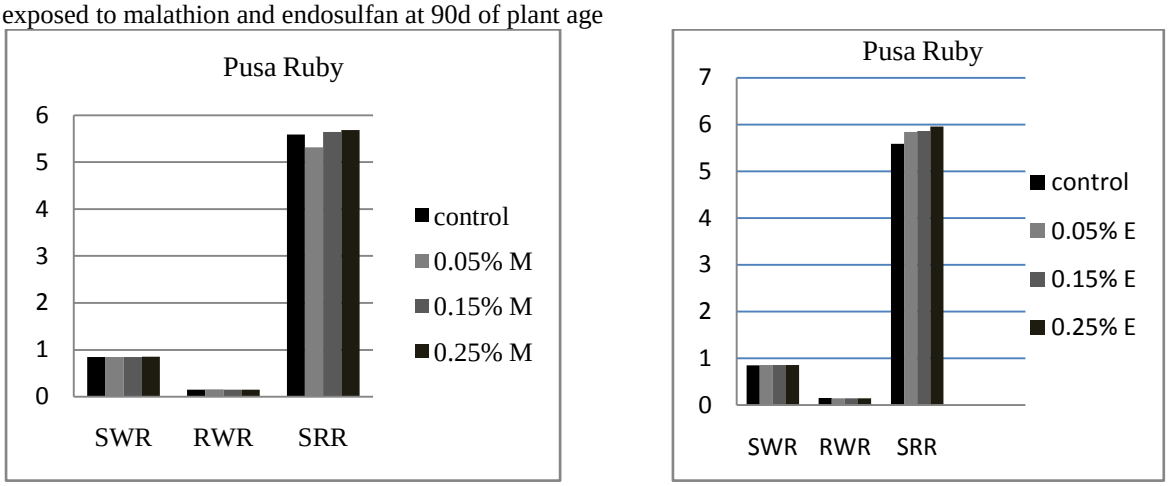

Figure 2. Shoot weight ratio (SWR), Root weight ratio (RWR) and Shoot root ratio (SRR) in Pusa Early Dwarf exposed to malathion and endosulfan at 90d of plant age

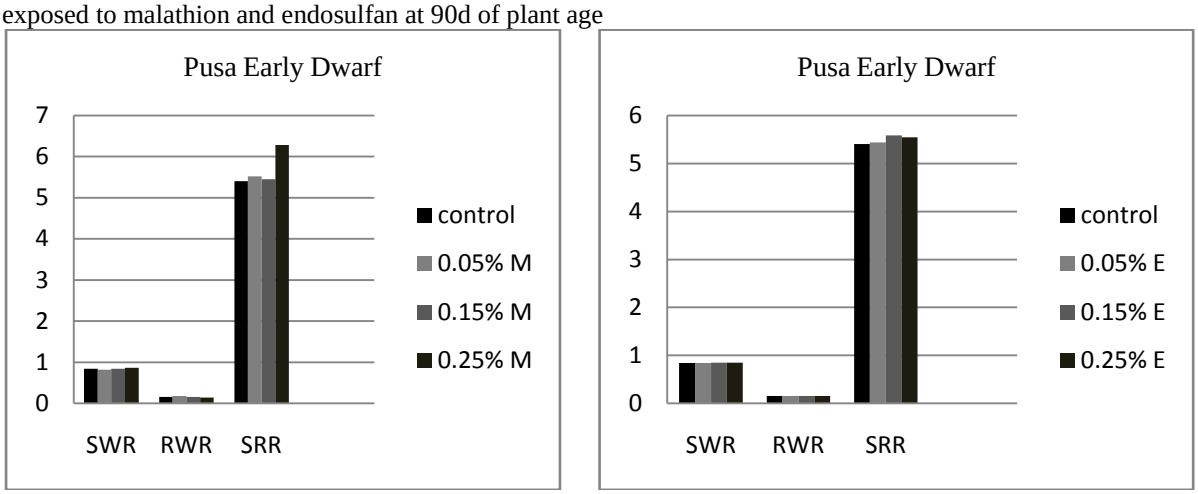

Table 1. Growth response of Pusa Ruby exposed to malathion and endosulfan at 90d of plant age

Attribute	Control	Malathion			Endosulfan			CD	CD
		0.05%	0.15%	0.25%	0.05%	0.15%	0.25%	5%	1%
Root length (cm)	30.400 ±0.132	30.601 ±0.625	28.905** ±1.068	26.850** ±1.240	28.916** ±0.725	23.745** ±0.115	19.480** ±0.252	0.385	0.918
Shoot length (cm)	53.425 ±4.880	53.626 ±5.265	51.800 ±5.126	47.720 ±4.940	51.811 ±4.865	43.825 ±4.005	36.335* ±3.410	14.249	33.964
Root f.wt. (g)	14.982 ±1.788	15.183 ±1.626	14.216 ±1.526	13.608 ±1.106	14.227 ±1.602	11.972 ±1.120	9.040* ±1.004	5.220	12.444
Shoot f.wt. (g)	108.463 ±5.526	109.664 ±4.988	104.526 ±5.480	98.780 ±4.966	104.537 ±5.212	88.639* ±4.042	70.390** ±4.093	16.135	38.460
Root d.wt. (g)	5.107 ±0.108	5.408 ±0.852	4.660* ±0.962	4.415* ±0.513	4.871 ±0.912	3.812** ±0.886	3.065** ±0.450	0.315	0.751
Shoot d.wt. (g)	28.542 ±2.071	28.744 ±4.206	27.443 ±3.186	25.108 ±2.004	27.454 ±4.176	22.284** ±1.988	17.962* ±2.846	6.047	14.414

Values are in mean, ± standard deviation, CD: critical difference, * significant at 5% level, ** significant at 1% level

Table 2. Growth response of Pusa Early Dwarf exposed to malathion and endosulfan at 90d of plant age

Attribute	Control	Malathion			Endosulfan			CD	CD
		0.05%	0.15%	0.25%	0.05%	0.15%	0.25%	5%	1%
Root length (cm)	32.714 ±2.245	33.915 ±3.412	31.219 ±3.575	29.164 ±3.520	31.230 ±2.891	26.059* ±2.955	21.794* ±2.850	6.555	15.625
Shoot length (cm)	55.739 ±4.804	56.940 ±5.117	54.114 ±5.605	50.034 ±4.660	52.125 ±4.712	46.139 ±4.615	40.649* ±3.810	14.027	33.435

Root f.wt. (g)	17.296 ±0.957	19.127 ±0.946	15.530 ±0.906	14.922* ±0.687	16.541 ±0.911	14.286* ±1.012	11.354* ±0.886	2.794	6.660
Shoot f.wt. (g)	110.777 ±5.166	112.978 ±5.174	106.840 ±5.846	101.094 ±4.636	106.851 ±4.779	90.953* ±4.896	75.804* ±4.332	15.084	35.955
Root d.wt. (g)	5.320 ±0.380	6.621* ±0.572	5.073 ±0.474	4.028* ±0.638	5.084 ±0.519	4.025* ±0.718	3.278* ±0.426	1.109	2.644
Shoot d.wt. (g)	28.755 ±1.129	29.957 ±2.216	27.656 ±3.606	25.321* ±2.957	27.667 ±3.563	22.497* ±3.662	18.175** ±3.027	3.296	7.857

Values are in mean, ± standard deviation, CD: critical difference, * significant at 5% level, ** significant at 1% level

CONCLUSION

It was inferred from the study that both malathion and endosulfan have an impact on the growth of the two varieties of tomato, viz, Pusa Ruby and Pusa Early Dwarf. The low concentration of malathion is stimulatory while at high concentration it shows inhibitory effect. Endosulfan was inhibitory in all cases. The plant growth with respect to shoot and root was found to be significantly affected, and the effect was more on the root than shoot. It was also concluded that of the two varieties of tomato, PED was relatively more resistant than PR.

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REFERENCES

Breeze, V.G. and West, C.J. (1987) Effect of 2, 3-D Butyl vapour on the growth of six crop species. Ann. Appl. Biol. 111(1): 185-192

Chauhan, S., Chauhan, S.V.S. and Chauhan, S. (2002) Pesticide induced cytological changes in *Allium cepa* root tip cell. Plant Archives 2(2): 189-192

Clarkson, D., Bull, P.B. and Moles, D.J. (1982) Effect of two granular nematicides on growth and nodulation of *Arachis hypogea* L. Plant and Soil 66: 413-416

Dhaliwal, G.S., Jindal, V. and Dhawan, A.K. (2010) Insect pest problems and crop losses: changing trends. Ind. J. Ecol. 37(1): 1-7

Enayathullah, S. and Mariappan, V. (1989) Systemic uptake and translocation of new fungicides panoram and vitavax in sorghum. Pesticides 23(3): 26

Kumar, G. and Chaudhary, N. (2012) Mitotoxic effect of 2,4 –D and endosulfan in root meristems of *Hordeum vulgare.* Chromos. Bot. 7(2):73

Kumar, S. and Khanna, A.S. (2006) Effect of neem based products on root-knot nematode *Meloidogyne incognita* and growth of tomato. Nematol. Medit. 34: 141-146

Osborne, L.S. (1986) Dip treatment of tropical ornamental foliage cuttings in fluvalinate to prevent spread of insect and mite infection. J. Econ. Entom. 79(2): 465-470

Raut, P.D, Chonde, S.G, Bhosale, P.R. and Darure, M.V. (2012) Effect of residual concentration of endosulfan on the nitrogenase enzyme activity in *Arachis hypogeal.* Annl. Biol. Res. 3(1): 192-195

Roberts, P.D., Berger, R.D., Jones, J.B., Chandler, C.K. and Stall, R.E. (1997) Disease progress, yield loss and control of *Xanthomonas fragarie* on the strawberry plants. Plant Disease 81(8): 917-921

Sinha, S. (1985) Field screening of insecticides for seed treatment of pulses. *Vigna radiata* (L.) Wilczeck. Seed Res. 13(1): 120-128

Thorn, C.W. and Perry, M.W. (1987) Effect of chemical removal of grasses from pasture lays on pasture and sheep production. Aust. J. Exp. Agric. 27(3): 349-358

Trifonova, Z.T. (2012) Effect of neem preparation on reproduction of nematode *Globodera rostochiensis* and growth of potato. J. Agric. Sci. 57(2): 91-97

Verma, Y., Hargan, M. C., Bhatt, A. and Ruparelia, S.G. (1997) Effect of synthetic pyrethroids on the root growth of *Alium cepa* Environ. Ecol. 15(3): 506-508

Wagner, J. and Stanton, T.L. (2006) Formulating relations with the Pearson square no. 1.1618 Colarado State University Extension www.ext.colostate.edu.

