



## Weed management practices in rice (*Oryza sativa*) + brahmi (*Bacopa monnieri*) intercropping system

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### ABSTRACT

A field study was carried out during two consecutive *kharif* seasons 2015–2016 at Norman E Borlaug Crop Research Centre, G B Pant University of Agriculture and Technology, Pantnagar, Uttarakhand, to evaluate the effect of different weed management practices and different row ratios on yield, yield attributes and economics of the rice (*Oryza sativa* L.) + brahmi (*Bacopa monnieri*) intercropping system. The dominant weed floras were *Echinochloa crus-galli*, *Echinochloa colona*, *Alternanthera sessilis*, *Caesulia axillaris* and *Cyperus rotundus*. Among different herbicides, pendimethalin followed by (fb) cyhalofop-butyl fb, one hand weeding at 45 days after sowing in 2:1 row ratios had minimum weed density (16.83 and 9.82/m<sup>2</sup>), dry weight (7.35 and 3.97 g/m<sup>2</sup>) and highest weed control efficiency (73.36 and 83.45%). Intercropping of rice with brahmi, exhibited greater potentiality and realized significantly higher plant height, dry matter accumulation, number of nodes, number of branches, number of panicles/m<sup>2</sup> and 1000 grain weight. Dry herbage yield of brahmi and grain yield were highest in sole crop of rice (5.3 and 6.56 t/ha) and brahmi (2.07 and 2.35 t/ha). Furthermore, pendimethalin fb cyhalofop-butyl fb one hand weeding at 45 DAS in 1:1 ratio of rice and brahmi gave highest net returns (255426.1 and 317163.1/ha) and benefit cost ratio (10.1 and 11.07) and also high value of land equivalent ratio (1.76 and 1.85) and area time equivalent ratio (0.88 and 0.92) during both years.

**Key words:** Benefit cost ratio, Brahmi, Direct seeded rice, Intercropping, Yield

Rice-wheat cropping system is one of the major dominating agricultural systems in India (Singh *et al.* 2014). The rice-wheat system occupies 24–26 million ha in Asia, mainly with 13.5 million ha in the Indo-Gangetic plains (IGP) of India (10 mha), Pakistan (2.2 m ha), Bangladesh (0.8 m ha) and Nepal (0.5 mha) and feeds about 1.3 billion people (20% of the world population) (Saharawat *et al.* 2010). Traditional crop establishment methods in rice such as puddle transplanted rice require large amount of water, energy and labour, which are becoming increasingly scarce and expensive. Changes from traditional transplanting system to direct-seeding occurred in Asian rice systems in the last two decades (Chauhan and Johnson 2010). Weed infestation, however continues to be a major bottleneck in dry seeded rice because of simultaneous emergence of rice and weeds (Farooq *et al.* 2011).

Although, agricultural research was originally focused on sole cropping and ignored the potential of intercropping, there has been a gradual recognition of the value of this type

of cropping system. The essential features of intercropping systems are that they exhibit intensification in space and time. Rice farmers are mostly involved in monoculture practices. Therefore, a shift from monocropping to inter/multiple cropping is an excellent strategy for intensifying land use and increasing income and production per unit area and also due to its role in reduction in weeds interference and other pests (Chen *et al.* 2012). Optimum crop geometry is one of the important factors of crop production, by efficient utilization of underground resources (Thavaprakasha *et al.* 2005). Brahmi (*Bacopa monnieri*) is one of the medicinal plants which can be grown like rice (*Oryza sativa* L.) in upland as well as in lowland conditions and the crop will be ready after 90 days of transplanting and can continue for a longer period as per availability of water. Thus, there is a need to find out a proper spacing of rice with brahmi so that weed problem can be limited to minimum extent. Considering these facts in the present investigation, two row combinations were taken with different weed management practices in rice + brahmi to find out the feasible and profitable intercropping system.

