EVALUATION OF MECHANICAL AND POWER WEEDER IN LOW LAND RICE CULTIVATION




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Executive summery

Weed control in irrigated rice is critical tasks. Chemical control is not environmentally safe method. Appropriate weed control by mechanical method is urgent need in crop production. BRRI already developed power and mechanical weeder to control the low land weed in rice culture. These machines need thorough investigation in the farmers' field. The field performance of two types of weeder including, BRRI mechanical and power weeder were compared with hand weeding in the farmers' field at Rashidpur in Mithapukur upazila under Rangpur district during *boro* (2015) season. Three treatments i.e. T1 = Hand weeding (HW), T2 = BRRI mechanical weeder (BMW) and T3 = BRRI power weeder (BPW) were used in the experiment. The experiment was carried out in randomized complete block design (RCBD) and replicated in four farmers' plots. BRRI dhan28 was used to conduct the experiment in both locations. The results revealed that among the mechanical weeder, the highest weed control efficiency (78%) obtained with BPW and the lowest (76%) measured in BMW. During weeding operation, BMW damaged lowest (9%) plants compared to BPW (11%). The effective field capacities were 0.06 hectare per hour and 0.09 hectare per hour for BMW and BPW, respectively. The lowest labor requirement was 582 man-hr/ha for BPW and the highest was 650 man-hr/ha for HB. Weeding cost showed highest in HB (Tk 4287/ha) followed by BMW (Tk 1103/ha) and BPW (Tk 950/ha). HB showed the highest weeding cost (78%) compared to BPW. BPW reduced the production cost. Weed control methods showed insignificant effect on grain yield. Input cost varied due to weed control method. BPW reduced 1.33-3.72% input cost than HB. Modification is needed to improve the performance of BRRI Power Weeder. BMW and BPW showed encouraging weed control efficiency, saved weeding cost without sacrificing grain yield and appeared as environmentally safe weed control technology in low land rice cultivation. It's application method is also an important factor contributing to total cost of production.

Introduction

Weeding is one of the most important farm operations in crop production system. Weed growing is a major problem for wet land crops particularly in cereal crops like rice causing a considerable lower yield. Weed can be thought of as any plant growing in the wrong place at the wrong time and doing more harm than good (Parish, 1990). It is a plant that competes with crops for water, nutrients and light. This can reduce crop production. Some weeds have beneficial uses but not usually when they are growing among crops. Weeds decrease the value of land, particularly perennial weeds which tend to accumulate on long fallows; increase cost of cleaning and drying crops (where drying is necessary). Weeds waste excessive proportions of farmers' time, thereby acting as a brake on development (Lavabre, 1991).

In Bangladesh, weeding operation is mostly performed manually that requires higher labor input and also takes more time for operation. Moreover, the labor requirement for weeding depends on weed flora, weed intensity, time of weeding and soil moisture at the time of weeding and efficiency of worker. Often several weeding are necessary to keep the crop weed free. Reduction in yield due to weed alone is estimated as 16-42% depending on crop and location and involves one third of the cost of cultivation (Rangasamy *et. al.*, 1993). Another study showed that delay and negligence in weeding operation affect the crop yield and the loss in crop yield due to weeds in upland crops vary from 40-60% and in many cases complete crop failure (Singh, 1988).

Weeding is generally done after 15-20 days of transplanting. The weed should be controlled and eliminated at their early stage. Depending upon the weed density, 20-30% loss in grain yield is quite usual, which might increase up to 80% if adequate crop management practice is not observed (Gunasena and Arceo, 1981). Weeds compete with crop plants for nutrients and other growth factors (Dryden and Krisnamurthy, 1977). Timely weeding is very much essential for a good yield and this can only be achieved by using mechanical weeder which can reduced the time spent on weeding (man-hour), drudgery involved in hand weeding. Hand weeding can give a clean weeding but it is a slow process (Biswas, 1990). As the time period available for weeding is limited, improved mechanical weeders are to be used to complete the weeding operation in due time at minimum cost.

There is an increasing interest in the use of mechanical intra-row weeder application because of concern over environmental degradation due to herbicide use and a growing demand for organically produced food. Today the agricultural sector requires non-chemical weed control methods that ensure food safety. Consumers demand high quality food products and pay special attention to food safety. Through the technical development of mechanisms for physical weed control, such as precise inter-and intra-row weeder, it might be possible to control weeds in a way that meets consumer and environmental demands and pollution free environment. Mechanical weed control methods ensure the safeguard against the soil and water pollution also.

1.1 Justification

Most of the farmers of Bangladesh control weed in rice field by hand weeding. Mechanical weed control not only uproots the weed between the crop rows but also keeps the soil surface loose, ensuring better soil aeration and water intake capacity. BRRI developed mechanical and power weeder to remove the unwanted plants in irrigated fields. These machines have higher field capacity over hand weeding and reduce the drudgery of the famers. There is a need to evaluate the farm level performance of those weeders. Therefore, the present study was undertaken with the following objectives.