RESEARCH ARTICLE

EVALUATION OF SITE-SPECIFIC NUTRIENT MANAGEMENT APPROACH IN TRANSPLANTED RICE UNDER SUB-HUMID CONDITION OF SOUTHERN RAJASTHAN

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Abstract: Site-specific nutrient management (SSNM) in a new approach that provides the proper quantity and timely supply of nutrients to the crop plants according its requirement in the existing soil and climate. With this background, a field experiment was conducted on a fixed site at Agriculture Research Station (MPUAT), Banswara, Rajasthan, during two consecutive *kharif* seasons of 2008 and 2009 to evaluate the plant based SSNM strategy for rice crop. The experiment consisted of seven treatments with the application of different category of nutrients, including control and State Fertilizer Recommendation (SFR). SSNM treatment (T_4) gave a maximum grain yield (74.00q ha^{-1}) which was recorded significantly 10, 12, 30, 55 and 58% higher compared to the Improved fertilizer recommendation (T_3), State fertilizers recommendation (T_2), SSNM-P (T_6), SSNM-N (T_5), and absolute control (T_1), respectively. The grain yield increased in T_4 could be recorded the maximum tillers (352 m^{-2}), Panicles (340 m^{-2}), grains (150.30 $panicle^{-1}$). The maximum B: C ratio (3.54) was also recorded with SSNM (T_4). The yield lower in N and P omission from SSNM treatments indicated that there is large response to added N but low response to added P due to variation in indigenous soil nutrient supply. Hence, high variability to applied N, P, K suggests the necessity of SSNM to improve the productivity of rice crop.

Keywords: Rice, SSNM, Grains yield, Nutrient

INTRODUCTION

Rice is one the most staple food of about 50% of the world's population and its area is concentrated mostly in South East Asia. Rice contributes around 45 per cent of India's total food grain production and it continues to hold the key for food sufficiency in the country. The sub-humid area of southern Rajasthan is also a major rice-growing zone during rainy season. Being the cereal crops, the nutrient requirement of rice is very high and due to imbalanced and unscientific nutrient management practice, the productivity of the crop is realized to decline with the available genetic resources. The conventional and injudicious fertilizer application practices are not only reduces nutrient use efficiency, but also causes nutrient imbalance in the soil resulting in decreased crop yield (Ladha *et al*. 2005). The productivity of rice may be increased by fine-tuning nutrient and crop management. Site-specific nutrient management (SSNM) provides a field-specific approach for dynamically applying nutrients to crops as and when needed. This approach advocates the optimal use of indigenous nutrients originating from soil, plant residues, manures, and irrigation water. Fertilizers are then applied in a timely fashion to overcome the deficit in nutrients between the total demand by rice to achieve a yield target and the supply from indigenous sources. An estimate of soil indigenous N, phosphorus (P), and K supply was obtained from omission plots situated in each field. There results from these plots were used as inputs in a model designed to estimate field-specific fertilizer requirements in the SSNM plots (Dobermann *et a*l, 2002).SSNM has been proposed an approach to tailor fertilizer application to match field-specific needs of crops to improve productivity and profitability (Buresh *et al*, 2010, Dobermann *et al*, 1996 and Wett *et al*, 1999). This could be done by utilizing available information on indigenous nutrient supplying capacity, nutrient contributions from organic manures, irrigation water, rainfall and crop residue pools and finally crop nutrient demand for targeted yield of crop. Based on these considerations, the present investigation was carried out to evaluate the SSNM approach for rice under sub-humid condition of southern Rajasthan.

MATERIAL AND METHOD

A field experiment was conducted on fixed site at agriculture research station (MPUAT), Banswara, Rajasthan during two consecutive *kharif* season of 2008 and 2009 to evaluate the agronomic management of seven nutrient options on growth and yield of rice. The experimental site is geographically situated at $23^0.33'$ and latitude, 74^0 27' E longitude and altitude of 220 M above Mean Sea Level. It is covered under humid southern plain agro-climatic zone of Rajasthan, which falls under sub-humid climate with dry, hot summer and mild winters. The average rainfall of the season was 862mm. The soil of experimental field is clay loam in texture, slightly alkaline in reaction with contain low in organic carbon (0.33%), low in available N(156.75 kg ha^{-1}), low in available phosphorous (17.76 kg ha^{-1}) and high available potassium (480 kg ha^{-1}). Initial soil

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samples were collected randomly from the experimental field, soil analysis was done by adopting standard procedures, and the SSNM recommendations were developed from soil test values and nutrient uptake requirements for the targeted yield of the crop. The experiment consisting of seven treatments was laid-out in a randomized complete block design with three replications. The treatments comprised viz. T_1- Absolute control (No NPK), T_2- State fertilizers recommendation (120-60-40 kg N-P_2O_5-K_2O ha^{-1}), T_3- Improved nutrient recommendation (120-60-40 & 25 kg N-P_2O_5-K_2O & $ZnSO_4$ ha^{-1}), T_4- Site- Specific Nutrient Management (142-37-0 & 25 kg N-P_2O_5-K_2O & $ZnSO_4$ ha^{-1}), T_5- N omission (SSNM-N), T_6- P omission (SSNM-P) and T_7- K omission (SSNM-K). The nutrient levels for T_4 to T_7 treatments were calculated based on the QUEFTS model (Janssen *et al.* 1990) taking into account organic carbon and available P and K in the soil as well as targeted yield of 5t ha^{-1} for using rice variety PRH 10. 1/3 dose of nitrogen, full dose of phosphorus, potassium and $ZnSO_4$ were applied at the time of transplanting as per the treatment in the form of urea for nitrogen, SSP for phosphorus, muriate of potash for potassium and $ZnSO_4$ for Zn. The first top dressing of N (one-third quantity) was applied at the tillering stage and second top dressing of N (one-third quantity) was applied at the panicle initiation stage. PRH-10 was transplanted during July with two seedlings per hill, with spacing of 20x10cm and harvested during the first week of November. Uniform cultural operations and plant protection measures were adopted in all the treatments. The observations on growth and yield parameters were recorded and the average of two years is reported and discussed.

Table 1. Effect of different nutrient management options on growth and yield attributes of rice (Pooled data of two years)

Treatment	Plant height (cm)	Tillers m^{-2}	Panicles m^{-2}	Grains $Panicle^{-1}$
T_1: Control (No NPK)	80.50	133.65	130.55	120.40
T_2: State fertilizers recommendation (120-60-40 kg N-P_2O_5-K_2O ha^{-1})	94.70	311.81	287.03	128.70
T_3: State fertilizers recommendation (120-60-40 kg N-P_2O_5-K_2O ha^{-1})	102.00	315.23	310.18	145.30
T_4 : Site-specific nutrient management (SSNM) (142-37-0 & 25 kg N-P_2O_5-K_2O & $ZnSO_4$ ha^{-1})	107.00	351.23	338.55	150.30
T_5: N omission (SSNM-N) (0-37-0 & 25 kg N-P_2O_5-K_2O & $ZnSO_4$ ha^{-1})	93.25	173.05	168.07	126.20
T_6: P omission (SSNM-P) (142-0-0 & 25 kg N-P_2O_5-K_2O & $ZnSO_4$ ha^{-1})	98.70	248.55	220.50	135.60
T_7 : K omission (SSNM-K) (142-37-0 & 25 kg N-P_2O_5-K_2O & $ZnSO_4$ ha^{-1})	100.40	332.95	318.72	152.30
CD (P=0.05%)	7.60	32.60	27.60	14.20

Table 2. Effect of different nutrient management options on growth and yield attributes of rice (Pooled data of two years)

Treatment	Grain yield ($q\ ha^{-1}$)	Straw yield ($q\ ha^{-1}$)	Harvest index	Cost of cultivation ($Rs\ ha^{-1}$)	Net return ($Rs\ ha^{-1}$)	B:C ratio	Agronomic efficiency (%)		
							N	P	K
T_1	31.12	46.08	40	23850	28930	1.21			
T_2	65.10	85.48	43	26478	81758	3.09	54.25	108.50	162.75
T_3	66.58	87.35	43	27438	83244	3.03	55.48	110.97	166.45
T_4	74.00	93.80	44	26975	95525	3.54	52.11	200.00	
T_5	33.22	48.17	41	25920	30222	1.17		89.78	
T_6	52.00	73.80	40	26359	61201	2.32	36.62	140.54	
T_7	73.68	92.56	44	26975	94689	3.51	61.40	199.14	
CD (P=0.05%)	3.20	3.42	1.0						

Table 3. Effect of different nutrient management options on nutrient uptake (Pooled data of two years)

Treatment	Nutrient uptake by grain (kg ha^{-1})			Nutrient uptake by straw (kg ha^{-1})			Nutrient uptake by straw (kg ha^{-1})		
	N	P	K	N	P	K	N	P	K
T_1	31.12	6.85	7.78	27.63	5.53	63.56	58.75	12.37	71.34
T_2	74.87	15.62	17.58	53.85	12.82	121.38	128.45	28.45	138.96
T_3	81.23	17.31	17.98	56.78	14.85	126.66	138.01	32.16	144.63
T_4	91.02	19.24	20.72	67.54	18.76	136.95	158.56	38.0	157.67
T_5	37.21	7.64	8.31	27.46	8.19	67.44	64.66	15.83	75.74
T_6	59.80	10.92	13.52	51.66	7.38	103.32	111.46	18.30	116.84
T_7	91.36	18.42	19.16	65.16	16.72	131.44	157.08	35.08	150.59
CD (P=0.05%)	9.20	2.60	2.80	8.55	2.80	4.60	12.47	4.20	12.81

RESULT AND DISCUSSION

Growth and yield attributes

Pooled data of two consecutive rainy seasons of 2008 and 2009 revealed that SSNM approach enhanced the plant height, number of effective tillers and panicles/hill and number of grains panicle^{-1} (Table 1). Application of SSNM treatment (T_4) significantly increased plant height (107cm) 34, 29, and 15% over control, SSNM-N and state fertilizers recommendation, respectively. Similarity, maximum number of tillers (352 m^{-2}) and panicle (340 m^{-2}) and number of grains (150.30 panicle^{-1}) were recorded with the application of T_4 which significantly increased 62, 51, 29, and 11% number of tillers m^{-2} and 62,51, 35 and18 9% number of panicles m^{-2} over T_1, T_5, T_6 and T_2, respectively. However, number of grains/panicle increased significantly 46, 33, 16, and 14, higher over T_1, T_5, T_6 and T_2, respectively. The similar results observed by Peng *et al*,2006 those found significantly increased average ear-bearing tiller rate (12.3%) and LAI for grain-filling stage (14.1-27.6%) and improved dry matter weight to application of nitrogen through SSNM approach over farmers field practices.

