INTRODUCTION

Upland rice is grown in rainfed, naturally well drained soils without surface water accumulation. It is grown on both level and slopy lands in around 15 million hectares globally out of total rice area of 156 million hectares. Nearly 100 million people depend on it as their daily staple food, globally (Arraudeau, 1995). Major upland rice areas are in Asia (8.9 million hectares) and others in Africa (3 million hectares) and Latin America (3.1 million hectares). India accounts for about 6.15 million hectares, which is approximately 16 percent of its total rice area. A major portion of this upland rice area is concentrated in the eastern states of Orissa, Jharkhand, West Bengal and Assam besides North eastern states. In Jharkhand, this crop is grown in an area of about 1.6 million hectares under direct seeded rainfed condition during monsoon season (June/July – September/October) with short duration varieties (80-105 days) of rice. The soils are characteristically of high porosity and of low fertility. In these soils, the productivity of the crop is not only low (650 kg/ha) but also inconsistent. Besides, several biological and physical constraints limit upland rice yield. Next to inadequate water supply, weeds are the major constraint in upland rice production. Direct-seeded upland rice ecosystems are most vulnerable to weed competition. Weeds reduce upland rice grain yield and quality. Estimates of yield losses caused by weeds in upland rice range from 30 to 100 percent.

Traditionally various weed control practices are adopted to control upland weed which are cost effective and practiced by the farmers. Various cultural practices in upland rice crop growing system can be adopted to avoid or minimize the weed infestation.

Conventional methods of weed control (manual and mechanical methods) are weather dependent, costly and labour intensive Hand weeding is the most common and predominant method of control but labours intensive. Indiscriminate use of chemicals for controlling weeds may pose environmental problems (Cheema and Khaliq, 2000). Each weed control method has merits and demerits. Weed populations vary so much between environments that a single weed control method is not sufficient to address the problem. Moreover, repeated use of a particular method may build up weed resistance to the control method. Hence, integrating all available weed control techniques, to manage weed populations in the best possible way, may help in developing the best weed management strategies. Such strategies include cultural, mechanical and chemical methods of weed control. All these practices are components of an integrated weed management system and none of these control measures on their own can be expected to provide acceptable levels of weed control. By combining cultural and conventional methods and following the principles of an integrated weed management system, we can reduce the use of herbicides and at the same time provide optimum economic returns to the grower.

Uneven crop stand provides less competition to weeds compared to good crop stand. Thus ensuring good population through better land preparation and employing approaches like seed treatment with emergence/growth stimulants, pre-heat treatment, soaking and drying of seed etc. may help minimizing weed population. Ready and uniform germination of crop seeds and their development into vigorous crop seedlings leaves less space for the weeds to grow amongst the crop plants. Uneven and low crop populations and weak crop seedlings, on the contrary, permit thick growth of weeds.

Emergence velocity and early growth are desirable physiological characteristics, which accelerate space and the use of environmental resources (Balbinot *et al*, 2001). A vigorously growing crop aids weed control by weakening the weeds by offering competition. In areas of thin crop stands or seeding skips, weeds may not be controlled even by the use of herbicides. Vigorous crop plants compete better with the weeds and they close in the ground quickly. Although early growth or vigour is a genetic character, it may possibly be influenced to some extent by treating seeds with growth regulators, hydration and dehydration and subjecting seed to different thermal gradients. Information available on means of promoting early vigour in upland rice cultivars is scarce. Selective crop stimulation can be achieved in many ways. Application of fertilizers in adequate quantities improves plant growth very much. However, uniform application of fertilizers to soil may benefit the crops and weeds alike. Sometimes, the absence of a nutrient or delayed application of it from a fertilizer mixture applied to a crop may cause its selective stimulation. Almost all the upland soils are low in nitrogen and phosphorus and have high phosphorus fixation capacity. Application schedule of these nutrients affects crop weed competition. Applying nitrogen at seeding may increase the weed growth in absence of optimum weed control measures. On the contrary, an early application of small amounts of nitrogen in the presence of effective weed control through a pre-emergence herbicide may provide an edge to crop plants over the weeds. Likewise a modified schedule of phosphorus may also influence crop-weed competition. Information on selective crop stimulation using modified fertilizer schedule in upland rice for ensuring good plant stand in India is, however, meagre.