### MATERIALS AND METHODS

An experiment was conducted during *kharif* seasons of 2015–2016 in D2 Block of Norman E Borlaug Crop Research Centre, G B Pant University of Agriculture and

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Technology, Pantnagar, Uttarakhand on direct seeded rice + brahmi intercropping system. The objective of study was to find the economics of the rice + brahmi intercropping system and also best weed management practice for the system as a whole. This centre is situated at an altitude of 243.84 m above sea level, 29°N latitude and 79.3°E longitudes. The research centre falls under foothills of Shivalik ranges of Himalaya, a narrow belt called “*tarai* belt” of Uttarakhand state. The soil of the experimental field was loam in texture. The experimental plot was medium in organic carbon (0.86 and 0.86%), available phosphorus (22.8 and 19.8%) and available potassium (145.4 and 145.4%), and low in available nitrogen (226.2 and 223.4%) with neutral pH (7.3) during 2015 and 2016. The experiment was carried out in Randomized Block Design by taking 10 treatments with three replications, i.e. two ratios 1:1, i.e. rice+brahmi in additive series (where brahmi crop was sown at the spacing of 40 cm and one row of rice was sandwiched between two rows of brahmi at 20 cm) and 2:1, i.e. rice + brahmi in replacement series (where brahmi crop was sown at the spacing of 20 cm after two rows of rice at 20 cm) and in both ratios, four different weed management practices were taken (pendimethalin 1 kg/ha + 2 hand weeding (H W), pendimethalin 1 kg/ha and pendimethalin 1 kg/ha + cyhalofop-butyl 20 g/ha +

1 hand weeding) and one treatment of sole rice and sole brahmi. Furrows were opened manually with the help of liners at a specified row to row distance of 20 cm. The rice variety Pant-18 was sown on June 9, 2015 and June 7, 2016 and brahmi variety CIM Jagriti was sown on June 10, 2015 and June 8, 2016 using a seed rate of 17 kg/ha and 3.3 t/ha in additive series and 21 kg/ha and 2.5 t/ha in replacement series, respectively. Pre-emergence herbicide was applied on June 13, 2015 and June 10, 2016 and post-emergence herbicide on July 23, 2015 and June 21, 2016. All the herbicides were sprayed using knapsack sprayer fitted with flat fan nozzle. The recommended fertilizer doses of rice (120:60:40) were applied uniformly through NPK (12:32:16) mixture and rest through urea and muriate of potash and the irrigation was given accordingly. Weedy check plots remained infested with native population of weeds till harvest. Observations on weeds were recorded with the help of quadrat 0.5 × 0.5 m<sup>2</sup> placed randomly at two spots in each plot at 60 days after sowing/planting (DAS/DAP). Weed population and weed dry weight were recorded at 60 days after sowing.

*Weed control efficiency:* The weed control efficiency (WCE) was taken at 60 DAS (at the harvest of intercrop) and finally at harvest of main crop of different treatments and was calculated by using the following formula (Mishra

Table 1 Effect of different intercropping treatments on total weed density, total weed dry weight and weed control efficiency and rice growth parameters in rice +brahmi intercropping

| Treatment                                                               | Total weed density (No./m <sup>2</sup> ) |                 | Total weed dry weight (g/m <sup>2</sup> ) |                | WCE (%) |       | Rice dry weight (g) |       | Plant height (cm) |        |
|-------------------------------------------------------------------------|------------------------------------------|-----------------|-------------------------------------------|----------------|---------|-------|---------------------|-------|-------------------|--------|
|                                                                         | 2015                                     | 2016            | 2015                                      | 2016           | 2015    | 2016  | 2015                | 2016  | 2015              | 2016   |
| Pendimethalin (PE) (1:1)                                                | 5.96<br>(34.50)                          | 4.81<br>(22.15) | 4.25<br>(17.11)                           | 4.00<br>(14.9) | 23.95   | 38.23 | 15.70               | 17.40 | 62.00             | 64.30  |
| Pendimethalin (PE) + 2 H.W. (30 and 45 DAS/DAP) (1:1)                   | 5.08<br>(24.83)                          | 4.12<br>(16.00) | 3.60<br>(12.00)                           | 3.20<br>(9.26) | 46.66   | 61.64 | 16.20               | 18.20 | 76.30             | 78.60  |
| Pendimethalin (PE) + Cyhalofop- butyl (PoE) + 1 H.W. (45 DAS/DAP) (1:1) | 4.62<br>(20.33)                          | 3.60<br>(11.82) | 3.13<br>(8.80)                            | 2.75<br>(6.60) | 60.90   | 72.65 | 18.40               | 19.80 | 84.30             | 87.00  |
| Weedy (1:1)                                                             | 7.42<br>(53.66)                          | 5.87<br>(33.49) | 4.85<br>(22.50)                           | 5.01<br>(24.1) | 0.00    | 0.00  | 15.00               | 16.00 | 45.20             | 48.00  |
| Pendimethalin (PE) (2:1)                                                | 5.62<br>(30.16)                          | 4.45<br>(18.82) | 3.43<br>(10.80)                           | 3.51<br>(11.3) | 60.86   | 52.83 | 16.26               | 17.80 | 63.00             | 67.40  |
| Pendimethalin (PE) + 2 H.W. (30 and 45 DAS/DAP) (2:1)                   | 5.00<br>(24.00)                          | 3.95<br>(14.66) | 3.45<br>(10.95)                           | 2.87<br>(7.27) | 60.32   | 69.75 | 17.86               | 19.60 | 72.40             | 79.00  |
| Pendimethalin (PE) + Cyhalofop- butyl (PoE) + 1 H.W. (45 DAS/DAP) (2:1) | 4.22<br>(16.83)                          | 3.39<br>(9.82)  | 2.99<br>(7.35)                            | 2.23<br>(3.97) | 73.36   | 83.45 | 19.20               | 21.40 | 100.60            | 106.00 |
| Weedy (2:1)                                                             | 7.41<br>(54.00)                          | 5.80<br>(32.65) | 5.35<br>(27.60)                           | 5.00<br>(24.0) | 0.00    | 0.00  | 15.60               | 16.00 | 46.80             | 51.00  |
| Sole rice (Pendimethalin (PE) + Cyhalofop-butyl (PoE) + 1 H.W. (45 DAS) | 4.32<br>(17.66)                          | 3.39<br>(9.82)  | 3.04<br>(8.26)                            | 2.50<br>(5.27) | 63.30   | 77.91 | 20.30               | 23.20 | 102.50            | 107.80 |
| Sole brahmi (30, 45 & 60 DAP)                                           | 4.96<br>(23.66)                          | 3.87<br>(14.00) | 3.43<br>(10.76)                           | 3.03<br>(8.20) | 52.20   | 65.83 | 0.00                | 0.00  | 0.00              | 0.00   |
| SEm±                                                                    | 0.04                                     | 0.02            | 0.04                                      | 0.01           | 0.61    | 1.09  | 0.28                | 0.33  | 1.22              | 0.84   |
| LSD (P=0.05)                                                            | 0.12                                     | 0.06            | 0.08                                      | 0.04           | 1.84    | 3.25  | 0.85                | 0.99  | 3.54              | 2.5    |

\*Figures in parenthesis are original values and data are square root transformed

and Mishra 1997) and expressed on per cent basis:

$$\text{WCE (\%)} = \frac{\text{Wd}_c - \text{Wd}_t}{\text{Wd}_c} \times 100$$

where,  $\text{Wd}_c$ , Weed dry weight in control plot (weedy check);  $\text{Wd}_t$ , Weed dry weight in treated plot (treatment).

## RESULTS AND DISCUSSION

**Weed flora:** The experimental plots were infested with mixed weed flora during both the years (2015–2016). The major weed flora observed in the experimental field included *Echinochloa crus-galli* (10, 8.63%), *Echinochloa colona* (9.2, 8.45%), *Alternanthera sessilis* (11.74, 11.63%), *Caesulia axillaris* (5.35, 4.45%) and *Cyperus rotundus* (56.2, 60.1%) and others (7.5, 6.7%).

**Total weed density and dry weight and weed control efficiency and rice dry and plant height:** All the weed control treatments significantly reduced the weed population and total dry weight of weeds compared to weedy check (Table 1). Lowest total weed density and dry weight were found under the intercropping of rice with brahmi (2:1 ratio) in which pendimethalin 1 kg/ha fb cyhalofop-butyl 100 g/ha fb one hand weeding at 45 days after sowing treatment were applied compared to other weed management methods (Table 1). It might be due to two fold action of this combination that affected both grasses and BLWS. In DSR, weed control at initial 30–45 days are very crucial, owing to slow growth of plants and poor canopy coverage by the crop (Mahajan and Chauhan 2013). It was observed that if weeds were not controlled properly within critical period of crop weed competition, their density continuously remained increasing and crop growth was badly affected. The removal of competitive effect of weeds reduce inter-specific competition for resources and enabled the crop plants to utilize available resources more efficiently throughout the growth cycle, which in turn positively influenced crop yield and biomass production (Gowda *et al.* 2009).

The performance of crops is directly related to the weed control efficiency. Maximum weed density and dry matter production of weeds were recorded in unweeded check due to uncontrolled weed growth (Table 1). Among the herbicidal treatments, highest weed control efficiency was recorded with application of pendimethalin 1 kg/ha as pre-emergence fb post-emergence application of cyhalofop-butyl 100 g/ha fb one hand weeding at 45 days after sowing in both the ratios during both the years followed by the sole rice treatment, respectively. Alone application of herbicides was recorded poor WCE as compared to sequential application due to control of only one group of weed flora, mainly grassy, whereas sequential application of herbicides managed all groups of weed flora (Kumar *et al.* 2017). The higher values of weed control efficiencies can be attributed to lower weeds number and weeds dry weight owing to better efficacy of herbicidal treatments which might have shifted the pendulum in favour of crop plants. Significantly higher values of rice dry matter and plant height was recorded in herbicidal treatment pendimethalin 1 kg/ha as pre-emergence

fb post-emergence application of cyhalofop-butyl 100 g/ha fb one hand weeding at 45 days after sowing in 2:1 row ratio followed by 1:1 row ratio (Table 1).

**Effect on growth and yield of brahmi:** Number of nodes in main branch, number of branches/spread material and brahmi dry weight were influenced significantly due to different intercropping treatments and were found maximum in treatment pendimethalin fb cyhalofop-butyl fb one hand weeding at 45 DAS in 1:1 ratio after sole crop treatment followed by the treatment pendimethalin fb two hand weeding at 30 and 45 DAS (Table 2).

Brahmi in sole stand recorded significantly higher herbage yield (Table 2) and was followed by additive and replacement series which in turn differed significantly from one another in rice + brahmi intercropping system during both years. Maximum herbage yield among intercropping treatments was recorded with the application of pendimethalin fb cyhalofop-butyl fb one hand weeding at 45 days after sowing/planting in 1:1 row ratio followed by treatment pendimethalin fb two hand weeding at 30 and 45 days after sowing/planting. The optimum space as available for brahmi plants under sole stand reduced the competition for moisture, nutrients and light among the brahmi plants as compared to that as provided under other intercropping combinations might be responsible for the production of higher yield attributes of sole crop of brahmi. These results are in agreement with the findings of Singh *et al.* (2008).

**Effect on yield and yield attributes of rice in rice + brahmi intercropping:** An increasing trend was observed with respect to number of panicles/m<sup>2</sup> in succeeding year due to development of both temporal and spatial complementarity and also increase in soil microflora due to release of some alkaloids by brahmi in the soil which in turn help in improving the health of the soil. All these attributes were influenced significantly by various intercropping treatments during both the years and maximum value was found in sole crop treatment which was significantly different with treatment pendimethalin fb cyhalofop-butyl fb one hand weeding at 45 DAS in 2:1 ratio of rice and brahmi (Table 2). This may be due to that rice plant may take up optimum water and nutrients led to better crop growth parameters (Bloach *et al.* 2005).

Sole stand of rice recorded significantly higher grain yield. This result might be due to less competition for sunlight, space, water and nutrients for sole crop as compared to intercropping treatments (Table 2). However, between additive and replacement treatments, significantly higher grain yield of brahmi under additive series might have happened mainly due to significantly higher plant population as compared to replacement series. Tripathi *et al.* (2005) also realized similar results for grain yield for chickpea in chickpea + mustard intercropping system. Grain yield was significantly influenced by different herbicidal treatments and row ratios during both the years. Among the treatments, pendimethalin fb cyhalofop-butyl fb one hand weeding at 45 days after sowing/planting in 1:1 row ratio (4.81 and 6.20 t/ha) followed by 2:1 row ratio (4.20 and 5.75 t/ha)

Table 2 Effect of different intercropping treatments on growth and yield of rice and brahmi economics in rice +brahmi intercropping

| Treatment                                                              | Brahmi dry weight (g) |      | No. of branches/ spread material |       | No. of nodes in main branch |       | Brahmi dry herbage yield (t/ha) |       | No. of panicles/ m <sup>2</sup> |        | Grain yield (t/ha) |       | Net returns (₹/ha×104) |          | Benefit cost ratio (B:C ratio) |       |
|------------------------------------------------------------------------|-----------------------|------|----------------------------------|-------|-----------------------------|-------|---------------------------------|-------|---------------------------------|--------|--------------------|-------|------------------------|----------|--------------------------------|-------|
|                                                                        | 2015                  | 2016 | 2015                             | 2016  | 2015                        | 2016  | 2015                            | 2016  | 2015                            | 2016   | 2015               | 2016  | 2015                   | 2016     | 2015                           | 2016  |
| Pendimethalin (PE) (1:1)                                               | 3.10                  | 3.80 | 5.60                             | 6.00  | 2.28                        | 2.50  | 1.72                            | 1.72  | 68.00                           | 71.00  | 3.20               | 3.80  | 23.04                  | 22.64    | 8.04                           | 8.98  |
| Pendimethalin (PE) + 2 H.W. (30 and 45 DAS/DAP) (1:1)                  | 4.53                  | 5.20 | 8.32                             | 8.80  | 2.40                        | 2.60  | 1.85                            | 1.90  | 84.00                           | 86.00  | 4.30               | 5.10  | 23.23                  | 26.88    | 7.24                           | 8.37  |
| Pendimethalin (PE) + Cyhalofop-butyl (PoE) + 1 H.W. (45 DAS/DAP) (1:1) | 5.13                  | 6.10 | 8.96                             | 9.40  | 2.56                        | 2.78  | 2.00                            | 2.12  | 100.00                          | 106.00 | 4.81               | 6.20  | 25.54                  | 31.71    | 10.10                          | 11.07 |
| Weedy (1:1)                                                            | 2.60                  | 2.90 | 5.12                             | 5.20  | 1.88                        | 2.00  | 0.40                            | 0.35  | 10.00                           | 13.00  | 0.00               | 0.00  | 17.28                  | 1.21     | 0.73                           | 0.51  |
| Pendimethalin (PE) (2:1)                                               | 3.67                  | 3.70 | 5.50                             | 5.80  | 2.03                        | 2.10  | 0.80                            | 1.05  | 70.00                           | 74.00  | 3.90               | 3.60  | 14.58                  | 16.03    | 5.80                           | 6.36  |
| Pendimethalin (PE) + 2 H.W. (30 and 45 DAS/DAP) (2:1)                  | 4.67                  | 4.90 | 6.40                             | 8.10  | 2.21                        | 2.23  | 1.20                            | 1.34  | 89.00                           | 93.00  | 3.61               | 4.80  | 17.41                  | 20.52    | 5.42                           | 6.40  |
| Pendimethalin (PE) + Cyhalofop-butyl (PoE) + 1 H.W. (45 DAS/DAP) (2:1) | 5.36                  | 5.76 | 7.02                             | 9.00  | 2.71                        | 2.44  | 1.30                            | 1.44  | 104.00                          | 108.00 | 4.20               | 5.75  | 19.30                  | 24.01    | 6.74                           | 8.38  |
| Weedy (2:1)                                                            | 2.83                  | 2.60 | 4.36                             | 4.70  | 1.84                        | 1.90  | 0.50                            | 0.44  | 15.00                           | 18.00  | 0.30               | 0.00  | 3.42                   | 21342.00 | 1.45                           | 0.90  |
| Sole rice (Pendimethalin (PE) + Cyhalofop-butyl (PoE) + 1 H W (45 DAS) | 0.00                  | 6.56 | 0.00                             | 10.86 | 0.00                        | 0.00  | 0.00                            | 0.00  | 120.00                          | 124.00 | 5.30               | 6.56  | 8.53                   | 10.83    | 2.98                           | 3.77  |
| Sole brahmi (30, 45 & 60 DAP)                                          | 5.70                  | 0.00 | 10.71                            | 0.00  | 3.20                        | 3.20  | 2.07                            | 2.35  | 0.00                            | 0.00   | 0.00               | 0.00  | 17.72                  | 20.57    | 5.22                           | 6.06  |
| SEm±                                                                   | 0.06                  | 0.09 | 0.09                             | 0.01  | 0.03                        | 0.036 | 0.02                            | 0.024 | 1.07                            | 1.28   | 0.057              | 0.065 | -                      | -        | -                              | -     |
| LSD (P=0.05)                                                           | 0.17                  | 0.27 | 0.26                             | 0.30  | 0.086                       | 0.107 | 0.06                            | 0.073 | 3.2                             | 3.85   | 0.172              | 0.195 | -                      | -        | -                              | -     |

PE, Pre-emergence; PoE, Post-emergence; DAS, Days after sowing; DAP, Days after planting; H.W., Hand weeding

recorded maximum grain yield of rice which was followed by treatment pendimethalin fb two hand weeding at 30 and 45 days after sowing/planting in 1:1 row ratio (4.3 and 5.1 t/ha). This might be due to effective control of weeds with the application of pre-emergence herbicide pendimethalin fb post-emergence herbicide cyhalofop-butyl along with one hand weeding at 45 DAS/DAP as a result of which there was poor growth and population of weeds.

During both the years, the intercropping patterns affected the net returns and benefit cost ratio. The highest net returns and benefit cost ratio was found in the treatment pendimethalin fb cyhalofop-butyl fb one hand weeding at 45 DAS in 1:1 ratio of rice and brahmi during both the years of experimentation (Table 2). Matusso *et al.* (2014) reported that maize + cowpea intercropping was more profitable than their sole crops. These results suggest that intercropping could improve the system's productivity, increase the income for smallholder farmers, and compensate losses.

It may be concluded that treatment pendimethalin 1 kg as pre-emergence fb cyhalofop-butyl 100 g/ha as post-emergence fb one hand weeding at 45 DAS in 1:1 ratio of rice and brahmi was found better in order to achieve maximum weed control efficiency, productivity and profitability under rice + brahmi intercropping system.

#### REFERENCES

- Baloch M S, Hassan G and Morimoto T. 2005. Weeding techniques in transplanted and wet seeded rice in Pakistan. *Weed Biology and Management* **5**: 190–96.
- Chauhan B S and Johnson D E. 2010. The role of seed ecology in improving weed management strategies in the tropics. *Advances in Agronomy* **105**: 221–62.
- Chen Y, Luan C and Shi X. 2012. *Xanthium* suppression under maize sunflower intercropping system. *Journal of Integrative Agriculture* **11**(6): 1026–37.
- Farooq M, Siddique K H M, Rehman H, Aziz T, Lee D J and Wahid A. 2011. Rice direct seeding: experiences, challenges and opportunities. *Soil and Tillage Research* **116**: 260–67.
- Gowda P T, Govindappa M, Murthy K N K, Shankaraiah C and Jnanesha A C. 2009. Effects of herbicides and cultural treatments on uptake of major nutrients by crop and weeds under aerobic rice cultivation. *Journal of Crop and Weed* **5**: 327–30.
- Kumar S, Kumar R, Mishra J S, Dwivedi S K, Prakash V, Bhakta N, Singh A K, Singh S K, Haris A A, Rao K K, Mondal S, Bhatt B P, Singh S and Yadav A. 2017. Evaluation of rice (*Oryza sativa*) cultivars under different crop establishment methods to enhance productivity, profitability and energetics of rice in middle Indo-Gangetic Plains of Eastern India. *Indian Journal of Agronomy* **62** (3): 307–14.
- Mahajan G and Chauhan B S. 2013. Herbicide options for weed control in dry seeded agronomic rice in India. *Weed Technology* **27**: 682–89.
- Matusso J M M, Mugwe J N and Mucheru-Muna M. 2014. Effects of different maize (*Zea mays* L.)-soybean (*Glycine max* (L.) Merrill) intercropping patterns on yields and its economics. *Academia Journal Agricultural Research* **2**(7): 159–66.
- Mishra M and Mishra A. 1997. Estimation of integrated pest management index in jute-A new approach. *Indian Journal of Weed Science* **29**(1&2): 39–42.
- Saharawat Y S, Singh B, Malik R K, Ladha J K, Gathala M, Jat M L and Kumar V. 2010. Evaluation of alternative tillage and crop establishment methods in a ricewheat rotation in North Western IGP. *Field Crops Research* **116**: 260–7.
- Singh R, Singh B P, and Tripathi K P. 2008. Effect of inputs on moisture use efficiency and productivity in green gram under low rainfall situation. *Journal of Agricultural Sciences* **78**(5): 408–12.
- Singh S S, Singh A K and Sundaram P K. 2014. Agrotechnological options for upscaling agricultural productivity in eastern Indo Gangetic plains under impending climate change situations: A Review. *Journal of Agrisearch* **1**(2): 55–65.
- Thavaprakasha N, Velayudham K and Muthukumar V B. 2005. Effect of crop geometry, intercropping systems and integrated nutrient management practices on productivity of baby corn (*Zea mays* L.) based intercropping systems. *Research Journal of Agricultural and Biological Sciences* **1**(4): 295–302.
- Tripathi A K, Kumar A and Nath S. 2010. Production potential and monetary advantage of winter maize (*Zea mays*) based intercropping systems under irrigated conditions in Central Uttar Pradesh. *Indian Journal of Agricultural Sciences* **80**(2): 125–8.
- Tripathi H N, Chand Subash and Tripathi A K. 2005. Biological and economic feasibility of chickpea (*Cicer arietinum*) + Indian mustard (*Brassica juncea*) cropping systems under varying levels of phosphorus. *Indian Journal of Agronomy* **50**(1): 31–4.