Running title: Investigating the Impact of Chemical Weed Management in Berseem.

**Implication of Herbicides for Weeds Management in improving Quality, Yield and Economic Return of Berseem**

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**Novelty statement**

Berseem fodder in Pakistan is heavily infested by weeds, which drastically reduce fodder yield besides impairing its quality. Very limited work has been undertaken with respect to weed management in fodder crops and scanty information is available regarding herbicide efficacy in berseem. Current research highlights the successful improvement in berseem fodder quality and yield attributes through timely application of herbicides.

**Abstract**

Sustainable fodder production for expanding livestock in the country has become a challenging task in the backdrop of shrinking land & water resources and uncertainty of climatic optima. Improved crop cultivars in conjunction with optimal weeds management methods that ensure better resource utilization resulting in better crop growth and productivity seem indispensable in this regard. Berseem (*Trifolium alexandrinum* L.) is one of the most important fodder crops of winter season and also known as the king of fodders, but it is heavily weeds infested. The most prominent weeds like *Trianthema partulacastrum* L. and *Digera muricata* L. deteriorate the quality and diminish the quantity of its production. Under this study, contribution of weedicides for improvement in fodder and crude protein yield of berseem by proper management of weeds was tested. In this connection four herbicides i.e., Connect (Atrazine), Panida Grande (Pendimethlin), Dual Gold (S-metolachlor), and Primextra Gold (S-metolachlor + Atrazine) were tested at four different application times i.e pre-sowing incorporation (0, 2, 4 days before sowing) and pre-emergence (just after sowing). Statistical analysis of data on weeds management, agronomic parameters and economic returns revealed that Pendimethalin herbicide performed significantly better than all other when pre-plant incorporated 4 days before sowing, indicating 94.73 % efficiency of weed control and produced maximum fodder yield (108.63 t ha-1), dry matter yield (14.72 t ha-1) and crude protein yield (2.92 t ha-1). In conclusion pendimethalin @ 2.5 L ha-1 should be applied at 4 DBS for better control of T. *partulacastrum*, *D. muricata* and other weeds in berseem efficiently and to improve the quantity as well as quality of berseem. Economic analysis showed a maximum benefit-cost ratio of 1.91 for plots where Pendimethalin herbicide was applied @2.5 liter ha-1 four days before sowing.

**Key words**: Herbicides application time; Weeds management; Fodder production; Quality and production of Berseem;

**Introduction**

Berseem (*Trifolium alexandrium* L.) is the main leguminous fodder crop cultivated in South East Asia due to its fast vegetative growth, multi-cut nature, better output of forage and supply of fodder for prolonged period with high palatability and maximum nutritive value. It contains about 62% total digestible nutrients and about 20-21% crude protein (Yadav *et al*., 2015). The financial structure of Pakistan is predominantly dependent of agricultural productivity as the agriculture sector lonely contributes about 19% in the Gross Domestic Product (GDP). The livestock is one of the most important agricultural subsection sharing approximately 11.22% towards the GDP which is about 60.54% of the total agriculture share in the GDP (Govt. of Pakistan, 2019).

Quality fodder is crucial for sustainable livestock production. There is a substantial gap among the fodder production and requirements, which multiplies during the lean periods of fodder production. The major scarcity periods are i.e. May-June and November-December (FRI, 2019). Fodder production and quality are very low at the farmer’s field compared to the potential yield and quality of improved forage cultivars. Hence, there is a dire need to bridge the gap among the fodder requirements and production. The major bottlenecks for higher forage productivity are poor seed quality, lack of knowledge regarding improved production technologies, poor soil health, faultiness in crop husbandry and weed infestation (Zulfiqar *et al.*, 2002). In Pakistan, weed infestation is responsible for huge loss of crop productivity (Matloob et al., 2019). Yield reduction from 5 to 100% is noticed in different crops depending on the weeds density, types, duration of competition and prevailing agro-climatic conditions (Ashiq *et al.* 2003). Weed competition deteriorates quality of fodder (leaf to stem ratio, palatability, crude protein); whereas, under weed free conditions, forage quality is improved (Gholami *et al*. 2013). Weeds reduce berseem fodder yield to the tune of 30 to 40%, and deteriorate its quality (Jain, 1998). Additionally, seed samples of infested berseem crop contain weeds like *Cichorium intybus* L. and *Sonchus Asper* L. as adulterants since their germination and flowering time coincides with that of berseem. The *C. intybus* can regenerate its vegetative shoots along with berseem after subsequent cuts (Rao, 2008). Parasitic weeds such as *Cuscuta campestris* also infest berseem crop.