1.2 Objectives

- To evaluate the field performance of mechanical and power weeder
- To estimate the yield and yield contributing character
- To compare the cost of mechanical over traditional method of weeding

Review of literature

Weed control is one of the most expensive field operations in crop production. Indeed, the detrimental effects of weeds in agriculture in developing countries far exceed those of all crop pests. Njoku (1996) reported that uncontrolled weeds growth reduces yield of the principal crops while untimely weeding reduces the returns from the overall investments in the production of crops. Igbeka (1984) reported that timeliness rather than frequency of weeding is a major determinant of effective weed control. Anyawu *et al.,* (1976) reported that biological method of weed control involves the use of parasites to control weeds that is killing weeds with their natural enemies. For this method to succeed, the insects that can feed on the weed are isolated. These insects are made to survive and reproduce in the environment where the weeds grow. Anyawu *et al.,* (1976) also reported that biological control of weeds includes the use of cover crops and leguminous which are grown in association with the crops. The cover crops creep on the land to cover the soil, thereby preventing development of weeds by chocking them out. The use of mucuna mulch can be used as an effective supplement with mechanical weed control. The effectiveness of supplementing mucuna mulching weed control must be considered with appropriate hand-pulling of weed using a special V-shaped hoe and mowing weeds with about a 2-kW engine mower. The combination of two or more methods of weed control at low input levels should be considered to reduce the weed competition to the possible minimum level; this was observed as the most appropriate solution to the problem of weed control by Singh *et al.,* (1985). Buckingham (1976) asserted that a complete weed control program must include primary tillage and secondary tillage planting practices, cultivation of row crops and the use of herbicides. Singh *et al.,* (1981) claimed that herbicides can reduce the labor requirement tremendously, but there was inconsistency in their performance. The inconsistency included the cost of herbicides relative to labor, farmers' lack of knowledge about the rate, time and method of application. Also, unavailability of herbicides and sprayers are some of the major factors that restrict the use of herbicides by small scale farmers. These limitations make mechanical method of controlling weeds preferable to the use of herbicides. So many researchers had worked on development and analysis of a ridge profile weeder (Odigbo and Ahmed, 1979; Oni, 1990; Nganilwa *et al.,* 2003). Kepner *et al.,* (1978) claimed that mechanical method of weed control is the best with little or no limitation because of its effectiveness. According to Kepner *et al.,* (1978) and Buckingham (1976), the primary objective of row crop cultivation is to enhance the use of farm machinery for eliminating weeds from the crop land. The effect of this method is to promote plant growth and better quality crops. However, the use of such machine is not common and the availability of a mechanical weeder is scarce.

2.1 Weed spectrum in rice

Identification of weeds is the basic step for planning sound weed management program. Depending upon the weed species, different weed management options are given keeping in view their susceptibility when growing in a crop (Walia, 2006).

The dominant grass weed species were *Echinochloa crusgalli* and *Echinochloa colona,* sedges were *Cyperus iria, C. rotundus* and *Fimbristylis miliacea* and broad-leaved weed species were *Ammania baccifera, Marsilia quadrifolia* and *Potamogeton distinctus* under puddled condition of sandy clay loam soil during rainy season. The broad leaved constituted 34.1 percent, grasses 42.2 percent and sedges 23.6 percent of the total weed population under weedy conditions (Singh *et al.,* 2007). The wet seeded rice was infested with composite weed flora comprising of 51.5% grasses, 30.9% sedges and 17.5% broad-leaved weeds (Ravisankar *et al.,* 2008). Ramachandra (2010) recorded the dominant weed species in transplanted rice as *Echinochloa crus galli* (L.) and *E. colona* (L.) under grasses; *Cyperus difformis* (L.), *Cyperus iria* (L.) and *Cyperus rotundus* (L.) under sedges and *Eclipta alba* (L.) Hassak and *Ammania baccifera* (L.) among the broad leaved weeds. Reddy (2010) reported that predominant weed species in the direct seeded rice were *Echinochloa crusgalli* (L.) under grasses; *Cyperus difformis* (L.) and *Fimbristylis miliacea* (L.) under sedges and *Eclipta alba* (L.) Hassak and *Ammania baccifera* (L.) under the broad leaved weeds.

2.2 Crop weed competition

Crop yield losses due to weeds mainly depend upon their intensity as well as on type of weed flora. There is a linear correlation between yield loss and population of weeds, however, above certain population limits, yield reductions becomes nearly constant due to self-competition among weed plants. The greatest loss caused by the weeds resulted from their competition with crop for growth factors viz., nutrients, soil moisture, light, space etc. (Walia, 2006).

2.3 Critical period of crop - weed competition

During early establishment, the weeds make 20 to 30 per cent of their growth, while the crop makes 2-3 per cent of its growth (Moody, 1990). The competition period up to 45 DAS had the greater impact on yield of wet seeded rice (Govindarasu *et al.,* 1998; Sathyamoorthy and Kandasamy, 1998). Chinnusamy *et al.* (2000) reported that maintaining a weed free period up to 45 DAT was essential to augment the yield of medium duration rice. Critical period for crop weed competition in rice was up to 40 days after transplanting (Tewary and Singh, 1991; Thapa and Jha, 2002). In rainfed low land rice, 30-60 days after sowing period was considered as critical period for crop weed competition to avoid grain yield losses (Moorthy and Saha, 2005).

2.4 Nature of crop - weed competition

Weeds are self-grown and appear simultaneously with crop plant creating severe competition for nutrient, space, moisture and solar energy resulting in low yield of crop. Grassy weeds were heavy competitors with rice crop and were followed by sedges and broad leaved weeds (Umapathy and Sivakumar, 2000). Chauhan and Johnson (2010) stated that when direct seeded rice was grown together with either jungle rice or Ludwigia spp, shoot competition reduced the growth and yield of rice more than root competition and rice grain yield was highly correlated with above and below ground biomass of the weeds.

2.5 Nutrient removal by weeds

Weeds usually grow faster than the crop plants and absorb added nutrient more rapidly and in larger quantities than by crops (De Datta and Baltazar, 1996) and thus deprive the supply of nutrients in time to the crop plants. Weeds removed nutrients (N, P and K) eight times higher under direct seeded rice compared to that of puddled transplanting (Singh *et al.,* 2002). Sudhalakshmi *et al.* (2005) reported that nutrient uptake by weeds was 30 kg N, 10 kg P and 17 kg K per hectare in transplanted rice in clay loam soil of Coimbatore. Puniya *et al.* (2007b) noticed that the highest loss of nutrients (N 42.07, P 10.00 and K 21.80 kg ha^{-1}) occurred with unweeded control due to more density and dry weight of weeds in transplanted rice during kharif in silt loam soil of Pantnagar.