Yield

Application of nutrients based on SSNM approach significantly influenced the grain and straw yields (Table 2). Maximum grain yield (74q ha^{-1}) produced with the application of SSNM (T_4) that significantly increased 58, 55, 29 and 12% higher over T_1, T_5, T_6 and T_2, respectively. Similarly, straw yield gets highest (94q ha^{-1}) with the application of T_4 that was calculated significantly 51, 48, 21 and 12% superior over T_1, T_5, T_6 and T_2, respectively. The highest grain yield in T_4 could be attributed to higher number of yield attributes compared to rest treatments. Similarly, higher straw yields in T_4 could be attributed to more plant height (11-34%) and number of tillers m^{-2} (10-62%) as compared to other treatments. Application of SSNM (T_4) recorded maximum harvest index (44.10%) that significantly superior to control (40.31%), SSNM-N (40.82%). SSNM-P (41.34%).The yield advantage through site-specific nutrient management (SSNM) over farmer practices and unbalance use of nutrient was reported by several workers (Timsina *et al*, 2010, Jat *et al*, 2011 and Nagegowda *et al*, 2011). The harvest index may be attributable to higher grain yield because of increased dry matter accumulation in panicle and grains (Gangaiah and Prasad, 1999) which attributed to higher number of panicles hill^{-1} and grains panicle^{-1}.

Economics

SSNM treatment added expenditure ranging from Rs. 497 to 3125 ha^{-1} over state fertilizers' recommendation and control, respectively (Table 2). The additional expenditure generated an extra produce worth Rs.13767 and 66595 ha^{-1} to state fertilizer recommendation and control, respectively. The maximum B:C ratio (3.54) was recorded with the SSNM practice that means higher net return (Rs 70913) archived due to get higher yield and judicial application of nutrient as compared to state fertilizer recommendation and control.

Agronomic efficiency

Agronomic efficiency (AE) expressed, as kg grain/kg nutrient was grater in SSNM treatment compared to state and improved fertilizer recommendation (Table 2). Agronomic efficiency of nitrogen under SSNM treatment was recorded (52.11kg rice/kg N) that range from 36.62-55.44 kg rice/kg N. Whereas, maximum agronomy efficiency of P was recorded 200 kg rice/kg P was that range from 89.78- 200 kg rice/kg P_2O_5. However, Potash has not applied in SSNM treatment because its availability is higher in soil. Total agronomy efficiency was recorded with SSNM Treatment (252.11 kg rice/kg NP) which range from 162-260.54kg rice/kg N and P_2O_5.

Agronomy efficiency was also increased with ZnSO4 application.

Nutrient uptake

A perusal of table 3 shows that maximum nitrogen uptake by grain, straw and grain straw was recorded in SSNM treatment which significantly superior over control, SSNM-N, SSNM-P and state fertilizers recommendation. The N uptake by grain (91.02kg ha^{-1}) in SSNM treatment increased 18, 34, 59, and 66 % over state fertilizer recommendation, SSNM-P, SSNM-N, and control treatments, respectively. Similarly, maximum N uptake (67.54 kg/ha) by straw under SSNM treatment that was also significantly 20, 23, 60 and 62 % higher over state fertilizer recommendation, SSNM-P, SSNM-N, and control, respectively. The total uptake of N by grain and straw was recorded maximum (158kg ha^{-1}) in SSNM treatment which significantly 13, 19, 29, 59 and 63% superior over T_3, T_2, T_6, T_5 and T_1, respectively. The increased nitrogen uptake by grain, straw and grain+straw might be due to the improved concurrent between plant N demand and supply by soil and amount of nitrogen application. The nitrogen application increased under SSNM approach to soil to be increased N supply to plant to get higher content and enhanced the yield. Similar, result was reported by nagegowda *et al*, 2011 those observed N uptake enhanced due to synchrony between demands of plant and supply from soil. Phosphorous uptake by plant was recorded maximum (38.00 kg ha^{-1}) under SSNM treatment that significantly increased 25, 52, 58, and 67% higher over T_2, T_6, T_5, and T_1, respectively. This uptake might be correlated with yield and phosphorus application. Similar finding were reported by Debermann *et al*, 2002. Maximum potash uptake (152.52kg K ha^{-1}) was recorded with SSNM treatment which also at par with SSNM-K treatment. It was not found limiting nutrient to production due to highly available in soil and adequate supply to plant. These results shown the maximum nutrient uptakes govern by nitrogen supply from soil and fertilizer to plant because nitrogen is most limiting factor due experiment conducted on low available N in soil.

CONCLUSION

On the basis, two years data may be concluded that the site- specific nutrient management approach provides nutrients in adequate responded the plant need compared that ultimately has reflected in terms of grain yield. This also economic practice compared blanket and improves recommendations.

REFERENCES

Buresh, R.J, Pampolino, M.F, Witt, C. (2010) Field-specific potassium and phosphorus balances and fertilizer requirement for irrigated rice-based cropping systems. *Plant Soil* 335:35–64.

Dobermann, A, Cassman, K.G, Sta. Cruz,. PC, Adviento. M.A, Pampolino, M.F (1996) Fertilizer inputs, nutrient balance, and soil nutrient-supplying power in intensive, irrigated rice ecosystems. II. Effective soil K supplying capacity. Nutr. *Cycling Agroecosyst*. 46:11–21

Dobermann, A, Witt,C.and Dawe, D. (2002). Performance of site-specific nutrient management in intensive rice cropping system in Asia. *Better crops Res*. 16(2):25-30.

Gangaiah, B. and Prasad, R. (1999) Response of scented rice (*Oryza sativa*) to fertilizers. *Indian J. Agron.*,, 44 (2): 294-296

Janssen, B.H, Guiking, F.T, Van der Eijk, D, Smaling, E.M.A, Wolf, J, van Reuler, H. (1990). A system for quantitative evaluation of the fertility of tropical soils (QUEFTS). *Geoderma*. 46:299–318

Jat, M. L, Saharawat, Y. S and Gupta, R. (2011).Conservation agriculture in cereal systems of South Asia: Nutrient management perspectives. *Karnataka J Agric Sci*. 24:100-105.

Ladha, J.K., H. Pathak, T.J. Krupnik, J. Six, and C. van Kessel. (2005). Efficiency of fertilizer nitrogen in cereal production: retrospects and prospects. Adv. Agronomy.87:85-156

Nagegowda, N.S., Biradar, D.P. and Manjunath, B. (2011).Effect of site specific nutrient management (SSNM) on growth and yield of rice in Tungabhadra project area. *Int. J. Sci. Nat.* 2(1):144-146.

Peng,S.B.,Buresh,R.J.,Huang,J.L.,Yang,J.C.,Zou, Y.B.,Zhong,X.Y., Wang,G.H. and Zhang,F.S. (2006). Strategies for overcoming low agronomic nitrogen use efficiency in irrigated rice system in China. Field Crop Res.96 (1):37-47

Timsina, J, Buresh, R.J, Dobermann, A, Dixon, J, Tabali, J. (2010). Strategic assessment of rice-maize systems in Asia. IRRICIMMYT Alliance Project "Intensified Production Systems in Asia (IPSA)", IRRI-CIMMYT, Joint Report, IRRI, Los Banos, Philippines.

Witt C, Dobermann A, Abdulrachman S, Gines H.C, Wang G, Nagarajan R, Satawatananont S, Son TT, Tan P.S, Tiem L.V, Simbahan G.C, Olk D.C. (1999) Internal nutrient efficiencies of irrigated lowland rice and in tropical and sub-tropical Asia. *Field Crops Res* 63:113–138.

RESEARCH ARTICLE

PGPR: AN ALTERNATIVE IN SUSTAINABLE AGRICULTURE

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Abstract: In the current farming practices, the use of PGPR as an alternative is likely to increase the soil fertility and produce better crop yield than the conventional mode of farming. This type of agriculture uses special farming techniques. Sustainable agriculture is vital in today's world as it offers the potential to meet our agricultural needs. In the present farming practice, PGPR and environmental resources can be fully utilized. The alternative scientific technologies are productive, economic, resource serving and appropriate to many farming situations all over India. Thus the technique is ecofriendly and ensures safe and healthy agricultural products. Microbial populations are instrumental to fundamental processes that drive stability and productivity of agro-ecosystems.

Keywords: PGPR, Sustainable agriculture, Conventional method, Biological farming, Mineralization

INTRODUCTION

In the present farming system, the use of PGPR as an alternative in agriculture practices may increase the soil fertility, reduce soil erosion, produce better crop yield than the conventional method of farming. There are many sustainable and viable alternatives to present commercial farming known as Biological farming, Eco agriculture, Organic farming, Natural farming, Agro-ecosystem etc.

Studies conducted by the University of California-Berkely at Ecology Action in California have established that 12 inches of precious, fertile top soil can be produced in a few years by the use of PGPR and other alternative conventional method in contrast to the natural process of soil formation that takes hundreds of years to produce the same quantity and quantity of top soil.

It has been proved by experimental work that bacterial inoculants can be successfully used for plant growth-promotion and for the other alternative practices in agriculture. The rhizospheric soils contain diverse type of efficient microbes with beneficial effects on crop productivity. The plant growth promoting rhizobacteria (PGPR) and cyanobacteria are rhizospheric microbes and produce bioactive substances to promote plant growth and/or protect them against pathogens (Glick, 1995; Harish et al., 2009a). This communication highlighted contributions of PGPR, cyanobacteria and some beneficial microbial interactions in the agriculture improvement and environment sustainability with the desire and even the demand for sustainability. Sustainable agriculture involves successful management of agricultural resources to satisfy human needs while maintaining environmental quality and conserving natural resources for future. Improvement in agricultural sustainability requires the optimal use and management of soil fertility and its physico-chemical properties. Both rely on soil biological process and soil biodiversity. This implies management practices that enhance soil biological activity and thereby buildup long term soil productivity and crop health. Such practices are of major concern in marginal lands to avoid degradation and in restoration of degraded lands and in regions where high external input agriculture is not feasible.