In Pakistan, berseem is the most important cultivated fodder crop of Rabi season. It is largely used as green forage crop and as pallets hay during off-season periods (Nigam *et al.* 2010). When berseem crop is sown during the second fortnight of September to cover the November-December fodder scarcity period, many seasonal weed species namely *Cyperus rotundus* L.*, Trianthema partulacastrum* L., *C. intybus*, and *Digera muricata* L. also emerge in great numbers and compete with berseem crop for nutrients, light, moisture and space (Tiwana *et al.*, 2002; Wasnik *et al.*, 2017). The highest competition among weeds and berseem has been recorded at the early stage of plant growth due to which establishment of plants decreases and considerable reduction (25-30%) occurs in the forage yield (Tiwana *et al.*, 2002; Alfred, 2012). Kantwa et al (2019) reported, maximum competition between crop & weeds in berseem at establishment stages that causes lower plant establishment with reduction in forage yield. Weeds infestation decreases fresh fodder and seed yield 20 to 30 and 13 to 37 percent respectively (Vijay *et al.,* 2017; Tyagi *et al.,* 2018). At higher weed densities in berseem, fodder quality is lowered due to high crude fiber and silica contents at harvest (Kumar *et al*., 2003). Chemical weed control has proved an efficient approach in controlling weeds in field crops. Kantwa et al (2019) reported that green fodder and seed yield of Berseem increased upto 81 and 119 percent respectively by the application of herbicides. Nevertheless, contrary to the cereals, their use in fodders is limited and very few herbicide molecules are actually being used. Meager information is available on the comparative performance of different herbicides in berseem especially with reference to their application window. Keeping in view the agro-economic significance of berseem as a fodder crop, the current study was conducted to study the influence of various herbicides weeds management of growth and quality in berseem and suggest the most suitable pre-emergence and pre-plant incorporation of herbicides for managing weeds in berseem.

**Materials and Methods**

**Site description:** The experiment was carried out at research farm of Fodder Research Institute, Sargodha (32.1233° N, 72.6805° E; 190 m above msl) during two Rabi seasons (2017-18 and 2018-19) to ascertain the most suitable herbicide and its application time for weed control in early sown berseem. Soil of experimental site was loam having organic matter 0.71%, pH 7.8, total N 0.062%, available phosphorous 7.41 mg kg-1, available potassium 167.33 mg kg-1 and saturation percentage of 37.8%.

**Experimental layout and treatments:** The experiment was laid out following randomized complete block design (RCBD) with split plot arrangements having four replications. Time of applications were kept in main plot and herbicides were assigned to sub plot. Treatments consisted of four herbicides and four application time periods. Pre plant incorporation (PPI) of Connect (Atrazine, 1073 gm ha-1), Panida Grande (Pendimethlin, 1088 gm ha-1), Dual Gold (S-metolachlor, 1440 gm ha-1), and Primextra Gold (S-metolachlor 600 gm ha-1+ Atrazine and others 525 gm ha-1) at recommended rates were applied PPI just before sowing (JBS), two and four days before sowing (2 & 4 DBS). A weedy check (control) was also maintained for comparison. Field selected for experiment was preferred where huge quantities of weed seeds were fallen during prior season resulting in diverse weed seed bank. The size of each experimental unit was kept as 3 m × 6 m. Berseem variety (Super late) was sown in standing water in the last week of September during both years. Five cuts were taken each at the time when fodder attained 60 cm height each year. The herbicides, Atrazine @ 2.5 L ha-1, Pendimethalin @ 2.5 L ha-1, dual gold @ 1.5 L ha-1 and Premixtra gold @ 1.5 L ha-1 were applied according to requirements. Fertilizer NP dose containing 57-57 kg ha-1 was applied in half N and full P at sowing and rest of half N after 25 days of sowing.