2.6 Effect of weed population on rice growth and productivity

Severe infestation of weeds suppressed the plant height (Bhargavi and Reddy, 1994) increased tiller mortality, decreased shoot and grain production (Srinivasan and Palaniappan, 1994). Singh *et al.,* (2002) observed that maintaining weed free condition till maturity gave significantly higher grain yield due to more panicles m^{-2} and lower density and dry weight of weeds. Moorthy and Saha (2005) reported that the losses in grain yield due to weed competition for first 30, 60, and 90 days were 17.7, 11.8 and 5.0 per cent, respectively. Weedy environment throughout the crop growth caused yield reduction to the tune of 57-61 per cent in case of transplanted rice and 64-66 per cent in case of wet seeded rice in comparison to season long weed free situation (Mukherjee *et al.,* 2008). The unit increase in intensity of monocots, dicots and weed dry weight causes decrease in Pusa Basmati 1 rice grain yield by 2.18, 1.64 and 2.85 q ha^{-1}, respectively during wet season (Singh *et al.,* 2008). Veeraputhiran and Balasubramanian (2010) observed that maintaining weed free condition till maturity produced the grain yield of 7139 kg ha^{-1} of transplanted rice. The overall effect of crop weed competition is the reduction in the economics as well as biological yield of rice.

2.7 Weed management methods

2.7.1 Cultural methods

Cultural practices greatly alter the competitive relationship between rice and weeds. Hence, proper agronomic management practices like suitable crop establishment method, efficient fertilizer use and timely weed control have to be planned to attain the target food production (Nagaraju, 1994). The closely spaced crop effectively smothered the weeds growing under crop canopy by not providing sufficient space for weed growth complemented by restricting sunlight from penetrating downwards (Brar and Walia, 2001).

Prasad *et al.* (2001) stated that transplanting recorded the lowest weed population (63.5 m^{-2}) and weed dry weight (24.1 g m^{-2}) which was followed by sowing of sprouted seeds in puddled condition and dry drilling of seeds. Francis (2007) found higher weed population (6.58 m^{-2}) and weed biomass (12.9 kg ha^{-1}) in SRI than conventional transplanted rice which can be attributed to more inter space area and less population.

Transplanted rice recorded the lowest weed count of 3.19 m^{-2} and weed dry weight of 2.44 g m^{-2} resulting in highest grain yield of 3105 kg ha^{-1} (Singh *et. al.,* 2007). Further, they reported that the weed intensity and weed dry weight increased with the increase in fertility level and was maximum with application of 120: 60: 60 kg NPK ha^{-1}.

Chauhan and Johnson (2010) stated that the risks of crop yield loss due to competition from weeds in direct seeded rice was greater than in transplanted rice because the weeds and rice emerge together and farmers are not usually able to use standing water to suppress weeds at the early growth stages of rice. Dry weight of grasses (6.18 and 8.77 g m^{-2}), sedges (3.32 and 4.97 g m^{-2}), broad-leaved weeds (1.85 and 2.74 gm^{-2}) at 45 and 60 DAS, the N-P-K uptake of 4.09-1.53-4.49 kg ha^{-1} by weeds at 60 DAS were minimum and the weed control efficiency was maximum (67.02%) in drum seeding method than wet and dry seeding (Singh and Singh, 2010).

Reddy (2010) reported that direct planting system recorded less total weed dry weight (1062 kg ha^{-1}) and nutrient removal by weeds (31:16:52 kg NPK ha^{-1}) over drum seeding. However, weed control efficiency was similar for both establishment methods.

2.7.2 Hand weeding

Hand weeding twice at 20 and 40 DAS was superior to the chemical weed control for all the growth and yield attributes, reflecting the higher grain yield of 2876 kg ha^{-1} in silty loam and calcareous soil during rainy season (Prasad *et. al.,* 2001). Chander and Pandey (2001) observed that hand weeding increased grain as well as straw yields compared to herbicides and weedy check because of frequent elimination of weeds that resulted in the reduced weed competition. Dutta *et. al.* (2005) reported that hand weeding twice at 21 and 42 DAS recorded the highest weed control efficiency and increased grain and straw yield of rice crop.

Hand weeding is very effective but it is tedious, time consuming and expensive in large scale cultivation. Continuous rains in rainy season and unavailability of man power make hand weeding difficult (Puniya *et. al.,* 2007). Pal *et. al.* (2009) opined that hand weeding on 20 and 40 DAT recorded highest grain yield of 5.08 t ha^{-1} in Gangetic alluvial soil because it gave very little scope to weeds to flourish and to compete with the crop preferably at the critical stage of crop weed competition.

2.7.3 Mechanical weeding

In the recent past, weed control is practiced more by chemical means supplemented by hand weeding. In the era of increasing labor scarcity and exploding pollution effects, weed management strategy could be reoriented towards mechanical means for satisfactory fertility and monetary benefits.

Mechanical weeding is accomplished through incorporation of weeds insitu may help in effective recycling of the depleted nutrients which in turn could have augmented the nutrient pool of the rhizosphere together with aeration of the root zone.

Rotary weeder was effective in controlling the weeds present in inter row space, but failed to control the weeds in intra row space or those in the vicinity of the crop (Choubey *et al.,* 1998). Uphoff (2002) reported that the mechanical hand weeder pruned some of the upper roots and encouraged deeper root growth.