The potential of PGPR in sustainable Agriculture

To come out from the conventional system of farming, there is a need of sustainable agriculture-farming system that are environmentally sustainable, economically viable, socially acceptable. In sustainable farming PGPR (plant growth promoting rhizo bacteria) play a vital role to increase the soil fertility and to enhance the crop yield. A group of biofertilizers comprising beneficial rhizobacteria are identified as PGPR. According to Paul and Clark (1989) soil has different kinds of microorganisms such as algae, fungi, bacteria, actinomycetes. The density of bacteria around rhizosphere is greater than the rest of the soil. (Lynch 1990) Some free living soil bacteria that function as PGPR are as follows: Azospirillium irakense, A lipoferum, A brasilense, Bacillus cerens, B polymyxa, B subtilis, Pseudomonas aeruginosa, P flourescence, Pputida,rhizobium, Burkholdaria, Azotobacter, (Rodriguez and Fraga 1999). Free-living PGPR have better role as a biofertilizers, (Podile and Kishore) plant growth promotion, increased yield, uptake of N and some other elements through PGPR inoculations. (Sheng and He, 2006; Glick et al, 2007) In addition, treatments with PGPR enhance root growth, leading to a root system with large surface area and increased number of root hairs (Mantelin and Touraine, 2004).

The bacteria that provide some benefit to plants are of two general types: those that form a symbiotic relationship, which involves formation of specialized structures or nodules on host plant roots, and those that are free living in the soil, the latter are found near the roots of the plant.(Kloeppar et al. 1988;Van peer and Schepper 1989).The symbiotic bacteria Rhizobia have been developed as a"biological" means of increasing crop yields. (Vance 1983;

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Bohold 1990; Sharma 1993)

PGPR inoculants contribute to plant growth promotion in number of ways, namely suppression of plant disease (bioprotectants), Phytohormones production (Biostimulus) and improved nutrients acquisition (Biofertilizers). Some mechanisms used by PGPR to stimulate plant growth are as follows:

Direct Mechanism-Solubilization of phosphorous,Nitrogen fixation,Sequestring Iron by siderophores, Production by phytohormones (Auxin,, Cytokinin, Gibbereline),Lowering Ethylene concentration.

Indirect Mechanism-Antibiotic production, Depletion of Iron from the rhizosphere, Induced systemic resistance, Synthesis of antifungal metabolites**,** In general, large bulk of artificial fertilizer is applied to replenish soil N and P with the resultant in high cost and environmental risk. Most of P which is insoluble compounds are unavailable to plants. N2-fixing and P-solubilizing bacteria (PSB) are important for crop plants as they increase N and P uptake and play a crucial role as PGPR in the biofertilization. (Zahir et al., 2004; Zaidi and Mohammad, 2006) Thus, the application of such microbes are environment friendly, bio-fertilizer may contribute to minimize the use of expensive phosphatic fertilizers. Phosphorus bio-fertilizers increase the availability of accumulated P by solubilization, efficiency of biological N2-fixation and the availability of Fe, Zn, etc. due to generation of plant growth promoting substances. (Kuceyet al., 1989) Inoculation of N2 fixing and PSB in combination was more effective than the single microbe in providing a more balanced nutrition to agriculture crops such as sorghum, barley, blackgram, soybean and wheat. (Alagawadi and Gaur) It has been demonstrated that inoculations with AM fungi improves plant growth under salt stress. (Cho et al., 2006) Kohler et al. (2006) demonstrated the beneficial effect of PGPR Pseudomonas mendocina strains on stabilization of soil aggregate. The three PGPR isolates Pseudomonas alcaligenesPsA15, Bacillus polymyxa BcP26 and Mycobacterium phlei MbP18 were able to tolerate high temperatures and salt concentrations and thus confer on them potential competitive advantage to survive in arid and saline soils such as calcisol (Egamberdiyev), Pseudomonas fluorescens MSP-393 could serve as the ideal bioinoculant for crops in saline soils. (Paul and Nair, 2008) Inoculations with selected PGPR and other microbes particularly AM fungi could serve as the potential tool for alleviating salinity stress in salt sensitive crops. Therefore, extensive investigations is needed in this area, and the use of PGPR and other symbiotic microorganisms, especially AM fungi, can be useful in developing strategies to facilitate sustainable agriculture in saline soils.

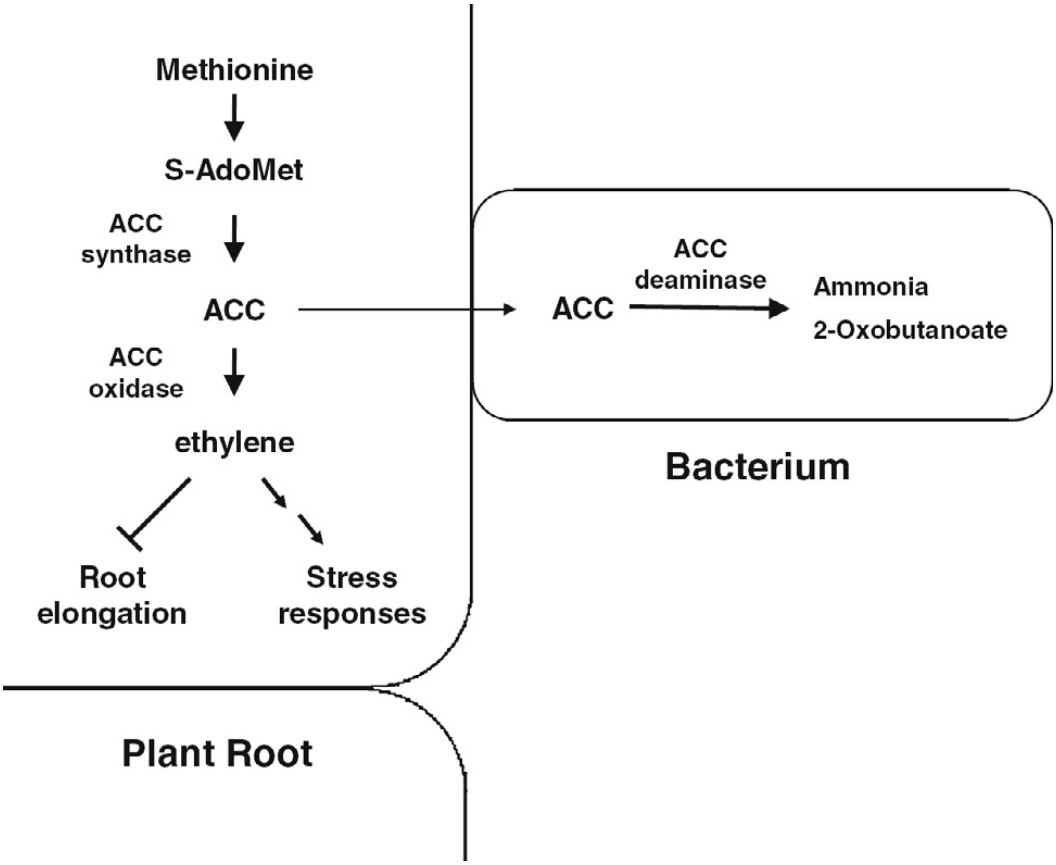

Fig 1. A possible mechanism of how stress controller bacteria reduce ethylene levels in the plant root using bacterial ACC deaminase.

Role of 1-Aminocyclopropane-1-carboxylic acid (ACC) deaminase-containing PGPR protect plants from the environmental stresses

It was proved by the experimental work that many plant growth promoting bacteria (PGPB) contain the enzyme 1-Aminocyclopropane-1-carboxylic acid (ACC) deaminase that cleave the ethylene precursor ACC to -ketobutyrate and ammonia and thereby lower the ethylene levels in developing or stressed plants (Saleem et al., 2007). Bacterial strains containing ACC deaminase can, in part, at least alleviate the stress induced ethylene mediated negative impact on plants. Such an aspect is extensively studied in numerous PGPBs like Agrobacterium genomovars and Azospirillum lipoferum, Alcaligenes and Bacillus, Burkholderia, Enterobacter, Methylobacterium fujisawaense, Pseudomonas Ralstonia solanacearum, Rhizobium, Rhodococcus, and Sinorhizobium meliloti and Variovorax paradoxus (Penrose and Glick, 2001; Belimov et al., 2001, 2005; Ma et al., 2003;) The ACC deaminase metabolizes the root's ACC into –ketobutyrate and ammonia and checks the production of ethylene which otherwise inhibits plant growth through several mechanisms. The plants treated with bacteria containing ACC-deaminase may have relatively extensive root growth due to lowered ethylene levels (Shaharoona et al., 2006) thus leading to resistance against diseases.

Need to promote Sustainable Agriculture

Alternative agriculture is a sleeping giant. Alternative agriculture techniques are not only ecofriendly but they have low cost, high efficiency of yield production of food. There is a need to spread awareness regarding its tremendous size and power. There is no doubt that it will gradually and beneficially replace and transform conventional agricultural system as the major source of sustainable food production for the population of the world. In general, huge bulk artificial fertilizes is applied to replenish soil N and P with the resultant in high cost and environmental risk. Most of P in insoluble compounds are unavailable to plants. N2-fixing and P-solubilizing bacteria (PSB) are important for crop plants as they increase N and P uptake and play a crucial role as PGPR in the biofertilization (Zahir et al., 2004; Zaidi and Mohammad, 2006). Thus, the application of such microbes as environment friendly biofertilizer may contribute to minimize the use of expensive phosphate fertilizers. Phosphorus biofertilizers increase the availability of accumulated P (by solubilization), efficiency of biological N2-fixation and the availability of Fe, Zn, etc. due to generation of plant growth promoting substances. (Kuceyet al., 1989) Finally,m we can say that the use of PGPR in sustainable agriculture can produce remarkable results. The synergistic effects of PGPR on the growth, yield, nodulation and seed quality of crop reflect the range of its profitability and commercialization.

Table 1. Plant growth promoting rhizobacteria (PGPR) as biocontrol agents against various plant diseases

PGPR	Experimental sites	Disease	References
Pseudomonas fluorescens	Rice field	Leaffolder insect in rice (Oryzasativa)	Radjacommare et al. (2002)
B. subtilisstrain GBO3	Greenhouse and field conditions	Downy mildew in pearl millet (Pennisetumglaucum)	Niranjan et al. (2003)
B. subtilisstrain IN937a	Field condition	CMV in cucumber	Jetiyanon et al. (2003)
Pseudomonas fluorescens	Saline field condition	Saline resistance in groundnut (Arachis hypogea)	Saravanakumar and Samiyappan (2007)
B. subtilisME488	In vitro and In vivo	Soil borne pathogen of cucumber and pepper (Piper)	Chung et al. (2008)
P. fluorescensstrain CHA0+ chitin bio-formulations	Banana under greenhouse and field conditions	Reduce the Banana Bunchy Top Virus	Kavino et al. (2008)

REFERENCES

Alagawadi, A.R., Gaur, A.C. (1992). Inoculation of Azospirillum brasilense and phosphate-solubilizing bacteria on yield of sorghum (*Sorghum bicolor L.*)

Cho, K., Toler, H., Lee, J., Owenley, B., Stutz, J.C., Moore, J.L., Auge, R.M. (2006). *Mycorrhizal*

Glick, B.R., Karaturovic, D.M., Newell, P.C. (1995). Anovel procedure for rapid isolation of plant growth-promoting pseudomonads. *Can. J. Microbiol*. 41, 533–536.

Glick, B.R., Todorovic, B., Czarny, J., Cheng, Z., Duan, J., McConkey, B. (2007). Promotion of plant growth by bacterial ACC deaminase. *Crit. Rev. Plant Sci.* 26, 227–242.

Harish, S., Kavino, M., Kumar, N., Samiyappan, R. (2009b). Differential expression of pathogenesis-related proteins and defense enzymes in banana: interaction between endophytic bacteria banana bunchy top virus and Pentalonia nigronervosa. *Biocontr. Sci. Technol.* 19, 843–857.

Kavino, M., Harish, S., Kumar, N., Saravanakumar, D., Damodaran, T., Soorianathasundaram, K., Samiyappan, R. (2007). Rhizosphere and endophytic bacteria for induction of systemic resistance of banana plantlets against bunchy top virus. *Soil Biol. Biochem*. 39, 1087–1098.

Kloepper, J.W., Lifshitz R, and Schroth, M.N. (1988). Pseudomonas inoculants to benefit plant production. ISI Atlas Sci: *Anim. Plant Sci*. pp. 60-64.

Kohler, J., Caravaca, F., Carrasco, L., Roldan, A. (2006). Contribution of Pseudomonas mendocina and Glomus intraradices to aggregates stabilization and promotion of biological properties in rhizosphere soil of lettuce plants under field conditions. *Soil Use Manage*. 22, 298–304.

Kucey, R.M.N., Janzen, H.H., Leggett, M.E. (1989). Microbially mediated increases in plant-available phosphorus. *Ad. Agron*. 42, 199–228.

Lynch, J.M. (1990) Beneficial interactions between microorganisms and roots *Adv.* **8**:335-345.

Mantelin, S., Touraine, B. (2004). Plant growth-promoting bacteria and nitrate availability: impacts on root development and nitrate uptake. *J. Exp. Bot*. 55, 27–34.

Podile, A.R.,Kishore, K. (2007). Plant growth-promoting rhizobacteria. In: Gnanamanickam, S.S. (Ed.), Plant Associated Bacteria. *Springer, The Netherlands*, pp.195-230.

Rodriguez, H., Fraga, R. (1999). Phosphate solubilizing bacteria and their role in plant growth promotion. *Biotech. Advan*. 17, 319–339.

Saravanakumar, D., Samiyappan, R. (2007). ACC deaminase from Pseudomonas fluorescens mediated saline resistance in groundnut (Arachis hypogea) plants. *J. Appl. Microbiol.* 102, 1283–1292.

Sheng, X.F., He, L.Y. (2006). Solubilization of potassium-bearing minerals by a wildtype strain of Bacillus edaphicus and its mutants and increased potassium uptake by wheat. *Can. J. Microbiol*. 52, 66–72.

Symbiosis and response of sorghum plants to combined drought and salinity stresses. *J. Plant Physiol. 163, 517–528.*

Van Peer-R, and Schippers-B. (1989). Plant growth responses to bacterization with selected *Pseudomonas* spp. strains and rhizosphere microbial development in hydroponic cultures. *Can. J. Microbiol.* **35**:456-463.

Zahir, A., Arshad, Z.M., Frankenberger, W.F. (2004). Plant growth promoting rhizobacteria. *Adv. Agron*. 81, 97–168.

Zaidi, A., Mohammad, S. (2006). Co-inoculation effects of phosphate solubilizing microorganisms and glomus fasciculatum on green grambradyrhizobium symbiosis. *Agric. Sci*. 30, 223–230.

RESEARCH ARTICLE

EFFECT OF ORGANIC AND INORGANIC SOURCES OF NUTRIENT ON PRODUCTIVITY, NUTRIENT UPTAKE AND ECONOMICS OF RICE (*ORYZA SATIVA* L.)

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Abstract: A field experiment was conducted at Instructional Farm of Narendra Deva University of Agriculture and Technology, Kumarganj, Faizabad (U.P.) during the *Kharif* 2013 to evaluate the Effect of Organic and inorganic sources of nutrient on productivity and nutrient uptake of rice (*Oryza sativa* L.). Twelve treatments comprised with different integrated modules of organic, inorganic and biofertilizer combinations. The various integrated nutrient management modules significantly influenced the yield, economic and nutrient uptake by rice. Among integrated modules the application of 100% RDF received maximum yield (60.61 grain and 78.86 straw q ha^{-1}) and nutrient uptake followed by 75% RDF+ 25% N (FYM+GM+BGA). The highest net return (78,409.00) and benefit: cost ratio (2.80) was computed under treatment T_2- 100% RDF which was closely followed by 75% RDF+ 25% N (FYM+GM+BGA).

Keywords: INM yield, Economic and nutrient uptake of rice

INTRODUCTION

Rice is one of the important cereal food crop for more than half of the world's population The global requirement of rice by 2050 AD world by 800 million tones, which is 26% higher than the present level of production. In India it is grown over an area 43.95 million hectare with a production of 106.54 million tones in 2013-14 *Anonymous* (2014). The area and production of rice in the state is about 13.84 mha and 14.00 mt, respectively with productivity of 2358 $kgha^{-1}$ *Anonymous* (2014). The ever increasing population of the country is forcing the planners to produce more and more with ever shrinking natural resources. Continuous use of high analysis fertilizers accelerated the mining of micro and secondary nutrients which brought down the productivity. Declining trend in productivity due to continuous use of chemical fertilizers alone has been observed. Therefore, emphasis should be to optimize the use of chemical fertilizers and to improve their use efficiency. Enhancing the productivity and soil fertility to feed the ever growing population from shrinking natural resources. It is impossible to attain the potential yields of crops without external supply of the nutrients through combination of inorganic and organics. The combined use of fertilizer, organic and biofertilizers increase the productivity of crops with significant residual effect in soil. In addition to saving of available nutrients integrated nutrient management also improved the soil organic carbon and nutrient status of the soil. Keeping this view, the present study was conducted to achieve the suitable INM modules on rice (*Oryza sativa* L.) productivity and uptake of nutrients and economics.

MATERIAL AND METHOD

The field experiment was conducted at Student's Instructional farm of Narendra Deva University of Agriculture and Technology, Kumarganj, Faizabad during *Kharif*, 2013 to explore the possibility of substituting fertilizer with FYM, Green manure (Dhaincha) and biofertiliser (Blue green algae) is an integrated manner for the crop. The treatment consisting of chemical fertilizer with different combination of organics (FYM, Green manure and BGA) viz. T_1 (control), T_2 (100% RDF) T_3 (75% RDF), T_4 (50% RDF), T_5 (75% RDF + 25% N-FYM), T_6 (75% RDF +25% N-GM), T_7 (75% RDF +25% N-FYM + GM), T_8 (75% RDF + 25% N-FYM + GM + BGA), T_9 (50% RDF + 50% N-FYM), T_{10} (50% RDF + 50% N-GM), T_{11} (50% RDF + 50% N-FYM+GM) and T_{12} (50%RDF + 50% N-FYM + GM + BGA) were comprised in Randomized Block replicated as thrice. The experimental soil was silty loam in texture having pH (1:25) 8.58, EC 0.41dSm^{-1}, Organic Carbon 2.40 g kg^{-1}, Available Nitrogen 170.50, Phosphorus 08.81, Potassium 215.52, Sulphur 8.97 kg ha^{-1} and Zinc 0.63 mg kg^{-1}. FYM, green manure (Dhaincha) and BGA were applied as per treatment. FYM, Green manure and BGA were incorporated before transplanting of rice seedling and BGA crust was applied uniformly in the plots 5-7 days after transplanting. Whereas half dose of nitrogen entire dose of phosphorus potash and Zinc were applied as basal application in the form of urea, diammonium phosphate, muriate of potash and zinc sulphate, respectively, remaining half dose of nitrogen was applied in two equally at tillering and panicle initiation stages. The farm yard manure was applied before fifteen days of transplanting and zinc sulphate was applied in the last plough. The seedling

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were transplanted with spacing of 20 x 10cm all the cultural practices were followed to raise a good crop. The grain and straw yield were recorded at maturity. The soil samples were collected as initial before and after harvest of the crop and analysed for chemical properties by following standard methods (Jackson, 1973). The plant samples were collected N, P, K, S and Zn content (Jackson, 1973) and nutrient uptake by grain and straw was computed. The experimental data were statistically analyzed using MSTATC. Economics and cost benefit: cost ratio was calculated by dividing gross income with total cost of cultivation.

RESULT AND DISCUSSION

Growth and yield attributes

It is evident from the data (table-1) that the grain yield ranged from 22.86 to 60.61 q ha^{-1} during the year of investigation whereas the straw yield for the same period ranged from 37.87 to 67.21 qha^{-1}. Grain and straw yields were significantly influenced by the application of fertilizers alone or in combination with FYM, green manuring and biofertilizer over the control. The maximum grain yield (60.61 and 61.66 q ha^{-1}) were recorded with the application of T_2 (100% RDF) which was closely followed by T_8 (75% RDF + 25% N-FYM + GM + BGA) and significantly superior over the treatment T_1 (control), T_3 (75% RDF), T_4 (50% RDF) and T_9 (50% RDF + 50% N-FYM) and statistically at par with treatment T_5 (75% RDF + 25% N- FYM), T_6 (75% RDF +25% N-GM), T_7 (75% RDF +25% N-FYM + GM), T_{10} (50% RDF + 50% N-GM), T_{11} (50% RDF + 50% N-FYM+GM) and T_{12} (50%RDF + 50% N-FYM+ GM + BGA). The minimum grain yield (22.86 and 23.01q ha^{-1}) was recorded with control, during both year of experimentation. This could be attributed to decomposition of succulent green manure, FYM and biological fixation, which favored for greater release of nutrients and their continuous availability in soil for sustaining higher grain and straw yield of rice. The findings are in agreements with the observation of Sharma and Gupta (2001), Singh, *et al.* (2002), Khursheed *et al.* (2013), Khairnar and Thakur (2011).