Weeds compete with rice for light, water, and nutrients, particularly for nitrogen (Becker and Johnson, 2001). The application and the timing of N need to be adjusted to benefit the rice crop rather than the weeds. Therefore, the dynamics of N supply must be synchronized to meet the demand by the rice crop (Cadisch and Giller, 1997; Myers *et al*., 1997; Becker and Ladha, 1997). Research on several crops has shown that crop–weed competitive interactions can be altered by N dose (Cathcart and Swanton, 2003), source (Davis and Liebman, 2001), application timing (Angonin *et al*., 1996), and application method (Kirkland and Beckie, 1998; Mesbah and Miller, 1999). Fertilizer use efficiency in upland rice is very low (less than 30 percent). Nitrogen recovery can be affected by N loss from nitrate leaching, particularly with erratic and unpredictable rainfall (George *et al*., 2002). Polyolefin resin coated controlled release N fertilizers have proven their effectiveness in improving N recovery with one or more applications in irrigated rainfed lowland rice and vegetable crops (Fasola *et al*., 2002). Several researchers (Koshino, 1993; Mikkelsen et al., 1994; Rietze and Seidel, 1994; Wang, 1996) have reported that controlled release fertilizers significantly reduce possible losses of nutrients, particularly losses of nitrate nitrogen, between applications and uptake by the plants through gradual nutrient release. They also reduce evaporation losses of ammonia and hence, substantially decrease the risk of environmental pollution. However, information about the efficacy of slow or controlled-release fertilizers in upland rice cultivation is meagre.

Intercrop systems are reported to use resources more efficiently and are able to remove more resources than monocrop systems, thus decreasing the amount available for weed production (Liebman, 1988; Zindahl, 1993). The most common reason for the adoption of intercropping is yield advantage, which is explained by the greater resource depletion by intercrops than monocultures, particularly when cereal and legume crops are grown together (Willey, 1979a, 1979b; Vandermeer, 1989; Ofori and Stern, 1987; Fukai and Trenbath, 1993). In addition, legume intercrops are included in cropping systems because they reduce soil erosion (Giller and Cadisch, 1995) and suppress weeds (Exner and Cruse, 1993). Weed suppression, the reduction of weed growth by crop interference, has been referred as one determinant of yield advantage of intercropping, being a viable alternative to reduce the reliance of weed management on herbicide use (Liebman, 1988; White and Scott, 1991; Liebman and Dyck, 1993; Midmore, 1993; Liebman and Davis, 2000). Population and growth of weeds were suppressed by intercropping, as compared to sole or mixed-cropping systems (Patra et al 1998). Under the present system of sole cropping, small farmers are unable to manage their diversified domestic needs to maintain their normal livings from their limited land, water and economic resources. This envisages going for another appropriate and more efficient production system which may ensure the proper utilization of their limited geo-agronomic resources towards increased production per unit area and time on sustainable basis (Trenbath, 1996). Thus it provides diversified needs of the small farmers, stability of yield over different seasons, better control of weeds, insects and diseases as well as control of soil erosion.

Keeping the above points in view, an investigation was planned with the following objectives.

i) To develop an appropriate seed management strategy for upland rice aimed at enhanced crop competitive ability against weeds,

ii) To develop fertilizer management strategies for avoidance of weed occurrence and minimization of crop-weed competition in upland rice, and

iii) To assess the impact of intercropping system in upland rice as a tool of weed suppression

To fulfil the above objectives, four field and few supportive laboratory experiments were carried out during four wet seasons between 2002 and 2005.