Randria miharisoa (2002) noticed that the mechanical weeding using rotating hoe with small toothed wheels increased the soil pores so that roots and microbes could more easily gain access to oxygen and also significantly increase the tiller production. The use of conoweeder resulted in 10 per cent grain yield increase during wet season while the yield increase was only three per cent higher in dry season than conventional method of weeding (Thiyagarajan *et. al.,* 2002). Cono weeding alone was found to contribute 17.43 per cent for grain yield when the average grain yield under the cono weeding treatments 3376 kg ha^{-1} was compared against the average grain yield under hand weeding treatments 2875 kg ha^{-1} (Sridevi, 2006). The impact of conoweeding in increasing the ammoniacal and nitrate nitrogen content of the rhizosphere soils was evident only at harvest (37.9 ppm) and grain filling stages (49.6 ppm) respectively while at the rest of the stages conoweeding had not set any notable impact on the nitrogen fractions of the rhizosphere soil (Sudhalakshmi *et. al.,* 2005).

Mrunalini and Ganesh (2008) opined that the implements like conoweeder that helped to save labor, time and reduced man-days required for weeding from 30 to 10 as they become more experienced in handling the conoweeder implement.

2.7.4 Economics of different weed management practices

Hand weeding is laborious and generally more expensive. The weed control cost is maximum for hand weeding (two hand weeding at 30 and 45 DAT) and the lowest for chemical weed management (Hasanuzzaman *et. al.,* 2007).

Khare and Jain (1995) reported that rotary weeder attained the highest net profit because of less cost of cultivation and thus resulted in the highest value of B:C ratio of 1.90 in sandy loam soil during wet season at Jabalpur.

Reddy (2010) reported that pre emergence application of pretilachlor + safener@0.45 kg ha^{-1} on 3 DAS + conoweeding on 45 DAS recorded the gross return of RS 65,961 ha^{-1}, net return of RS 46,793 ha^{-1} and B: C ratio of 3.4 and was comparable with pretilachlor + safener @ 0.45 kg ha^{-1} on 3 DAS + motorized weeding on 45 DAS during wet season.

Materials and Methods

This chapter represents the details of various materials and methodologies followed for the experimental work. The experiment was conducted for studying the yield performance of BRRI power weeder over traditional method of weeding.

3.1.1 Experimental location

This experiment was conducted in the farmers' field, Rashidpur, Mithapukur, Rangpur (Map 1).

Map 1: Location of study area at Rangpur

3.1.2 Treatments

Three treatments were designed to conduct the experiments, such as

T1 = Hand weeding (HW) at 25 DAT and 55 DAT

T2 = BRRI mechanical weeder (BMW) at 25 DAT

T3 = BRRI power weeder (BPW) at 25 DAT

3.1.3 Characteristics of weeder

BRRI mechanical weeder (Photo 3.1a)

Price : 800/-

Line spacing : 20, 25 cm

Capacity : 10 deci/hr.

Man and woman can operate the machine easily.

BRRI power weeder (Photo 3.1b)

Engine type: Petrol engine

Weight : 16.5 kg

Price : 60,000/-

Line spacing: 30 cm

Capacity : 0.33 acre/hr

Photo 3.1a BRRI mechanical weeder

Photo 3.1b BRRI power weeder

3.1.4 Experimental design and treatment

The experiment was carried out in randomized complete block design (RCBD) and replicated in five plots. Fifteen farmer's plots within one kilometer radius were selected to conduct this study (Appendix 1).

3.1.5 Traditional seedbed preparation

Seedbed preparation often involves secondary tillage by using spade and puddling was done after inundating the field (Photo 3.2). Drainage canals were constructed for proper water removal. Puddled soil was leveled and raised to 5-10 cm height. Organic manure (decompose) and a small amount of inorganic fertilizer was applied as basal dressing to increase seed vigor and easier uprooting for transplanting. Sprouted seeds were broadcast.

Photo 3.2 Seedlings at field in the conventional method

3.2 Land preparation

The field was prepared using common tillage practice, which is first plowing (primary tillage) once, followed puddling (secondary tillage) twice and leveling using two-wheel tractor under the flooding conditions (Photo 3.3). After first rotary tilling, the field was flooded with water and kept as such for 7 days and then second rotary tilling was done on 8th day and the field was leveled by a plank.

Photo 3.3 Land preparations using two wheel tractors in flooding condition

3.3 Fertilizer application

During final land preparation, all cares were taken for uniform leveling of the land. A fertilizer dose per bigha of 18 kg P, 15 kg K, 15kg S and 1.5 kg Zn as triple super phosphate, muriate of potash, gypsum and zinc sulfate, respectively was applied at final land preparation.

3.4 Seedling uprooting

The nursery bed was made wet by application of water one day before uprooting the seedlings (Photo 3.4). The seedlings were uprooted on 16 January 2015 without causing much mechanical injury to the roots and they were immediately transferred to the main field.

Photo 3.4 Rice seedlings uprooting from farmers field

3.5 Hand transplanting

During boro season, forty three days old seedlings were uprooted carefully from the nursery field and transplanted in each of the well puddle unit plots on two the same day (Photo 3.5). The date of transplanting for boro rice was 17th and 18th January, 2015. A spacing of 20×20 cm from row to row was tried to maintain but plant to plant spacing can be varied and the plant to plant spacing depends largely on the skill of the labor.

Photo 3.5 Seedling transplanting

3.6 Labor requirement

The amount of human labor involved in each operation was investigated through field measurements.

3.7 Water management

Irrigation water was applied time to time as when required uniformly in hand and mechanical transplanted plots for proper growth and development of crops. Maximum irrigation was needed at the panicle initiation stage.