Nutrients uptake

The uptake of N, P, K, S and Zn by grain at different integrated nutrient modules f fertilizers, FYM, green manure and biofertiliser ranged 26.28 – 78.79, 5.7-20.60, 11.20 – 44.85, 2.97 – 10.03 kg $ha^{-1}$and 36.10 – 128.25 g ha^{-1}. The straw yield of rice followed the same trends as grain yield with each of the treatments. The nutrient (N, P, K, S and Zn) uptake after the application of RDF alone in combination of FYM, green manure and biofertiliser are presented in table 2. The highest uptake of these nutrients was recorded in the treatment 100% RDF followed by T_8 (75% RDF + 25% N-FYM + GM + BGA) which were significantly superior in potassium content over 75 %, 50% RDF application and control. There was significant rise in nutrient uptake in rice grain and straw were also influence with various organic treatments. FYM was the excellent source of N and its application increased the grain and straw yield as well as nutrient uptake of rice. It might be due to favorable soil condition which enhanced nutrient availability and nutrient uptake as well as a better growth and activity of roots. The application of FYM, Green manure and BGA might be responsible for increasing the nutrient uptake by grain and straw. Use of chemical fertilizer all the nutrients were present in balanced proportion; it might be responsible for increasing the nutrients uptake by crop. This might be due to the high nutrient uptake by crop. Similar finding was observed by Pandey *et al.* (2007), Rakesh *et al.* (2009), Lal and Sharma (2013). The organic manure recorded comparatively lower uptake of N, P, K, S and Zn as compared to integration of organic manure with inorganic fertilizer. (Sowmya *et al.* (2011). The highest nutrient uptake recorded in T_2 treatment and the lowest in T_1 (control). Similar results was obtained by Singh *et al.* (2008) who reported green manure was the N-Fixing and its application increase the grain and straw yield as well as nutrients uptake by rice crop.

Economics

Economic yield and added benefits as influenced by integrated nutrient management use of chemical fertilizer, organic manure and biofertilizer on rice have been calculated and presented in table 1. The highest grain and straw yield of 60.61 and 78.86 q ha^{-1} recorded in T_2 (100% RDF) give the highest maximum grass income 10, 2451.00 followed by T_8. This is due to higher production of grain and straw. The highest net return 78,409.00 was found under treatment T_2- 100% RDF which was closely followed by T_8- 75% RDF+25%N-FYM,GM and BGA 77,085.00 this variation might be due to higher cost of cultivation. Which varied in the treatment this trend in economic return is mainly due to the treatment effect on the grain and straw yield of rice. Higher benefit cost ratio 2.80 was also computed with the treatment T_2-100% RDF which was closely followed by T_8. Moreover, if the improvement in soil physico-chemical and biological properties are considered, the incorporation of organic manure and biofertilizer would be much more beneficial compared to inorganic fertilizer.

Table 1. Effect of integrated nutrient management on yield and Economic of various treatment combinations in rice crop.

Treatments	**Grain yield (tha^{-1})**	**Straw yield (tha^{-1})**	**Total cost of cultivation (□. ha^{-1})**	**Gross return (□ . ha^{-1})**	**Net return (□ . ha^{-1})**	**Benefit : cost ratio**
T_1 – Control	22.86	37.87	17873	41079	25100	1.40
T_2 - 100% RDF	60.61	78.86	27985	102451	78409	2.80
T_3 - 75% RDF	51.41	67.21	25261	86996	65096	2.58
T_4 - 50% RDF	40.40	55.34	22733	69122	49156	2.16
T_5 - 75% RDF + 25% N-FYM	55.01	74.47	29761	93854	67817	2.28
T_6 - 75% RDF +25% N-GM	56.82	76.37	28754	96777	71842	2.50
T_7 - 75% RDF +25% N-FYM + GM	58.76	78.12	29257	99824	74473	2.55
T_8 - 75% RDF + 25% N-FYM + GM + BGA	59.96	78.35	28625	101744	77085	2.69
T_9 - 50% RDF + 50% N-FYM	52.72	71.91	31733	90109	61972	1.95
T_{10}- 50% RDF + 50% N-GM	54.07	73.53	29718	92350	66309	2.23
T_{11}- 50% RDF + 50% N-FYM+GM	56.51	75.21	30726	96026	69061	2.25
T_{12}- 50%RDF + 50% N-FYM + GM + BGA	57.98	77.08	29453.5	98798	73249	2.49
SEm±	2.39	3.02	-	-	-	-
C.D. at 5%	7.02	8.86	-	-	--	-

Table 2. Effect of integrated nutrient management on yield and nutrient uptake by grain in rice crop.

Treatments	**Nutrient Uptake (kg ha^{-1})**									
	Nitrogen		**Phosphorus**		**Potassium**		**Sulphur**		**Zinc (g ha^{-1})**	
	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw
T_1 – Control	26.28	15.52	5.715	2.69	11.2	39.76	2.97	3.56	36.1	43.32
T_2 - 100% RDF	78.79	40.21	20.6	8.04	44.85	100.16	10.03	8.99	128.25	122.55
T_3 - 75% RDF	62.72	31.58	15.42	5.51	32.39	78.64	7.71	6.86	90.48	92.08
T_4 - 50% RDF	47.26	24.90	10.9	4.15	21.41	60.87	5.66	5.53	66.74	69.73
T_5 - 75% RDF + 25% N-FYM	67.66	35.74	17.05	6.18	35.21	88.62	8.25	7.74	102.1	105.9
T_6 - 75% RDF +25% N-GM	71.02	37.43	18.18	6.95	37.5	93.17	8.52	8.02	105.86	110.51
T_7 - 75% RDF +25% N-FYM + GM	72.77	39.33	18.48	7.17	39.85	95.63	9.24	8.25	115.7	116.24
T_8 - 75% RDF + 25% N-FYM + GM + BGA	76.05	39.94	19.45	7.91	42.45	98.68	9.43	8.54	123.7	120.09
T_9 - 50% RDF + 50% N-FYM	64.13	34.55	14.99	6.04	33.62	84.13	7.76	7.62	93.95	98.88
T_{10}- 50% RDF + 50% N-GM	66.86	36.10	15.92	6.32	35.56	88.24	7.96	7.94	96.62	101.69

T_{11}- 50% RDF + 50% N-FYM+GM	71.05	37.39	17.2	6.77	38.86	92.51	8.88	8.27	103.7	107.02
T_{12}- 50%RDF + 50% N-FYM + GM + BGA	73.5	39.31	18.23	7.48	41.6	95.58	9.12	8.71	114.40	112.31
SEm±	2.40	1.67	0.69	0.30	1.60	3.41	0.40	0.20	3.98	2.93
C.D. at 5%	7.04	4.90	2.02	0.88	4.69	9.99	1.16	0.59	11.68	8.60

CONCLUSION

The integrated nutrient management practices brought considerable improvement in the available N, P, K, S and Zn status in soil. The integration of inorganic fertilizers coupled with FYM, green manure and biofertilizer can sustain the rice grain productivity. Therefore it could be recommended that the application of FYM, GM and biofertilizer would not only improve the productivity and income but would also maintain the soil health. However, there are indications that over time, the application of FYM, GM and BGA alone will improve soil fertility levels.

REFERENCES

Anonymous (2014). Agricultural Statistics at a glance, Directorate of Economics and Statistics Department of Agriculture and Cooperation pp72-73

Anonymous (2014). Economics survey of India, Economic Division Ministry of Finance, Government, of India, New Delhi pp 45-55

Jackson, M.L. (1973). Soil chemical analysis, prentice Hall of India, Pvt. Ltd, New Delhi.

Lal, B. Sharma, G.D.; Gautam, P.; Rana, R. (2013) Effect of integrated nutrient management and spacing on growth parameters, nutrient content and productivity of rice under system of rice intensification. *International journal of research in biosciences*; **2** (3): 53-59.

Pandey, P. C., Kumar, V.; and Rathi, A. S. (2007). Effect of inorganic fertilizers and FYM on productivity of rice and soil fertility in long term rice-wheat cropping system. *Progressive Research*; **3** (1): 76-78.

Rakesh, Sahu, D.L.; Kanvar and Rishikesh Thakur (2009) impact of integrated source of management on production and nutrient uptake by rice crop. *Journal of Soil and Crop;* **19** (2): 205-209.

Sharma, M. P., Bali, S. V. and Gupta, D. K. (2001) Soil Fertility and Productivity of rice–wheat cropping system in an Inceptisol as influenced by integrated nutrient management. *Indian Journal of Agricultural Sciences***71,** 82-83

Singh, Surendra, Singh, R. N., Prasad., J. and Kumar, B. (2002) Effect of green manuring, FYM and biofertilizer to fertilizer nitrogen and major nutrient uptake by upland rice. *Journal of the Indian Society of Soil Science* **50**, 313-314

Singh, Y. V.; Dhar, D. W. and Agarwal, B. (2011) Influence of organic nutrient management on *Basmati* rice (*Oryza sativa* L.)-Wheat (*Triticum aestivum*)-green gram (*Vigna radiata*) cropping system. *Indian Journal of Agronomy*; **56**(3):169-175.

Sowmya, C.; Ramana, M.V. and Kumar, M. (2011). Effect of systems of rice cultivation and nutrient management options on yield, nutrient uptake and economics of rice. *Crop Research* (*Hisar*); **42** (2):63-69.

RESEARCH COMMUNICATION

PERFORMANCE OF COMBINATION OF HERBICIDES ON GROWTH FACTORS, YIELD AND ENERGETICS OF TRANSPLANTED RICE (*ORYZA SATIVA* L.)

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Abstract: A field experiment was carried out during *Kharif* 2013-2014 at the Instructional-Cum Research Farm, Indira Gandhi Krishi Vishwavidyalaya, Raipur (C.G.).The soil of the experimental field was sandy loam in texture. The soil was neutral in pH low in low in nitrogen, medium in phosphorus and potassium content. The experiment was laid out in randomized block design, comprising three replications and twelve treatments. The results revealed that hand weeding at 25 and 45 DAT registered maximum growth characters of rice like dry matter, number of tillers hill^{-1}, yield and energetics. It was followed by treatments bispyribac-Na + (chlorimuron-ethyl+ metsulfuron-methyl) @ 20 + 4 g ha^{-1} at 25 DAT (T_5) and bispyribac-Na+ ethoxysulfuron @ 25 + 18.75 g ha^{-1} at 25 DAT (T_4) and minimum was observed under weedy check (T_{12}).

Keywords*:* Ethoxysulfuron, Number of tillers, Transplanted rice, Grain yield, Energetics

INTRODUCTION

Weeds are one of the major constraints responsible for low yield of rice in India. Moist conditions of the hydromorphic ecosystems encourage rapid establishment of weeds and permit rapid weed growth. All the three types of weeds viz. narrow leaved, broad leaved and sedges compete with rice crop for resources. Based on nature and intensity of weed infestation, yield of transplanted rice was reduced by 47 percent failure of the crop (Balaswamy, 1999). In order to realize maximum benefit of applied monetary inputs, two to three hand weeding were most effective against all types of weeds in this crop (Halder and Patra 2007). However, continuous rains during cropping season, scarcity and high wages of labor during weeding peaks particularly at early crop-weed competition make this operation difficult and uneconomic. Therefore, application of herbicide mixtures may be useful, particularly in absence of an effective broad spectrum herbicide in rice to control highly diverse weed flora (Rao and Singh 1997). The present study was undertaken to evaluate the performance of combination of herbicides on growth factors, yield and energetics of transplanted rice.

MATERIAL AND METHOD

A field experiment was conducted at Instructional Cum Research Farm, Indira Gandhi Krishi Vishwavidyalaya, Raipur (C.G.) during *kharif* season of 2013. The soil of experimental field was *inceptisols*, low in nitrogen, medium in phosphorus and potassium contents with neutral pH. The experiment was laid out in Randomized Block Design, comprising three replications and twelve treatments which included bispyribac- Na 25 g ha^{-1} at 25 DAT, pretilachlor 1000 g ha^{-1} at 3 DAT, pyrazosulfuron-ethyl 20 g ha^{-1} at 3 DAT, bispyribac-Na + ethoxysulfuron @ 25 + 18.75 g ha^{-1} at 25 DAT, bispyribac + (chlorimuron- ethyl + metsulfuron-methyl) @ 20 + 4 g ha^{-1} at 25 DAT, azimsulfuron @ 35 g ha^{-1} at 23 DAT, pretilachlor *fb* ethoxysulfuron @ 750 / 18.75 g ha^{-1} at 3 fb 25 DAT , pretilachlor *fb* (chlorimuron -ethyl + metsulfuron – methyl) @ 750 / 4 g ha^{-1} at 3 fb 25 DAT , pyrazosulfuron-ethyl *fb* manual weeding @ 20 g ha^{-1} at 3 fb 25 DAT, pretilachlor (6%) + bensulfuron (0.6%) 6.6% Gr 660 g ha^{-1} at 4 DAT, hand weeding at 25 and 45 DAT and weedy check. Medium duration rice cultivar MTU-1010 was taken as a test crop. Transplanting was done on 16th july, 2013 with a spacing of 20 cm x 10cm and fertilizer dose was 100, 60 and 40 kg ha^{-1} of N, P_2O_5 and K_2O respectively. Full dose of phosphorus and potash along with one third of nitrogen was applied as basal. Rest of nitrogen was applied in two splits at tillering and panicle initiation. Harvesting was done on 5th November. Observations of weed density and dry weight were taken at harvest by placing a quadrate of 0.5 m × 0.5 m randomly at five places in each plot.

Sterility percentage

The number of filled and unfilled spikelets per panicle was counted from five panicles selected randomly for measurement of panicle length and sterility percentage was computed with the following formula:

Sterility percentage

$$= \frac{\text{Number of unfilled spikelets panicle}^{-1}}{\text{Total number of spikelets panicle}^{-1}} \times 100$$

Energetics

Energy inputs were calculated and estimated in Mega Joule (MJ) ha^{-1} with reference to the standard values prescribed by Mittal *et al.* (1985). The standard energy coefficient for seed and straw of rice was

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multiplied with their respective yields and summed up to obtain for rice was calculated by adding the respective values of rice crop. Energy use efficiency, energy output-input ratio were calculated as per the following formula:

Total produce (q)

Energy use efficiency

= (q MJ-1 x 10-3) Energy input (MJ x 10-3)

Energy Output – Input Ratio =

Energy output

Energy input

RESULT AND DISCUSSION

Effect on crop

All the herbicide combinations had significantly higher values of crop growth and yield contributing characters over the weedy check. Among the herbicide treatments, highest number of tillers hill^{-1} (13.60 at 60 DAT and 13.73 at harvest), dry matter of plant g hill^{-1} (20.63 at 60 DAT and 35.29 at harvest) and yield were recorded with application of bispyribac-Na + (chlorimuron-ethyl+ metsulfuron-methyl) @ 20 + 4 g ha^{-1} at 25 DAT (T_5) and was closely followed by bispyribac-Na+ ethoxysulfuron @ 25 + 18.75 g ha^{-1} at 25 DAT (T_4) and minimum sterility percent (6.19) were observed. On the contrary, hand weeding at 25 and 45 DAT produced significantly higher number of tillers^{-1} (15.91 at 60 DAT and 14.58 at harvest), dry matter of plant g hill^{-1} (22.90 at 60 DAT and 38.37 at harvest) and minimum sterility percent (4.95) at harvest over weedy check and most of the herbicidal treatments.

Grain and straw yield of transplanted rice varied significantly due to weed control treatments. Significantly maximum grain and straw yield (52 q ha^{-1} and 63.06 q ha^{-1} respectively) was obtained with hand weeding at 25 and 45 DAT over rest of the treatments. Among the herbicides, application of bispyribac-Na + (chlorimuron-ethyl+ metsulfuron-methyl) @ 20 + 4 g ha^{-1} at 25 DAT (T_5) recorded maximum grain and straw yield (50.60 and 62.18 q ha^{-1}) which was obvious due to its higher values of yield attributes and minimum sterility percent as compared to rest of the treatments. However, this treatment was at par with treatment bispyribac-Na+ ethoxysulfuron @ 25 + 18.75 g ha^{-1} at 25 DAT (T_4). These findings are in close proximity with that of Bali *et* al. (2006) (Table 1).

Energetics

The highest energy input was registered under hand weeding at 25 and 45 DAT (T1) (12.81) followed by pyrazosulfuron-ethyl fb manual weeding @ 20 g ha-1 (T9) (12.59). The highest energy output (155.26) and net energy output (121.00) was observed under hand weeding at 25 and 45 DAT (T1) followed by bispyribac-Na + (chlorimuron-ethyl + metsulfuron-methyl) @ 20 + 4 g ha-1 (T5) and bispyribac-Na + ethoxysulfuron @ 25 + 18.75 g ha-1 (T4). The maximum energy use efficiency and energy output: input ratio was recorded under bispyribac-Na + (chlorimuron-ethyl + metsulfuron-methyl) @ 20 + 4 g ha-1 at 25 DAT (T5) (9.09 q MJ x 10^{-3} and 12.26) followed by hand weeding at 25 and 45 DAT (T11) and bispyribac-Na + ethoxysulfuron @ 25 + 18.75 g ha-1 (T4).The highest energy output, energy use efficiency and energy output : input ratio was mainly due to higher grain and straw yield. Similar findings have been also reported by Azad *et al*. (1990) (Table 2).

Table 1. Effect of herbicide combination on growth parameters, sterility and yield of transplanted rice

Treatments	No. of tillers hill^{-1}		Dry matter of plant (g hill^{-1})		Sterility (%)	Grain yield (q ha^{-1})	Straw yield (q ha^{-1})
	60 DAT	At harvest	60 DAT	At harvest			
Bispyribac –Na @ 25 g ha^{-1}	11.66	11.91	17.78	33.09	7.45	48.60	60.51
Pretilachlor @ 1000 g ha^{-1}	9.35	9.80	15.93	25.25	10.15	41.90	52.62
Pyrazosulfuron-ethyl @ 20g ha^{-1}	9.67	10.00	16.65	26.43	9.34	42.50	54.25
Bispyribac-Na +Ethoxysulfuron @ 25 + 18.75 g ha^{-1}	12.82	12.86	19.26	33.91	6.76	50.00	61.47
Bispyribac-Na + (chlorimuron-ethyl + metsulfuron-methyl) @ 20 + 4 g ha^{-1}	13.60	13.73	20.63	35.29	6.19	50.60	62.18
Azimsulfuron @ 35 g ha^{-1}	11.20	11.57	17.43	29.60	7.79	45.20	57.57
Pretilachlor *fb* Ethoxysulfuron @ 750 /18.75 g ha^{-1}	10.51	10.85	17.25	29.32	8.28	44.60	56.00
Pretilachlor *fb* (chlorimuron-ethyl + metsulfuron-methyl) @ 750/ 4 g ha^{-1}	10.93	11.25	17.31	29.48	7.95	45.00	56.99
Pyrazosulfuron-ethyl @ 20 g ha^{-1} *fb* manual weeding	12.43	12.59	18.24	33.39	7.21	49.80	61.31
Pretilachlor(6%) + bensulfuron (0.6%) 6.6% GR@ 660 g ha^{-1}	10.26	10.47	16.81	27.47	8.94	43.20	55.98
Hand weeding at 25 and 45 DAT	15.91	14.58	22.90	38.37	**4.95**	**52.00**	**63.06**
Weedy check	7.60	7.68	12.49	23.90	**19.30**	**21.87**	**40.76**
SEm	**0.88**	**1.04**	**1.26**	**2.48**	**0.62**	**2.17**	**2.37**
LSD (P= 0.05)	**2.58**	**3.06**	**3.69**	**7.27**	**1.81**	**6.35**	**6.94**

Table 2. Effect of herbicide combination on energetics of transplanted rice

Treatments	Energy input (MJ x10^{-3} ha^{-1})	Energy output (MJ x10^{-3} ha^{-1})	Net Energy output (MJ x10^{-3} ha^{-1})	Energy use efficiency (q MJ x10^{-3} ha^{-1})	Energy output input ratio
Bispyribac –Na @ 25 g ha^{-1}	12.41	147.08	134.67	8.79	11.85
Pretilachlor @ 1000 g ha^{-1}	12.52	127.37	114.85	7.55	10.17
Pyrazosulfuron-ethyl @ 20g ha^{-1}	12.40	130.29	117.89	7.80	10.51
Bispyribac-Na +Ethoxysulfuron @ 25 + 18.75 g ha^{-1}	12.41	150.34	137.93	8.98	12.11
Bispyribac-Na + (chlorimuron-ethyl + metsulfuron-methyl) @ 20 + 4 g ha^{-1}	12.41	152.11	139.70	9.09	12.26
Azimsulfuron @ 35 g ha^{-1}	12.41	138.41	126.00	8.28	11.15
Pretilachlor *fb* Ethoxysulfuron @ 750 /18.75 g ha^{-1}	12.53	135.56	123.03	8.03	10.82
Pretilachlor *fb* (chlorimuron-ethyl + metsulfuron-methyl) @ 750/ 4 g ha^{-1}	12.52	137.39	124.87	8.15	10.97
Pyrazosulfuron-ethyl @ 20 g ha^{-1} *fb* manual weeding	12.59	149.84	137.25	8.83	11.90
Pretilachlor(6%) + bensulfuron (0.6%) 6.6% GR@ 660 g ha^{-1}	12.48	133.48	121.00	7.95	10.70
Hand weeding at 25 and 45 DAT	12.81	155.26	142.45	8.98	12.12
Weedy check	12.37	83.10	70.73	5.06	6.72

CONCLUSION

It may be concluded from the investigation that hand weeding at 25 and 45 DAT registered maximum growth characters of rice like number of tillers hill^{-1}, dry matter accumulation, grain and straw yield, higher energy out: input ratio, energy output and energy use efficiency with minimum sterility percent It was followed by treatments bispyribac-Na + (chlorimuron-ethyl + metsulfuron-methyl) @ 20 + 4 g ha^{-1} (T_5) and bispyribac-Na + ethoxysulfuron @ 25 + 18.75 g ha^{-1} (T_4).

REFERENCES

Azad, B.S., Singh, H. and Bhagat, K.L. (1990). Efficacy of Oxyflurofen in controlling weeds in transplanted rice. *Oryza* **27**(4): 457-459.

Bali, A.S., Singh, M., Kachroo, D., Sharma, B.C. and Shivran, D.R. (2006). Efficacy of herbicides in transplanted,medium-duration rice (*Oryza sativa* L.) under subtropic conditions of Jammu. *Indian Journal of Agronomy* **51**(2): 128-130.

Balaswamy, K. (1999). Effect of urea forms and herbicides on weed competition and density in transplanted rice. *Journal of Research, ANGRAU*, **27**(3): 5-11.

Halder, J. and Patra, A.K. (2007). Effect of chemical weed control methods on productivity of transplanted rice. *Indian Journal of Agronomy* **52**(2): 111-113.

Mittal,V.K., Mittal, T.P. and Dhawan, K.C. (1985). Research digest on energy requirements in Agriculture sector (1971-82) ICAR/AICARP/ERAS/ **85**(1).Ludhiana: 159-163.

Singh, V.P.,Singh, G. and Singh, M. (2004). Effect of fenoxaprop- P- ethyl on transplanted rice and associated weeds.Indian Journal of Weed Science **36** : 190-192.

RESEARCH COMMUNICATION

EFFECTS OF PHOSPHORUS LEVELS AND WEED MANAGEMENT ON GRAIN YIELD AND PHOSPHORUS CONTENT IN PIGEONPEA AND SOYBEAN INTERCROPPING SYSTEM

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Abstracts: The intercropping systems have opened up new horizons to augment pulse crop productivity per unit area per unit time. In case of pigeonpea the vegetative growth in initial stages is very slow; therefore, the intercrop should be selected in such a way which could complete its grand growth period before attaining the peak growth of pigeonpea. Seeding soybean as intercrop with pigeonpea may serve this requirement (Saraf *et al*., 1975).

Keywords: Pigeonpea, Phosphorus, Soyabean, Weed

INTRODUCTION

Phosphorus is an essential plant nutrient and its importance in improving the crop production is well recognised from time immemorial. It enhances profused root growth, controls photosynthesis and breakdown of carbohydrates and transfer of energy within the plants. On the other hand, phosphorus stimulates pod setting, hastens maturity and provides extensive and vigrous root system (Dwivedi & Bapat,1996).

Intercropping can be a potential biological tool to manage weeds, yet the system by itself would not be able to provide an acceptable and satisfactory level of weed control, especially during early stage of crop growth because the crop canopy is inadequate to stress weed growth. Further, control of weeds through cultural or mechanical methods may often be difficult owing to narrow inter-row spacing. Therefore, there is a need to develop an alternate system.

Therefore, efforts are needed to workout suitable levels of phosphorus and weed management practices for pigeonpea + soybean intercropping system. Keeping these points in view, the present experiment entitled "Effect of phosphorus levels and weed management on grain yield and phosphorus content in pigeonpea + soybean intercropping system" was carried out during two consecutive years from 2008-09 to 2009-10.

Objectives

1. To study the effect of phosphorus levels and weed management on yield and phosphorus concentration of pigeonpea in pigeonpea + soybean intercropping system
2. To study the effect of phosphorus levels and weed management on yield and phosphorus concentration of soybean in pigeonpea + soybean intercropping system

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METHODOLOGY

Field experiments were conducted for two consecutive years during 2008-09 and 2009-10 to study the effect of phosphorus levels and weed management on yield and quality of pigeonpea + soybean intercropping system at the Raj Mohini Devi College of Agriculture and Research Station, Ajirma Farm, IGKV, Ambikapur (C.G.). The soil of the experimental field was red and yellow classified as *Inceptisols* and texturally recognized as sandy-loam, which constitute upland bunded farming situation. The soil of experimental site was low in nitrogen (198.2 kg ha^{-1}), phosphorus (8.4 kg ha^{-1}) and medium in potassium (282.2 kg ha^{-1}) content. The soil was slightly acidic in reaction (5.7 pH). The experiment was laid out in split plot design comprising 4 phosphorus levels i.e. P_0 = 0, P_1 = 25, P_2 = 50 and P_3 = 75 P_2O_5 kg ha^{-1} as main-plot treatments and 6 weed management practices i.e. W_1 = Weedy check (unweeded control), W_2 = Hand weeding (once) 20 DAS, W_3 =Hand weeding (twice) 20 & 40 DAS, W_4 = Chlorimuron ethyl (8 g ai/ha) as post emergence, W_5= Fenoxaprop- ethyl (80g ai/ha) as post emergence and W_6 = Metribuzine (350g ai/ha) as pre emergence as sub-plots treatments with three replications.

RESULT

The findings of two years revealed that the grain yield and phosphorus content in grain of pigeonpea and soybean in intercropping system was significantly influenced by phosphorus levels. Application of 75 kg P_2O_5 ha^{-1} registered significantly higher grain yield of pigeonpea and soybean as well as phosphorus content in their grain as compared to rest of the treatments, however it was at par with 50 kg P_2O_5 ha^{-1} during both the years. Similar findings have been also reported by Prasad *et al.(*2001).

As regard to weed management practices, significantly higher grain yield of pigeonpea and

soybean phosphorus content in their grain were recorded under hand weeding (twice) 20 and 40 DAS as compared to rest of the weed management treatments, however, application of metribuzine @ 350 g ha^{-1} as pre-emergence showed the statistically similar result during both the years. Similar findings have been reported by Jain and Tiwari (1992) and Prasad *et al. (*2001).

Table 1. Grain yield and phosphorus content in pigeonpea and soybean as influenced by phosphorus levels and weed management in pigeonpea + soybean inter cropping system

Treatment	Pigeonpea				Soybean			
	Grain yield (q ha^{-1})		Phosphorus content (%) in grain)		Grain yield (q ha^{-1})		Phosphorus content (%) in grain	
	2008-09	2009-10	2008-09	2009-10	2008-09	2009-10	2008-09	2009-10
Phosphorus levels (kg ha^{-1})								
P_0=0	12.39	11.58	0.340	0.334	8.87	8.48	0.68	0.66
P_1=25	14.03	13.49	0.363	0.365	10.69	10.35	0.71	0.69
P_2=50	15.04	14.34	0.384	0.374	12.11	11.25	0.73	0.71
P_3=75	15.89	15.47	0.398	0.388	12.33	11.53	0.75	0.73
SEm+	0.37	0.34	0.006	0.007	0.13	0.10	0.004	0.004
CD (P=0.05)	1.28	1.16	0.020	0.022	0.44	0.33	0.015	0.015
Weed Management								
W_1 = Weedy check (unweeded control)	6.96	6.54	0.345	0.330	7.79	7.15	0.62	0.60
W_2 = Hand weeding (once) 20 DAS	14.16	13.43	0.363	0.353	10.29	9.87	0.70	0.68
W_3 = Hand weeding (twice) 20 & 40 DAS	17.38	16.70	0.405	0.395	13.28	12.55	0.77	0.74
W_4 = Chlorimuiron ethyl (8 g ai/ha) as post emergence	15.20	14.52	0.371	0.363	10.77	10.20	0.72	0.70
W_5= Fenoxaprop ethyl (80 g ai/ha) as post emergence	15.41	14.82	0.372	0.365	10.93	10.49	0.72	071
W_6= Metribuzine (350 g ai/ha) as pre emergence	16.92	16.30	0.387	0.381	12.93	12.16	0.76	0.73
SEm+	0.51	0.49	0.006	0.008	0.26	0.25	0.006	0.007
CD (P=0.05)	1.47	1.41	0.020	0.024	0.75	0.71	0.016	0.019

CONCLUSION

In pigeonpea and soybean inter cropping system, use of 75 kg P_2O_5 ha^{-1} and hand weeding twice at 20 and 40 DAS gave significantly highest grain than others, however it was comparable to 50 kg P_2O_5 ha^{-1} and Metribuzine @ 350 g ai ha^{-1} as pre emergence, respectively.

REFERENCES

Jain, H.C. and Tiwari, J.P. (1992). Influence of weed control and fertility levels on soybean. *Indian J. Weed Sci.* 20(2) : 68-74.

Prasad, K. Gautam, R.C. and Mohta, N.K. (1985). Effect of planting patterns and weed control methods on growth characters, yield and yield attributes of arhar intercropped with soybean. Indian J.Agron 30 (4): 429-433.

Prasad, K., Yadav, C.B. and Prasad, K. (2001). Intercropping studies of pigeaonpea and soybean with varying phosphorus does under rainfed conditions of central Uttar Pradesh. *Crop Research Hisar* 21(3):290-294.

Saraf, C.S., Singh, A. and Ahlawat, I.P.S. (1975). Studies on intercropping of compatible crops with pigeonpea. *Indian J. Agron*. 20:127-130.