**Crop harvesting and data recording:** Observation records revealed that germination properly completed in three days after sowing in all treatments including weedy check. On very next day seedling started to die and all seedlings completely died in all treatments where herbicide was applied just after sowing. While all other treatments were looking fresh especially, pendimethalin treatments (4DBS, 2DBS and JBS). After application of second irrigation (12 days after sowing), seedling started to die from Atrazine, Dual gold and Primextra and up-to 15 days of sowing seedling died significantly in all treatments except Pendimethalin. Data on plant population and weed density (spp. wise) was recorded after twenty-five (25) days of sowing, with the help of 1m x 1m quadrate. The weeds namely; *Trianthema portulacastrum,* *Digera muricata*, *Cichorium intybus* and *Cyperus rotundus* were prominent in the experiment field.

Berseem crop was harvested for 1st cut after 55 days of sowing on attaining the height of 60 cm. Subsequent cuttings were also obtained when the plants attained the height of 60 cm. Data on weed density (m-2) total weed density (m-2), plant population (m-2), dry weight of weeds (g m-2)) was taken after 25 days of sowing. Total fodder yield of five cuts (ton ha-1), dry matter yield and crude protein yield (t ha-2) were recorded at harvest. Weed density and plant population were obtained by 1m x 1m quadrate (three random throws) in each sub-plot and then took average. The number of weeds with their species were also recorded. After counting, the weeds were uprooted and weighed, then oven dried at 70 °C till removal of all moisture and recorded the dry weight (g-m-2) of total weeds density. Number of tillers m-2 were recorded after 55 days of sowing before taking the first cut of fodder by randomly selecting from each treatment. Fresh forage yield was calculated by harvesting the whole plot with the help of spring balance. Dry matter yield of Berseem was determined from dry matter ratio which were calculated by weighing fresh and oven dried samples. Crude protein was estimated using recommended procedure (AOAC, 1990). Weed control efficiency percentage was find out by the formula:

WCE= (Total weed in weedy check – weeds in treatment) / total weeds of weedy check x 100.

Economic return was determined according to prevailing market rate for cost of cultivation and grass income.

**Statistical analysis**

All the recorded data were statistically analyzedFisher’s analysis method of variance (ANOVA) was used to analyze the entire data and means of treatments were compared with LSD (least significant difference test) at probability level 5% (Montgomery, 2013)

**Results**

**Weed density**

Effect of herbicides and their time of application on weed density per m2 were recorded as presented in tables 1, 2 and 3. Interactive effect of herbicides and their time of application on weeds density were also noted. The data indicates that weed density was affected significantly with herbicide application. Data showed that maximum numbers i.e., 127 plants of *Trianthema portulacastrum*, 18 plants of *Digera muricata L*, 13 plants of *Cichorium intybus*, 15 plants of *Cyprus rotundus* and total weeds density of 173 plants m-2 were recorded in weedy check treatment. This followed by dual gold application JBS & JAS, pendimethalin JBS, 4 DBS and dual gold 2 DBS with values of 96 plants m-2, 56 plants m-2 5 plants m-2, 10 plants m-2 and 110 plants m-2 respectively. Whereas lowest weeds density were observed in treatments where Pendimethalin was applied.

**Weed control efficiency (%age) and weeds dry weight (gm** **m-2)**

The results revealed that interactive effect of weedicides and time of application showed significant differences on weed control efficiency (WCE) percentage and weed dry weight (WDW) (Table 4). Treatments of pendimethalin pre-plant incorporation (PPI) 4DBS, 2DBS, JBS and JAS showed higher WCE (94.73, 95.46, 96.18 and 97.98 %) respectively, which is statistically superior as compared to all other treatments. Minimum WCE (37.03 %) was observed in the treatment where Dual gold 2 DBS was applied. Highest weeds dry weight (31.37 gm m-2) was recorded in weedy check and lowest (0.27 gm m-2) in treatment where Pendimethalin was applied just after sowing.

**Plant density (m-2) and tillers (m-2)**

Data analysis revealed that interactive effect of treatments indicated significant differences (p<0.05) on plant density 25 DAS and number of tillers at first harvest (Table 5). Highest plant density (427 m-2) was observed in treatment where Pendimethalin was applied 4DBS, which was statistically at par with weedy check (411 m-2) and lowest plant density (0.00 m-2) was recorded where Atrazine was applied JBS. Highest number of tillers (671 m-2) were achieved by the application of PPI of Pendimethalin 4DBS which was followed by penclimethalin PPI 2DBS (636 m-2)as compared to the weedy check (365 m-2). Rest of herbicides treatments produced lowest number of tillers as compared to weedy check.

**Forage yield and dry matter (t ha-1)**

Statistically analyzed data of forage yield and dry matter indicated significant interactive effects of treatments on fresh fodder and dry matter yield (table 6). Data revealed that higher values of both parameters were obtained by the application of Pendimethalin PPI (4DBS, 2DBS and JBS) treatments as compared to the other treatments and the weedy check. In case of all Pendimethalin treatments forage and dry matter yield gradually decreased as time period decreased between sowing and pre-plant incorporation. The maximum green forage yield (108.63 t ha-1) and dry matter (14.72 t ha-1) was observed when pendimethalin PPI 4DBS applied which was statistically at par with Pendimethalin PPI, 2DBS and JBS. The percent increased in fodder and dry matter yield was 41.31 t ha-1 and 58.62 t ha-1 respectively with the application of Pendimethalin PPI 4DBS as compared to weedy check.

**Crude protein yield (t ha-1)**

The results revealed that interactive effect of treatments indicated significant differences on production of crude protein (Table 4). Only Pendimethalin treatments gave higher crude protein yield over weedy check. Highest crude protein yield (2.913 t ha-1) was observed when pendimethalin 4DBS incorporated in soil which was followed by when penclimethalin 2DBS applied (2.813 t ha-1) which was statistically higher than weedy check (1.683 t ha-1). All other herbicides gave lower crude protein yield because of reduction in total dry matter yield due to phytotoxicity effect. The crude protein production was inversely related to production of dry matter.

**Economic analysis**

The pooled data regarding total net income, gross income, and benefit cost ratio (BCR) of different treatments was analysed to calculate the economic capability of all agronomic practices imposed which is presented in table 7A and 7B. The data revealed that significantly highest gross income (Rs. 407362 ha-1) net income (Rs. 192196 ha-) and BCR of 1.89 was recorded from Pendimethalin PPI 4DBS treatment which was statistically similar with Pendimethalin PPI 2DBS and followed by weedy check with gross income Rs. 288262 ha-1, net income Rs. 85094 ha-1 with BCR of 1.42.

**Discussions**

The major weeds present in early sown berseem consists of *Trianthema portulacastrum*, *Digera muricata*, *Cichorium intybus* and *Cyperus rotundus* (sedges) (Pathan and Kamble 2012; Tyagi *et al*. 2018). The forage berseem yield decreased up to 23 to 30 % due to weed infestation (Joshi and Bhilare 2006; Alfred 2012) and weeds present in berseem field gave more competition stress for essential nutrients, light, space and moisture (Kewat *et al.,* 2005). Vijay *et al*., 2017 and Tyagi *et al.,* 2018 also reported that weeds infestation decreased forage and seed yield of Berseem 20 to 30 and 13 to 37 percent respectively. The phytotoxicity of herbicides influenced berseem plant density up to 100% when applied as PE JAS of crop. Priyanka *et al* (2018) reported similar findings that Pendimethalin and Oxadiargyl caused 75% injury when applied as pre-emergence. Leroux and Buhler (2005) also reported mortality of seed and fodder pearl millet with the pre-emergence application of S-metolachlor benoxacor at recommended dose, however, some other researchers differ from that results. All characters during the study were significantly influenced due to the application of PPI and PE weedicide after 25 days of sowing and at harvest of crop for fodder. In treatments Pendimethalin PPI 4DBS gave higher number of plant m-2 and lower number of weeds as compare to other herbicide treatments while most weed infestation was recorded in weedy check. Maximum yield related characters such as plant density, number of tillers, dry matter, crude protein (%) and fodder yield was recorded in Pendimethalin 4DBS, PPI. This might be due to less number of weeds m-2 and phytotoxic effect as compared to weedy check and other herbicide treatments. In weedy check weeds infestation continued and influenced the crop growth. Parallel findings are reported by Naik *et al.* (2018); Menon *et al.* (2016); Deivasigamani (2016), Singh *et al*. (2012). Dry weight of weeds (g m-2) was statistically higher in weedy check than all other treatments and lowest dry weight of weeds (g m-2) was noted in Pendimethalin treatment. The results were also correlated with the observations of Pathan and Kamble (2012); Pathan *et al*. (2013). Pre plant incorporation of Pendimethalin 4DBS statistically at par with 2DBS recorded maximum and showed statistically higher WCE with higher fodder yield as compare to other treatments. The maximum WCE might be due to the decrease in weeds dry weight in Pendimethalin treatment as compare to the weedy check. The research findings are similar to the findings of Tiwana *et al*. (2002); Pathan and Kamble (2012); Pathan *et al.* (2013). Kumar et al (2018) observed that more than 80 percent weeds can be managed in berseem by the application of Pendimethalin 0.3 kg a. i/ha. Prajapati *et al*. (2015) also observed that weed dry weight significantly lower because of application of Pendimethalin and Imazethapyr resulting in maximum WCE. Data analyzed indicated that herbicides have significant influence on the number of tillers/m2 (Table 5) after 55 days of sowing at harvest of crop. The means of treatment revealed that highest number of tillers were achieved by the application of Pendimethalin (PPI) 4DBS, which was followed by Pendimethalin (PPI) 2DBS and weedy check. Pendimethalin 4DBS efficiently controlled the weed density this might be due to absence of weeds and berseem crop used maximum resources and established well due to which produced higher number of tillers per m2. These research findings are in line with Malik *et al*. (2009) who stated that by controlling broad leaved weeds, number of tillers significantly increased. Kantwa et al (2019) also reported, maximum competition between crop - weeds in berseem at establishment stage that causing lower plants density and substantial reduction in fodder tonnage. The two years pooled data depicted that herbicides treatments significantly influenced all cuttings of forage yield (table 6). The treatment which suppressed more weeds significantly produced higher fodder and dry matter production over the weedy check and the treatments where plant density decreased might be due to phytotoxicity of herbicides. Maximum crude protein yield were noted from the plot where Pendimethalin @ 2.5 L ha-1 PPI 4DBS. These findings are parallel with the findings of Tiwana *et al.* (2002) who stated that Butachlor @ 1-2 kg ai ha-1 significantly increased the fresh fodder and dry matter production of berseem while crude protein productivity exhibited superiority with Pendimethalin treatments over the weedy check. Kantwa et al (2019) reported that green fodder and seed yield of Berseem increased 81 and 119 percent respectively with the application of herbicide over weedy check. The increase in this parameter might be due to reduction in weed density and competition due to which crop uptakes more nutrients. Similar findings were also reported by Dhar *et al*. (2006) and Rao *et al.* (2007). The maximum fodder yield (table 6) was recorded under treatment where Pendimethalin PPI 4DBS, which might be responsible for maximum gross income and also highest net income was recorded under the same treatment followed by weedy check. All other herbicides treatments showed lower gross income and B.C.R. This may be due to phytotoxic effect of herbicides as well as higher competitive influence on growth and production resulted in less return. These research findings are similar to the findings of Kumar *et al*. (2012), Mishra *et al*. (2012) and Thakur *et al*. (2016).

**Conclusion**

Berseem is the most important winter fodder crop but it is heavily infested by weeds especially, *Trianthema partulacastrum* L. and *Digera muricata* L. These weeds caused substantial yield and quality losses in berseem and growed vigorously on the expense of berseem growth. Reduction in yield and quality of barseem increased when suitable doses of herbicides were not applied at appropriate time. Therefore, it is concluded that Pendimethalin @ 2.5L ha-1 should be applied at 4 days before sowing for better chemical control of *T*. *partulacastrum*, *D. muricata* and other weeds in berseem efficiently and to avoid quality and yield losses of berseem.

**Authors Contributions**

MRG and AR conceived the idea and planned the experiment, AR, MA and JS collected the field data and arranged in tables, WN, SAR and JS analyzed the data and made illustration, MRG, SAR & SH drafted the manuscript, SAR interpreted the results, reviewed the contents and finalized the manuscript in its present shape.

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**Table 1:** Effect of herbicides on weeds density (m-2) spp. wise (*Trianthema partulacastrum* (T. P) *Digera* *muricata* ( D. M).(values are means of two years data).

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Weedicides | T. P. Density (m2) | | | | | D. M. density (m2) | | | | |
| Time of application | | | | | | | | | |
| 4DBS | 2DBS | JBS | JAS | Means | 4DBS | 2DBS | JBD | JAS | Means |
| Control | 127.4 a | 127.4 a | 127.4 a | 127.4 a | 127.4 a | 18.25 a | 18.25 a | 18.25 a | 18.25 a | 18.25 a |
| Atrazine | 3.75 f | 4.13 f | 5.37 f | 2.50 f | 3.94 d | 2.75 defg | 2.372 efg | 4.625 bc | 3.75 cd | 3.374 b |
| Pendimethalin | 1.38 f | 1.25 f | 1.63 f | 1.37 f | 1.41 d | 1.00 hi | 1.873 gh | 0.000 i | 0.500 i | 0.843 c |
| Dual gold | 63.75 c | 91.37 b | 97.5 b | 23.70 e | 69.08 b | 3.120 defg | 2.750 defg | 2.373 efg | 5.500 b | 3.436 b |
| Premixtra | 53.67 d | 65.37 c | 53.75 d | 27.75 e | 50.14 c | 3.620 cde | 2.250 fgh | 4.000 cd | 3.500 cdef | 3.343 b |
| Means | 49.98 b | 57.89 a | 57.12 a | 36.53 c |  | 5.748 b | 5.499 c | 5.849 b | 6.300 a |  |
| LSD for time/ herbicides | 2.3156 | | | | 4.6380 | 0.1691 | | | | 0.7194 |
| LSD for interaction | 8.6100 | | | |  | 1.2978 | | | |  |

**Table 2**: Effect of herbicides on weeds density (m-2) spp. wise, *Cichorium intybus* (C. I), *Cyperus rotundus* (C. R) (values are means of two years data).

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Weedicides | C. I. Density (m2) | | | | | C. R. Density (m2l | | | | |
| Time of application | | | | | | | | | |
| 4DBS | 2DBS | JBS | JAS | Means | 4DBS | 2DBS | JBD | JAS | Means |
| Control | 12.87 a | 12.87 a | 12.87 a | 12.87 a | 12.87 a | 15.00 a | 15.00 a | 15.00 a | 15.00 a | 15.00 a |
| Atrazine | 4.00 cd | 1.00 f | 1.25 f | 3.00 de | 2.313 c | 3.50 ghi | 6.50 c | 6.35 cd | 3.00 hi | 4.84 d |
| Pendimethalin | 1.38 f | 1.00 f | 0.50 f | 1.37 f | 1.06 d | 5.37 cde | 3.75 fgh | 4.50 efg | 1.37 j | 3.75 e |
| Dual gold | 3.00 de | 4.86 bc | 2.87 e | 5.00 bc | 3.93 b | 10.00 b | 10.30 b | 5.25 de | 5.00 ef | 7.64 b |
| Premixtra | 2.60 e | 0.375 f | 5.25 b | 2.50 e | 2.68 c | 10.12 b | 5.00 ef | 6.37 cd | 2.50 ij | 5.998 c |
| Means | 4.77 ab | 4.02 c | 4.55 b | 4.95 a |  | 8.798 a | 8.110 b | 7.495 c | 5.375 d |  |
| LSD for time/ herbicides | 0.3073 | | | | 0.5610 | 0.3741 | | | | 0.6374 |
| LSD for interaction | 1.049 | | | |  | 1.199 | | | |  |

**Table 3**: Effect of herbicides on total weeds density (m-2) and weeds control efficiency (%) (values are means of two years data).

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Weedicides | Total weeds density (m-2) | | | | | Weeds control efficiency (%) | | | | |
| Time of application | | | | | | | | | |
| 4DBS | 2DBS | JBS | JAS | Means | 4DBS | 2DBS | JBD | JAS | Means |
| Control | 173.38 a | 173.38 a | 173.38 a | 173.38 a | 173.38 a | - | - | - | - | - |
| Atrazine | 14.00 ef | 14.00 ef | 16.63 e | 12.25 ef | 14.22 d | 91.93 | 91.93 | 90.41 | 92.93 | 91.8 |
| Pendimethalin | 9.13 ef | 7.88 ef | 6.63 ef | 3.38 f | 6.75 e | 94.73 | 95.46 | 96.18 | 97.99 | 96.09 |
| Dual gold | 79.75 c | 109.75 b | 108.00 b | 47.50 d | 86.25 b | 53.96 | 37.03 | 37.76 | 72.62 | 50.22 |
| Premixtra | 70.00 c | 73.25 c | 68.38 c | 35.00 d | 61.91 c | 59.70 | 57.92 | 60.01 | 79.82 | 64.36 |
| Means | 69.25 b | 75.65 a | 74.80 a | 54.30 c |  | 75.08 | 70.58 | 71.09 | 85.78 |  |
| LSD for time/ herbicides | 4.072 | | | | 7.012 |  | | | |  |

LSD interactive effect =13.189

**Table 4**: Effect of herbicides on weeds dry weight (g m-2) and crude protein (t ha-1) (values are means of two years data).

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Weedicides | Weeds dry weight (g m-2) | | | | | Crude protein yield (t ha-1) | | | | |
| Time of application | | | | | | | | | |
| 4DBS | 2DBS | JBS | JAS | Means | 4DBS | 2DBS | JBD | JAS | Means |
| Control | 31.37 a | 31.37 a | 31.37 a | 31.37 a | 31.37 a | 1.683 d | 1.683 d | 1.683 d | 1.683 d | 1.683 b |
| Atrazine | 1.26 h | 1.12 h | 1.33 h | 0.98 h | 1.17 d | 0.925 f | 0.4675 h | 0.000 i | 0.000 i | 0.3481 d |
| Pendimethalin | 0.82 h | 0.63 h | 0.53 h | 0. 27 h | 0.56 d | 2.913 a | 2.813 b | 2.403 c | 0.000 i | 2.032 a |
| Dual gold | 12.76 c | 16.46 b | 11.88 cd | 5.23 g | 11.58 b | 0.940 f | 0.883 f | 0.725 g | 0.000 i | 0.6369 c |
| Premixtra | 9.80 e | 10.26 de | 7.63 f | 3.85 g | 7.88 c | 1.058 e | 0.905 f | 0.713 g | 0.000 i | 0.6687c |
| Means | 11.20 b | 11.96 a | 10.55 c | 8.34 d |  |  |  |  |  |  |
| LSD for time & herbicides | 0.5577 | | | | 1.0725 | 0.056 | | | | 0.0444 |
| LSD for interactive effect | 1.9971 | | | | | 0.0970 | | | | |

**Table 5**: Effect of herbicides on plants density (m-2) 25 DAS, and Av. No. of tillers (m-2) at harvesting (values are means of two years data).

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Weedicides | Plants density (m-2) 25 DAS | | | | | Av. No of tillers (m-2) at harvest | | | | |
| Time of application | | | | | | | | | |
| 4DBS | 2DBS | JBS | JAS | Means | 4DBS | 2DBS | JBD | JAS | Means |
| Control | 410.6 a | 410.6 a | 410.6 a | 410.6 a | 410.6 a | 365.0 d | 365.0 d | 365.0 d | 365.0 d | 365.0 b |
| Atrazine | 139.5 e | 33.5 h | 0.00 i | 0.00 i | 43.25 e | 231.3 fg | 78.75 j | 0.00 k | 0.00 k | 78.75 d |
| Pendimethalin | 426.7 a | 386.1 b | 350.0 c | 0.00 i | 290.7 b | 670.5 a | 636.3 b | 496.3 c | 0.00 k | 451.3 a |
| Dual gold | 142.4 e | 131.8 e | 100.0 f | 0.00 i | 93.56 d | 247.5 f | 206.3 h | 176.3 i | 0.00 k | 157.5 c |
| Premixtra | 246.7 d | 135.4 e | 66.13 g | 0.00 i | 112.06 c | 273.7 e | 221.3 gh | 166.3 i | 0.00 k | 165.3 c |
| Means | 273.2 a | 219.5 b | 185.4 c | 82.13 d |  | 359.0 a | 301.5 b | 241.7 c | 73.00 d |  |
| LSD for time & herbicides | 5.604 | | | | 11.384 | 10.402 | | | | 9.559 |
| LSD for interactive effect | 21.1120 | | | | | 19.9890 | | | | |

**Table 6**: Effect of herbicides on fodder yield (t ha-1) and dry matter yield (t ha-1) (values are means of two years data).

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Weedicides | Fodder yield (t ha-1) | | | | | Dry matter yield (t ha-1) | | | | |
| Time of application | | | | | | | | | |
| 4DBS | 2DBS | JBS | JAS | Means | 4DBS | 2DBS | JBD | JAS | Means |
| Control | 76.87 c | 76.87 c | 76.87 c | 76.87 c | 76.87 a | 9.283 d | 9.283 d | 9.283 d | 9.283 d | 9.283 b |
| Atrazine | 36.23 e | 17.97 g | 0.00 h | 0.00 h | 76.87 a | 4.733 f | 2.387 h | 0.00 i | 0.00 i | 1.780 d |
| Pendimethalin | 108.6 a | 105.9 a | 90.67 b | 0.00 h | 76.32 a | 14.72 a | 14.21 b | 12.11 c | 0.00 i | 10.26 a |
| Dual gold | 39.12 e | 35.80 e | 30.84 f | 0.00 h | 26.44 c | 5.06 f | 4.74 f | 3.95 g | 0.00 i | 3.438 c |
| Premixtra | 47.18 d | 37.60 e | 28.20 f | 0.00 h | 13.55 d | 5.820 e | 4.933 f | 3.825 g | 0.00 i | 3.644 c |
| Means | 61.60 a | 54.84 b | 45.33 c | 15.37 d |  | 7.923 a | 7.109 b | 5.833 c | 1.856 d |  |
| LSD for time & herbicides | 2.083 | | | | 1.58 | 0.3215 | | | | 0.2235 |
| LSD interactive effect | 1.5715 | | | | | 0.5123 | | | | |

**Table 7A:** Economic comparison of different herbicides and their applications time.

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Weedicides | Cost of cultivation (Rs ha-1) | | | | Grass income (Rs ha-1) | | | |
| Time of application | | | | | | | |
| 4DBS | 2DBS | JBS | JAS | 4DBS | 2DBS | JBD | JAS |
| Control | 203168 | 203168 | 203168 | 203168 | 288262 | 288262 | 288262 | 288262 |
| Atrazine | 193690 | 188215 | 100324 | 100324 | 135825 | 67387 | 0 | 0 |
| Pendimethalin | 215166 | 214368 | 209778 | 100,007 | 407362 | 397387 | 340012 | 0 |
| Dual gold | 195545 | 194552 | 193061 | 101314 | 146662 | 134250 | 115612 | 0 |
| Premixtra | 197963 | 195092 | 192272 | 101314 | 176887 | 141000 | 105750 | 0 |

**Table 7B**: Net return in response of herbicides application.

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Weedicides | Net return (Rs ha-1) | | | | Benefit cast ratio | | | |
| Time of application | | | | | | | |
| 4DBS | 2DBS | JBS | JAS | 4DBS | 2DBS | JBD | JAS |
| Control | 77655 | 77655 | 77655 | 77655 | 1.42 | 1.42 | 1.42 | 1.42 |
| Atrazine | -57866 | -120828 | -100324 | -100324 | 0.701 | 0.358 | 0 | 0 |
| Pendimethalin | 192196 | 183019 | 130234 | -100,007 | 1.89 | 1.85 | 1.62 | 0 |
| Dual gold | -48883 | -60302 | -77449 | -101314 | 0.75 | 0.69 | 0.599 | 0 |
| Premixtra | -21076 | -54092 | -86522 | -101314 | 0.895 | 0.721 | 0.550 | 0 |