3.8 Performance Parameter

3.8.1 Theoretical field capacity

The theoretical field capacity of a machine is the rate of field coverage that would be obtained if the machine performs its function 100% of the time at the rated forward speed and always covers 100% of its rated width. Therefore,

$$C_0 = \frac{w \times s}{c} \qquad (1)$$

Where,

C0 = Theoretical field capacity, ha/hr

w = Operating width of the weeder, m

S = Transplanting speed, km/hr

C = Constant, 10

3.8.2 Actual field capacity

It is the ratio of actual average rate of field coverage by the machine to the total time during operation. Therefore,

$$C = \frac{A}{T} \qquad (2)$$

Where,

C= Actual field capacity, ha/hr

A= Total transplanted area, ha

T= Total operating time required for transplanting, hr

3.8.3 Field efficiency

It is the ratio of effective field capacity to the theoretical field capacity of a machine under field conditions and the theoretical maximum productivity and it can be calculated by the following equation:

$$Eff = \frac{c}{c_0} \times 100 \qquad (3)$$

Where,

Eff = Field efficiency, %

C = Actual field capacity, ha/hr

C0= Theoretical field capacity, ha/hr

3.8.4 Fuel consumption

Fuel consumption was measured by filling the fuel tank twice, before and after each operation. Re-filled volume was the actual fuel consumption according to the following equation:

$$Fc = \frac{Fr}{t} \quad (4)$$

Where,

Fc = fuel consumption, l/hr

Fr = re-filled volume of fuel, l

t = operating time, hr

a. Hand weeding

b. BRRI mechanical weeder

c. BRRI power weeder

Photo 3.6 Field performance of weeder machine

a. Hand weeding

b. BRRI mechanical weeder

c. BRRI power weeder

Photo 3.7 Crop performance of experimental plot

3.9 Weed species

Data on weed density were collected from each plot at vegetative growth stage of the rice plants by using 0.5m × 0.5m quadrate as per method described by Cruz *et al*. (1986). The quadrate was placed in three spots at random outside 1 m^2 central areas, kept for taking yield data. The weeds within the quadrate were counted species-wise and converted to number m^{-2} multiplying by four.

3.10 Weeds biomass

After counting the weed density, the weeds inside each quadrate were uprooted, cleaned, separated species-wise and dried first in the sun and then in an electrical oven for 72 hours at a temperature of 80^0c. The dry weight of each species was taken by an electrical balance and expressed in gm^{-2}.

3.11 Weeding efficiency

To determine the weeding efficiency in three places of each plot bamboo frame of 1×1 m was thrown in the field randomly and the number of weeds was counted (Photo 3.8). The weeding efficiency was computed by using the following equation:

$$\text{Weeding efficiency, } \Sigma = \frac{W_1 - W_2}{W_1} \times 100 \qquad (5)$$

Where,

W1 = number of weeds before weeding

W2 = number of weeds after weeding

Σ = weeding efficiency

Photo 3.8 Data collection on number of weeds/m^2

3.12 Tiller damage

In order to determine the damaged plant, as a quality of work done (Tewari *et al.*, 1993) in three places of each plot, bamboo frame of 0.50 × 0.50 m was thrown in the field randomly and the number of damaged plants in the frame were counted. The percent of breakage of rice tiller was computed by using the following equation:

$$DP = \frac{Q_1}{Q_2} \times 100 \qquad (6)$$

Where,

DP = Damaged tillers (%);

Q1 = Number of tillers broken in the row after weeding operation

Q2 = Total number of plants in the row

3.13 Comparative inputs

Comparative input of three weed management practices is given in Table 3.1. Rice variety, land preparation, basal dose, fertilizer rate, cultural practices, pest and disease management were similar in all the weed management practices. Almost line sowing was done HW whereas, 20 × 20 cm was maintained in BMW and BPW.

Table 3.1: Comparative inputs in three weed management practices

Sl.No	Parameters	HW	BMW	BPW
1	Variety	BRRI dhan28	BRRI dhan28	BRRI dhan28
2	Date of Seeding	05/12/14	05/12/14	05/12/14
3	Date of transplanting	18/01/15	17/01/15	17/01/15
4	Age of seedling	43 days	44 days	44 days
5	Spacing	Almost line transplanting	20×20 cm	20 × 20 cm
6	Basal Fertilizer	TSP@136kg ha^{-1} MOP@111kg ha^{-1} Gypsum@111kg ha^{-1} Zn@11.25kg ha^{-1}	TSP@136kg ha^{-1} MOP@111kg ha^{-1} Gypsum@111kg ha^{-1} Zn@11.25kg ha^{-1}	TSP@136kg ha^{-1} MOP@111kg ha^{-1} Gypsum@111kg ha^{-1} Zn@11.25kg ha^{-1}
7	Weeding	Two time	One time	One time
8	Top dressing	Urea 272 kg ha^{-1}	Urea 272 $kgha^{-1}$	Urea 272 $kgha^{-1}$
8a	1st top dress	Urea 99 kg ha^{-1}	Urea 99 $kgha^{-1}$	Urea 99 $kgha^{-1}$
8b	2nd top dress	Urea 124 kg ha^{-1}	Urea 124 $kgha^{-1}$	Urea 124 $kgha^{-1}$
9	Insecticide	Virtako one time @ 75 g ha^{-1}	Virtako one time @ 75 g ha^{-1}	Virtako one time @ 75 g ha^{-1}
10	Fungicide	Nativo one time @ 300 g ha^{-1}	Nativo one time @ 300 g ha^{-1}	Nativo one time @ 300 g ha^{-1}
11	Date of maturity	25/04/15	27/04/15	26/04/15

3.14 Cultural practices (weeding)

Weeding was done manually by hand twice at 25 DAT and 55 DAT and machine weeding once at 25 DAT. After that no other weeding operation was done up to harvest. During weeding, different weed species grown in the experimental plot were identified and counted species-wise.

3.15 Pesticide and Insecticide application

Severe pest infested in the plant during the *boro* season. However, the pests were controlled by a single application of Virtako and Nativo at the vegetative growth stage.

3.16 Yield and yield contributing characters

Grain yield were recorded from pre-selected 10 m^2 land area and adjusted moisture content of 14% moisture level. The plant height was measured from the base of the hill to the tip of the longest panicle (Photo 3.9). Length of the panicle was taken from the basal node of the rachis to the apex of each panicle. Twelve hills from each of the plots were collected randomly. The panicles that had at least one grain were considered as effective tillers. The panicles that had no grain were considered as non effective tillers. The number of effective and non effective tillers of each hill was noted and the total number of tillers was counted for each hill (Photo 3.10). For computing aboveground biomass and yield contributing characters, 4 hills were collected from the outside of the selected area. The dry weight of straw was determined after oven-drying at 70°C to constant weight. Panicle number of each hill was counted to determine the panicle number m^{-2}. Plant samples were separated into straw and panicles. Panicles were hand-threshed and the filled spikelets were separated from unfilled spikelets. Aboveground total biomass was the total dry matter of straw, rachis, and filled and unfilled spikelets. Spikelets per panicle, grain-filling percentage (100×filled spikelet number/total spikelet number) and harvest index (100×filled spikelet weight/aboveground total biomass) were calculated. Border areas of all sides of the plot were excluded to avoid border competition effects. One thousand clean, dried seeds were collected and weight was measured by an electric balance. The moisture content was determined by digital moisture. Harvesting index is the ratio of grain yield to biological yield and harvesting index (HI) was calculated by the following formula stated below.

$$HI = \frac{\text{Grain Yield}}{\text{Biological yield}} \times 100 \qquad (7)$$

Where,

HI= Harvesting index, %

Photo 3.9 Measuring the plant height and panicle length


Photo 3.10 Counting of effective and total tillers per hill

3.17 Harvesting

When about 85-90% of the grains become golden yellow, the crop was thought to be matured (Photo 3.11). The crops established by different planting methods attained maturity at different dates. On maturity, the crops were harvested. Then the harvested crop of each plot was separately bundled, properly tagged and then brought to threshing floor.

Photo 3.11 Hand harvesting

3.18 Economic analysis

In order to estimate the production cost, the data on working speed, total time and labor inputs by the weeder, manual worker and materials inputs to complete the operations were recorded. Rental charge of the machines also include in the cost estimation. Land value and interest on investment was considered to calculate the total input cost. Market price of the produce was collected from the local markets to compute total production cost, gross return, gross margin and benefit-cost ratio. The benefit-cost ratio (BCR) was computed as follows:

$$\text{BCR} = \frac{\text{Gross return}}{\text{Production cost}} \quad (8)$$

3.19 Statistical analysis

Data were analyzed by using statistical software Statistix 9.0. Means were compared with least significant difference (LSD) test.

Results and discussion

The results of the weed parameters, crop characters of boro rice (BRRI dhan28) which were influenced by different weed management practices have been presented and discussed in this chapter.

4.1 Number of seedlings per hill

Seedlings are transplanted manually in all the experimental plots. Distributions of numbers of seedlings per hill are given in Fig. 4.1. Number of seedling per hill depends on farmers' skill. Number of seedlings per hill varied in different plots. Three to six numbers of seedlings per hill were obtained in most of the places.

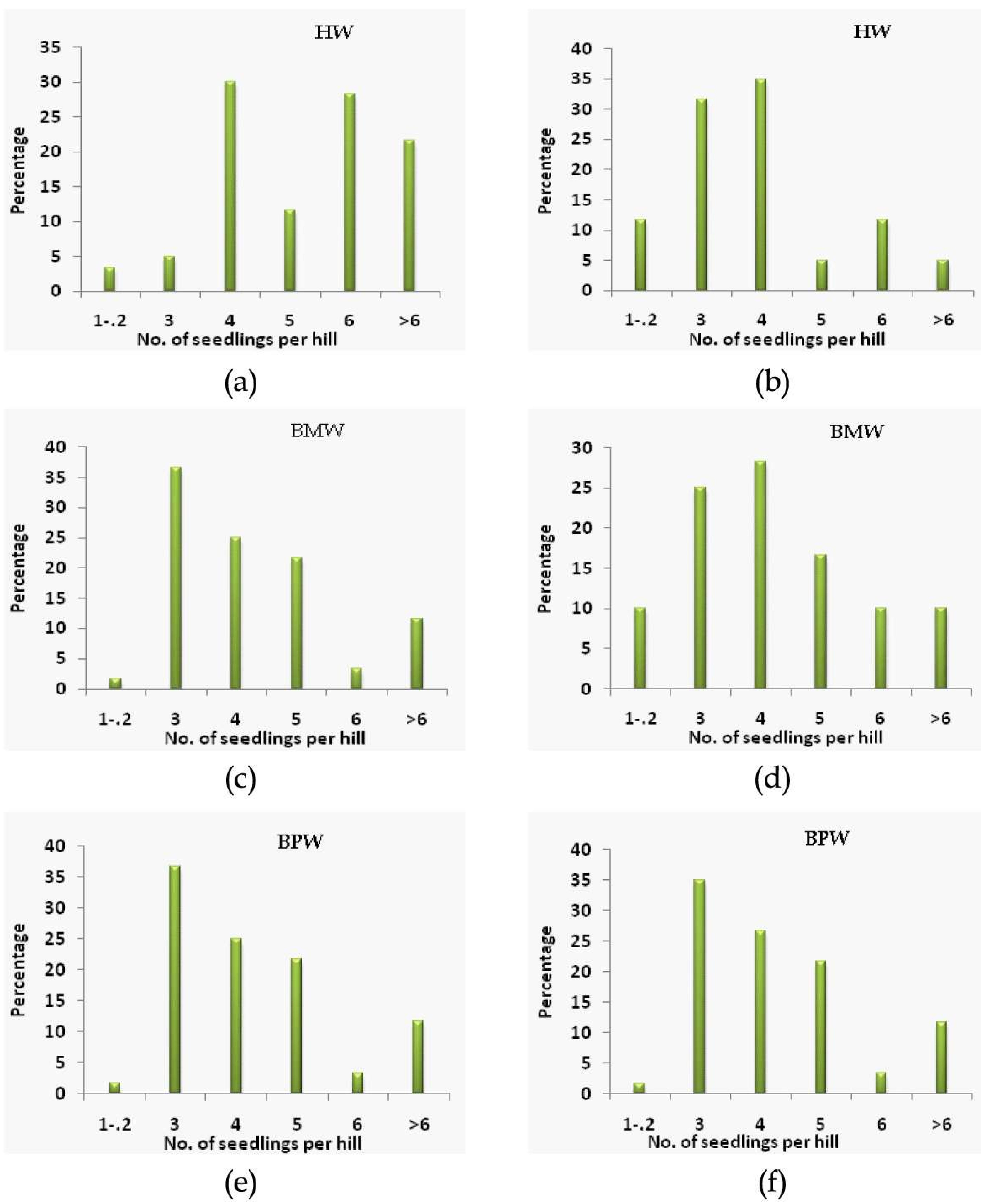


Fig. 4.1 Seedling densities in weeding application methods

4.2 Hill spacing

Hill spacing is an important parameter for weeding operation by using weeder. Hill to hill spacing can be varied. Hill to hill spacing depends largely on the skill of the labor. Results on hill spacing were not consistent which is shown in Fig. 4.2 shows the histogram of hill spacing for weeding application methods. It was observed from the figure that, more than 75% of the plant did not maintain the spacing uniformly, which affected the operation of the power weeder.

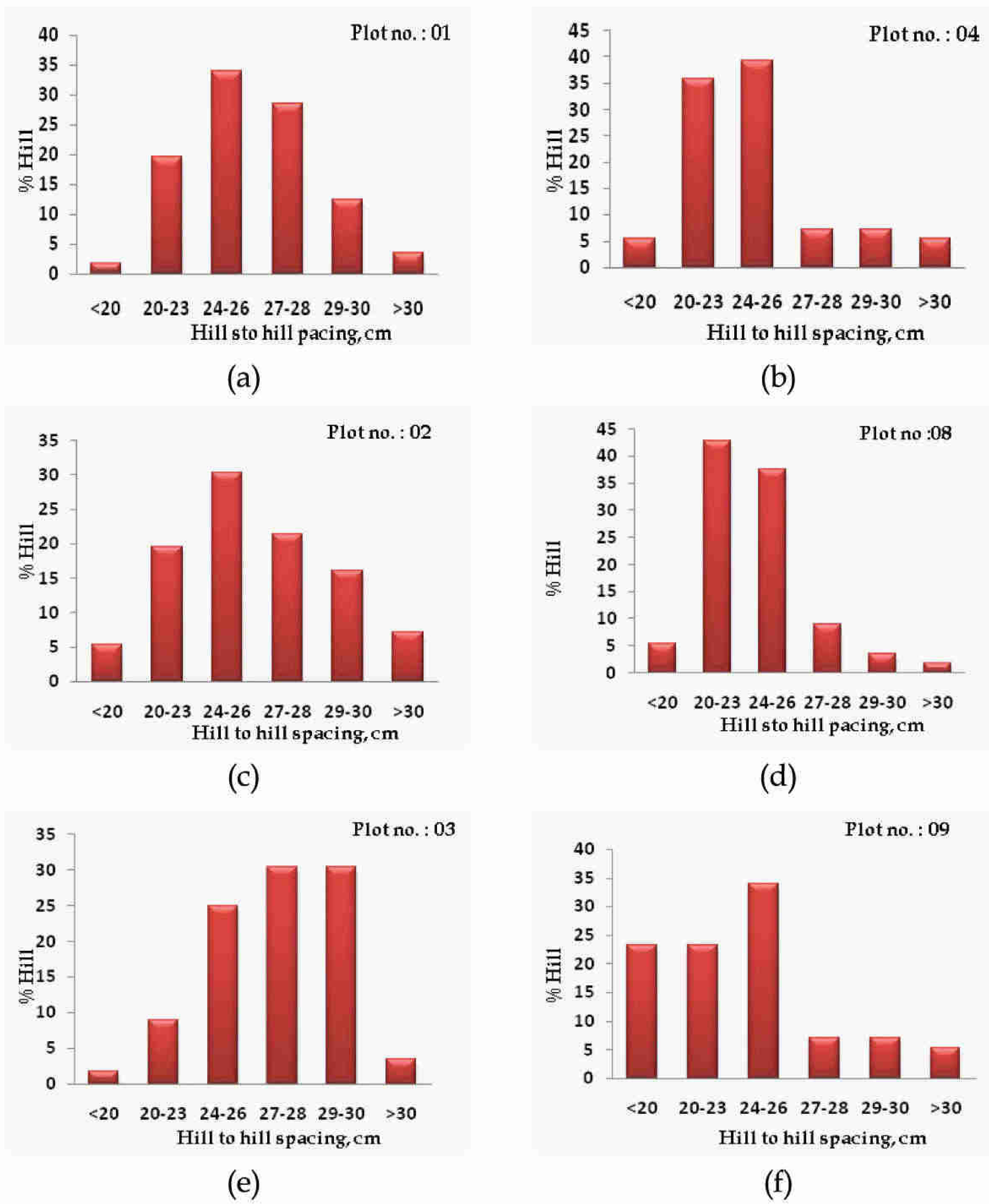


Fig. 4.2 Histogram of hill to hill spacing

4.3 Hill density

The experimental results of the hill density or the hill/m^2 of three weeding methods were graphically presented in Fig. 4.3. Hill density was higher for BMW plots than HW and BPW. The hill density for BPW plot was 18.35 hill/m^2 and hill density for HW and BMW were 17.93 and 19.72, respectively.

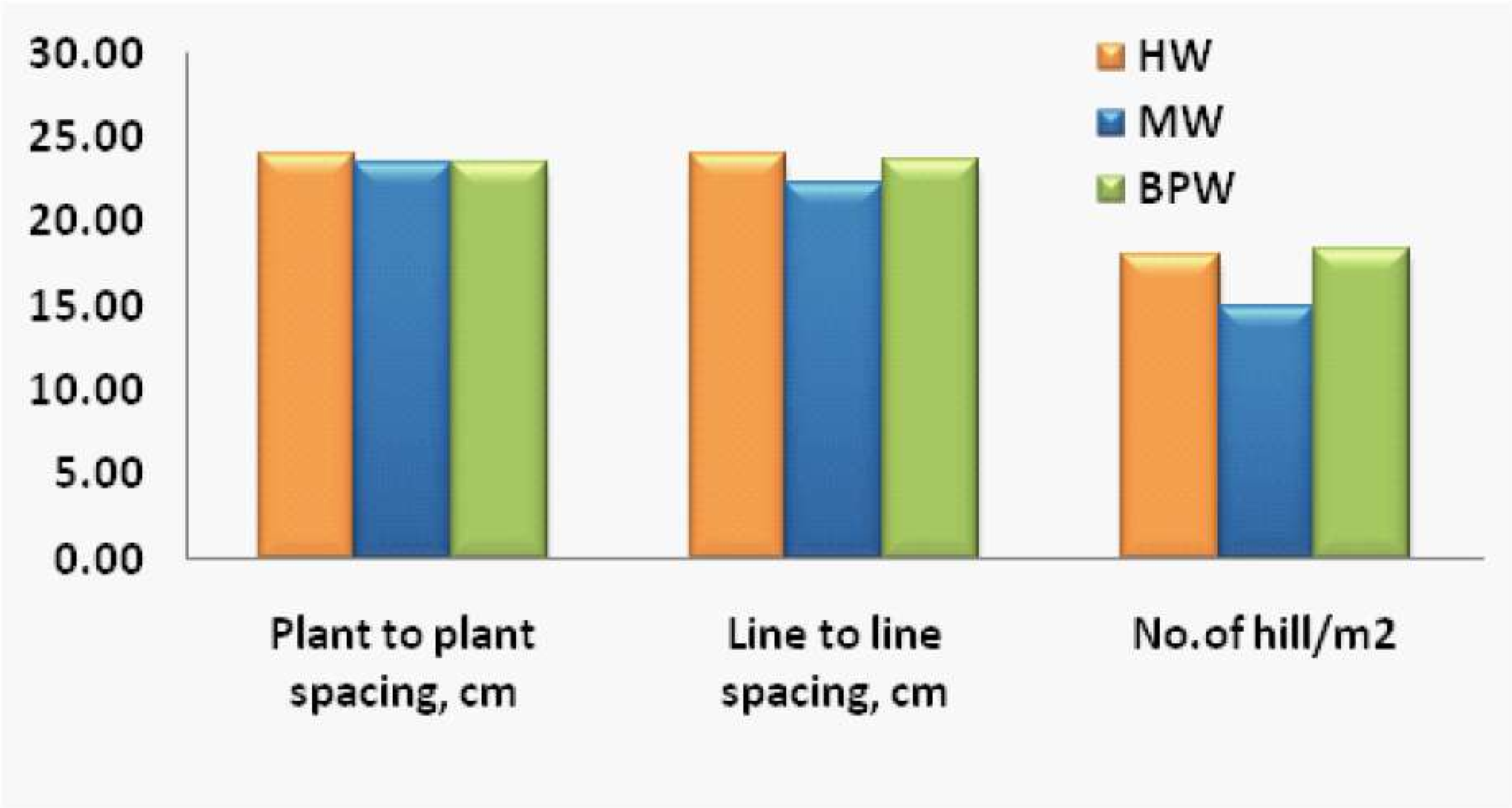


Fig. 4.3 Hill density of different weed control plot

4.4 Infesting weed species growth

Eight different weed species belonging to three families of which 4 annual and 4 perennial were found to infest the experimental plot. Local name, scientific name, family name, life cycle and types of the weed species have been presented in the Table 4.1. Among eight weed species, one was sedge, one was broad leaf and six were grasses. The most predominant weed species in the experimental plots was Chesra *(Scripus juncoides),* other important weeds were Angta *(Panicum repens)*, Anguli (*Digitaria sanguinalis* L.; Scop), Durba (*Cynodon dactylon* L.; pers) and Chela ghash (*Rottboellia protensha* Hack.). The Khudeshama (*Echinochloa colonum* L.;Beauv) was the least abundant weed species in the experimental plot. Some upland weeds observed in the fields due to dry condition of land.

Table 4.1 Infesting weed species growth in the experimental plots

Sl. No.	Local Name	Scientific name	Family name	Life cycle	Type
1	Chesra	*Scripus juncoides*	Cyperaceae	Perennial	Sedge
2	Angta	*Panicum repens*	Gramineae	Perennial	Grass
3	Chela gash	*Rottboellia protensha Hack.*	Gramineae	Perennial	Grass
4	Amrulshak	*Oxalis stricta*	Oxalidaceae	Annual	Broad leaf
5	Durba	*Cynodon dactylon L.; pers*	Gramineae	Perennial	Grass
6	Khudeyshama	*Echinochloa colonum L.;Beauv*	Gramineae	Annual	Grass
7	Anguli	*Digitaria sanguinalis L.; Scop*	Gramineae	Annual	Grass
8	Chapra	*Eleusine indicanL.; Gaertn*	Gramineae	Annual	Grass

4.5.1 Field capacity

Field capacity is an important factor for any kind of machine operation. The figure 4.4 showed that field capacity of BMW (0.06 ha/hr) obtained higher than BPW (0.09 ha/hr). