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Evaluation the growth, productivity and profitability of rice (Sukhadhan-3 variety) under different methods of weed management

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ABSTRACT

A field experiment was conducted to assess the growth, productivity and profitability of rice (Sukhadhan-3 variety) under different methods of weed management at Bhanu-11 Rupakot, Tanahun during rainy season 2017. The experiment was laid out in randomized complete block design with three replications and ten treatments. The phenological, growth, yield and yield attributing characters were observed in the experiment. Results revealed that maximum grain yield (5.91 ton ha^{-1}) was obtained in application of butachlor at 4 days after transplanting (DAT) which was statistically at par with all other treatments except single manual weeding, single cono-weeding and non-weeding plots (3.66 ton ha^{-1}). The highest grain yield obtained from this treatment was might be due to higher number of effective grains per panicle (203 grains), less sterility (6.4%), high test weight (30.7g) with good harvest index (38.4%). Although the single application of butachlor as pre emergence spray showed highest grain yield which seems economically viable and profitable practice to the farmers but it is not environmentally safe to the whole universe.

Introduction

Rice is one of the most important staple food crops of Nepalese people. Area and production of rice in fiscal year 2016/17 was 15,52,469 ha and 52,30,327 MT with productivity of 3.37 ton ha^{-1} (MoAD, 2017). Productivity of rice is very low as compared to other developed countries. Different biotic as well as abiotic constraints were related to lower productivity of rice. Weed is one of the major constraints in rice production. Crop loss in rice due to presence of weeds was reported about

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37-79% (Menakanit, 1991).Weed competes with rice for light, nutrient, water and space and in the absence of control media weed also remove the considerable quantity of nutrient resulting significant losses too. It also produces allopathic compounds which also reduce the yield (Yaduraju et al. 2005). Weeds not only compete with rice but also affect human health, animal health and environmental safety (Monaco et al. 2002). There are about 30,000 species of weeds currently identified in world. Among them, 18,000 species have been identified that causes serious problems in animal, human and environment. Ananthakumari and Rao (1993) observed that different types of weed flora, sedges, broad leaf weeds and grasses compete with rice. The major proportions of rice (more than 90%) are transplanted into permanent water. That type of environment promotes the germination of those aquatic and semi-aquatic weeds which provides competitive advantages for these weeds over the establishing transplanted rice seedlings (Pratley et al. 2004). Rice is a weak competitor against weeds and major farmers only have little options and resources available to control weeds effectively (Rodenburg and Johnson, 2009).

An appropriate weed control method has always been major input in production package and sustainable development. In order to control weeds efficiently, there are different ways practiced such as hand weeding method, mechanical weeding, chemical weeding method and combination of them. The traditional method practiced to control weed are hand pulling and hand manual weeding. Hand weeding is the most widely practiced method against weeds in rice systems. It effectively reduces direct competition from weeds and also prevents weeds from producing and shedding seeds (Rodenburg and Johnson, 2009). Manual weeding is although effective but it has many problems like labor scarcity, cost increase and challenging weather condition. Also, it is impractical and incomplete due to regeneration or escape of perennial weeds having many flushes (Antralinna et al. 2015).

Chemical method for weed control is cheaper, more convenient and efficient. Herbicide looks better than other method because of their performance, competitive capacity against weeds, easy use and economically acceptable. However there are many risks associated with herbicides application such as environmental pollutions (Mehdizadeh et al. 2019) and effects on non-target organism (Mehdizadeh and Gholami Abadan, 2018), but still weed control is strongly dependent on herbicides (Khizar et al. 2003; Kim et al. 2006). Several pre-emergence herbicides like butachlor, oxyfluorfen, pendimethalin, thiobencarb, and nitrofen either alone or in combination with hand weeding provide a fair degree of weed control. However, the continuous uses of chemical method leads to environmental pollution, risks the development of genetic resistance and there are potential downsides to their widespread use associated with their impact on non-farmland

vegetation and on human health (Johnson and Mortimer, 2005). In some cases, residual effect of herbicide on succeeding crops has been observed (Jackson, 1996). This experiment was conducted to evaluate appropriate methods for weed management in rice cultivation.

Materials and Methods

Study area and climatic situation

The study was conducted in Bhanu-11 Rupakot, Tanahun during rainy season 2017. The experiment site is located at 28 7' to 28 10' North and longitude from 84 24' to 84 28' East at an altitude of 800 m above sea level. The study area is selected as a representative of farming system that resembles mostly mid hills in case of Nepal. During the rainy season, the site receives ample rainfall from June to September. The total annual rainfall is reported as 2800 mm, and maximum temperature is reported as 28-39 °C and minimum temperature is 6-10 °C.

Design of experiment

The experiment was conducted using a randomized complete block design (RCBD) using 10 treatments and 3 replications. Gross plot size was 6 m^2 (3 x 2 m) with net plot size 4.40 m^2 (2.20 x 2). Space between the plots was 0.5 m and the space between the block was also 0.5 m. The plant geometry was maintained 20 x 20 cm.

Table 1. Details about treatment used in research.

Treatments	Treatment combination	Symbol
T_1	Single manual weeding (at 21 DAT*)	SMW
T_2	Double manual weeding (at 21 DAT + 42 DAT)	DMW
T_3	Triple manual weeding (at 21 DAT, 42 DAT, & 63 DAT)	TMW
T_4	Single cono-weeding (at 21 DAT)	SCW
T_5	Double cono-weeding (at 21 DAT and 42 DAT)	DCW
T_6	Triple cono-weeding (at 21 DAT, 42 DAT, & 63 DAT)	TCW
T_7	Butachlor at 4 DAT (as pre emergence)	BPE
T_8	Butachlor at 4 DAT + Single manual weeding (21 DAT)	BSMW
T_9	Butachlor at 4 DAT + Double manual weeding (21 and 42 DAT)	BDMW
T_{10}	No weeding (Control check)	NW

*DAT: days after transplanting

Data collection and statistical analysis

Phenological, yield and yield related data were taken and entered into MS Excel and analysis was carried out by statistical R software and drc Package (Mehdizadeh et al. 2016).

Weed density and frequency

Weed density and frequency was calculated for each of the treatment plots by using these formula reported by Nkoa et al. (2015):

$$D_i\ (Number\ m^{-2}) = \frac{Y_i}{S_a}$$

$$F_i = Z_i \times \frac{100}{n}$$

Where, D: density of species i; Y_i: number of individual weed plant of species i contained in the sampling unit (quadrant or field); S_a: surface area of sampling unit; F_i: frequency value for species i; Z_i: number of sampling units with species i present; and n: total number of sampling unit surveyed.

Results and Discussion

Plant height (cm)

Plant height shows the significantly difference relationship among the treatments of the experiments. The data revealed that the treatment with triple manual weeding (102.30 cm) is superior to other which is statically similar to treatment with butachlor followed by double manual weeding. All other treatments except single manual weeding and control checks are at par with these treatments. Similarly, control treatment is inferior to other. Hasanuzzaman et al. (2009) reported that the tallest plant height was found in butachlor with manual weeding (145.3 cm) which is statistically similar to triple manual weeding (143.1) and shortest plant height was found in control treatment (120.2 cm) which is accordance to our result. The higher weed control efficiency in these treatments may be the reason behind the difference in plant height among the treatments.

Panicle length

The data revealed that panicle length show the significant different relationship among the treatments of the experiment. The treatment with double manual weeding is superior to other (24.63 cm) and is statistically similar to all the treatments except single manual weeding, single cono-weeding and control treatment which is statistically inferior to other. Similar type of results was also obtained by Kumar et al. (2017). The result may be due to reduced crop weed competition

and better sink capacity performed longest panicle size ultimately increasing panicle weight and also grain weight.

Flag leaf area

Flag leaf area showed the significant relationship with the treatments of the experiment. The data revealed that the flag leaf area was highest in treatment with triple manual weeding (40.87 cm^2) which is statistically similar to treatment with butachlor followed by double manual weeding (40.80 cm^2). All the treatments were statistically at par with these treatments except treatment with single manual weeding, single cono-weeding and control check. The control treatment was statistically inferior to other (30.47 cm^2). The results also coincide with Parthipan et al. (2013). The reason might be due to better environment with increased uptake of both macro and micro nutrients by rice due to reduced crop weed competition.

Number of effective tiller/m2

The number of effective tiller/m^2 shows significant difference among the treatments in the experiment. The data showed that maximum number of effective tillers/m^2 is found in treatment with butachlor as pre-emergence (203.3). Similarly, all the treatments are at par with this treatment except treatments with single cono-weeding and control check. The lowest number of effective tiller/m^2 was seen in control treatment. The result is also supported by Parthipan et al. (2013). The highest effective tillers were found in pre-emergence chemical treatment and double manual weeding and lowest was found in control treatment. This is because of severe weed infestation occurred in the plots due to competition for moisture, nutrients between weed and rice plants.

Number of Non-effective tiller/m2

Non effective tiller/m^2 showed the significant difference to all the treatments. Maximum number of non-effective tiller/m^2 was found in treatment number 10 (control check) which gives 19 non effective tillers/m^2 which is statistically superior to other. Similarly, all are statistically similar to this treatment except treatment with double cono-weeding.

50% heading days

The 50% heading days show the significant difference among the treatments. Treatment 1 (single manual weeding) takes lowest times for 50% heading i.e. 89.33 days. Treatments 2, 6, 8, 3, 5

and 9 are at par with treatment 1. Similarly, treatment 10 (control check) takes highest time for 50% heading i.e. 93.67 days. Treatments 7 and 4 are at par with treatment 10.

Table 2. Effect of different weed management practice on growth parameters of rice.

Treatments	Plant height (cm)	Panicle length (cm)	Flag leaf area ($cm^{2)}$	Number of effective tiller/m^2	Number of Non effective tiller/m^2	50% heading days
T_1: SMW	97.22^{bc}	21.57^{b}	34.33^{cd}	172.0^{ab}	12.33^{b}	89.33^{c}
T_2: DMW	98.91^{abc}	24.63^{a}	38.07^{abc}	187.3^{ab}	14.67^{b}	91.33^{bc}
T3:TMW	102.30^{a}	23.65^{a}	40.87^{a}	193.3^{ab}	14.33^{b}	90.33^{bc}
T4:SCW	99.12^{abc}	20.82^{bc}	36.10^{bc}	166.3^{b}	14.00^{b}	$91.^{67ab}$
T5:DCW	101.8^{ab}	23.89^{a}	38.23^{abc}	168.7^{ab}	11.67^{ab}	90.33^{bc}
T6:TCW	100.700^{ab}	23.56^{a}	36.87^{abc}	198.0^{ab}	14.00^{b}	90.33^{bc}
T7:BPE	101.3^{ab}	23.65^{a}	39.70^{ab}	203.3^{a}	14.33^{b}	92.00^{ab}
T8:BSMW	101.5^{ab}	23.53^{a}	40.57^{ab}	186.3^{ab}	12.00^{b}	90.33^{bc}
T_9:BDMW	102.2^{a}	24.16^{a}	40.80^{a}	190.7^{ab}	12.33^{b}	90.33^{bc}
T_{10}:Control	94.32^{c}	19.77^{c}	30.47^{d}	164.3^{b}	19.00^{b}	93.67^{a}
F- Value	*	*	*	*	*	*
LSD (5%)	4.954	1.690	4.625	35.22	4.009	2.011
CV %	2.89	4.30	7.17	11.22	16.86	1.29 %
Grand mean	99.940	22.923	37.600	183.033	13.867	90.967

*: significance at 0.05.

Number of effective grains per panicle

The data revealed that the number of effective grains per panicle has significant difference within the treatments. Maximum number of effective grains per panicle is observed in treatment number 7 (butachlor at 4 DAT) with 171.0 grains per panicle. Treatments with butachlor followed by double manual weeding, triple manual weeding and double cono-weeding are at par with previous treatment. Similarly, control treatment, single and triple cono-weeding had the least number of effective grains per panicle and was at par with each other. Similar result was obtained by Reshma et al. (2015) where maximum grains were obtained by herbicide treatment and hand

weeding and it was at par with triple manual weeding. It indicated that weed free condition encouraged the number of filled grains/panicle and negative effect of weeds on plant growth resulted in decreased number of filled grains/panicle.

Number of non-effective grains per panicle

The data showed that the number of non-effective grains per panicle has significantly difference relationship to the treatments in the experiment. From the data, the most number of non-effective grains per panicle can be seen in treatment number 4 (single cono-weeding at 21 DAT) which is 18.33. Similarly, control treatment, single manual weeding and triple manual weeding are statistically at par to these treatments.

Grain yield

Significance difference can be seen among the treatments of experiment in case of grain yield. Grain yield from treatment 7 is seen superior as 5.907 ton ha^{-1} which is statistically similar to treatment number 9, 8, 2, 5, 3 and 6. Similarly, treatment number 1, 4 and 10 are statically inferior to previous ones. The result is supported by Bhowmick and Ghosh (2002) where they found in case of manual weeding, double manual weeding was superior than other, this was might be due to the higher crop growth of rice in terms of foliage, large amount of photosynthesis, which act as source and helped in developing yield attributes due to low crop weed competition and finally the higher grain yield. In case of chemical treatment highest was obtained in treatment with butachlor application (5.907 ton ha^{-1}). Similar result was obtained by Madhavi and Reddy (2002) where higher grain yield was obtained by butachlor treatment followed by manual weeding which was at par with double manual weeding.

Maturity days

The significant difference can be seen among treatments for maturity days of rice, where treatment number 10 (control check) takes highest time for maturity i.e. 128.3 days. Similarly, the treatment 1 (single manual weeding) had the lowest maturity days i.e. 123 days. Treatments 2, 8, 5, 6, 3 and 9 were at par with treatment 1.

Straw Yield

Straw yield showed no significant difference among with the treatments. However the highest straw is seen in treatment number 8 (butachlor at 4 DAT and single manual weeding) as 9.697 t/ha

followed by treatment with butachlor at 4 DAT (9.500 ton ha^{-1}). Similarly, the less straw yield is seen in treatment number 1 (single manual weeding).

Table 3. Effect of different weed management practice on yield and yield parameters of rice.

Treatments	No. of effective grains/Panicle	No. of Non effective Grains/panicle	Grain Yield (ton ha^{-1})	Maturity days	Straw Yield (ton ha^{-1})
T1: SMW	137.7^{cde}	15.67^{abc}	4.267^{b}	123^{d}	8.090
T2: DMW	133^{de}	13.00^{bcd}	5.530^{a}	124.7^{bcd}	8.790
T3:TMW	154.0^{abc}	14.33^{abcd}	5.490^{a}	123.7^{cd}	9.133
T4:SCW	121.7^{ef}	18.33^{a}	4.257^{b}	125.7^{b}	8.123
T5:DCW	155.0^{abc}	10.00^{de}	5.493^{a}	124.0^{bcd}	9.393
T6:TCW	114.0^{f}	6.667^{e}	5.130^{a}	123.7^{cd}	9.320
T7:BPE	171.0^{a}	11.67^{cd}	5.907^{a}	125.0^{bc}	9.500
T8:BSMW	160.7^{ab}	12.67^{bcd}	5.557^{a}	24.0^{bcd}	9.697
T9:BDMW	148.3^{bcd}	9.667^{de}	5.763^{a}	123.3^{cd}	9.000
T10:Control	127.7^{ef}	17.00^{ab}	3.660^{b}	128.3^{a}	8.620
F- Value	*	*	*	*	NS
LSD	18.14	3.362	0.8577	1.787	2.386
CV %	7.43	21.84	9.79	0.84%	10.50
Grand Mean	142.3	12.90	5.105	124.533	8.967

*: significance at 0.05.

Test weight (g)

Test weight show significant difference among the treatments and treatment number 7 (butachlor at 4 DAT) is observed as superior. Treatments number 2, 4 and 5 are statistically similar to treatment number 7. Similarly, treatment number 8 and 6 are at par with previous ones. Treatment number 1 is inferior to other which is at par with treatment 10 and 9. The variation in test weight may be due to the influence of the grain size by management within the treatment. Similar result was observed by Mustafa et al. (2017) where they found 1000 grain weight was highest in treatment with butachlor application (20.48 g). The reason might be due to the fact that the weeding kept the rice field weed free and soil was well aerated which facilitated the crop for absorption of greater amount of plant nutrients, moisture and greater reception of solar radiation

for better growth. Similarly, weed free condition also increase higher mobilization of photosynthetic product from source to sink.

Panicle weight (g)

The panicle weight shows the treatments are significantly different with each other. Treatment number 7 is superior to other. Similarly, treatment number 8 is at par with treatment number 7. Similarly treatment number 10 (control check) is inferior to other and it is statistically similar to treatment number 1. Treatment number 6 and 4 are at par with treatment number 1 and 10. The variation in the panicle weight may be due to reduction of dry matter accumulation, photosynthetic rate of flag leaf and root oxidative activity in rice grains which ultimately reduce panicle weight by weed competition.

Sterility percentage

The data revealed that the treatments are significantly related to sterility percentage. The highest sterility percentage is seen in treatment number 4 (single cono-weeding at 21 DAT) as 13.08%. The sterility percentage of treatment number 4 is statistically at par with treatment number 10 (control) and treatment number 1 (single manual weeding at 21 DAT) with sterility percentage 11.75% and 10.27% respectively. Similarly, treatment number 6 (triple cono-weeding at 21, 42 and 63 DAT) had less sterility percentage i.e. 5.533% which is statistically at par with treatment number 7 (butachlor at 4 DAT), 9 (butachlor at 4 DAT and double manual weeding) and 5 (double cono-weeding) with sterility percentage 6.353%, 6.120% and 6.107% respectively.

Harvest Index (%)

The significant difference is seen among the treatment in which treatment number 9 (butachlor at 4 DAT and double manual weeding) is superior to other. Also treatment 2 (double manual weeding at 21 and 42 DAT) is statistically superior to treatment number 1. Treatment number 7, 3 and 5 are at par with treatment number 9 and 2. Similarly treatment number 10 (control) is statistically inferior to other. The results coincide with the result of Kumar et al. (2017) where they found the highest harvest index in double hand weeding (40%) which is statistically similar to herbicide with manual weeding (39.65%).

Table 4. Effect of different weed management practice on test weight, panicle weight, harvest index and sterility percentage of rice.

Treatments	Test weight (g)	Panicle weight (g)	Harvest Index	Sterility
T1: SMW	25.43^{e}	3.520^{f}	34.45^{d}	10.27^{abc}
T2: DMW	30.53^{a}	4.643^{bcd}	38.68^{a}	8.940^{bcd}
T3:TMW	27.83^{bcd}	4.567^{cd}	37.63^{abc}	8.697^{bcde}
T4:SCW	29.92^{a}	3.667^{ef}	34.35^{d}	13.08^{a}
T5:DCW	30.20^{a}	4.690^{bcd}	36.89^{abc}	6.107^{de}
T6:TCW	28.80^{abc}	4.187^{de}	35.55^{cd}	5.533^{e}
T7:BPE	30.69^{a}	5.670^{a}	38.40^{ab}	6.353^{de}
T8:BSMW	29.33^{ab}	5.200^{ab}	36.37^{bcd}	7.307^{cde}
T9: BDMW	27.23^{cde}	4.840^{bc}	39.05^{a}	6.120^{de}
T10: Control	26.07^{de}	3.167^{f}	29.88^{e}	11.75^{ab}
F-test	*	*	*	*
LSD (at 5%)	2.020	0.6256	2.302	3.362
CV %	4.12	4.30	36.124	23.29
Grand mean	28.604	4.415	3.72	8.415

*: significance at 0.05.

Conclusion

Weed is the major problem behind the growth and development of the rice. Timely weeding with correct management practice is required during the process. The environmental factor and climatic pattern differentiate the weed availability. Different method of weeding may vary with environment and may be useful according to climatic condition of the place. Single application of butachlor as pre emergence spray showed the highest grain yield which seems economically viable and profitable business to the farmers but it is good from environmental and animal health point.

Conflicts of Interest

No conflicts of interest have been declared.

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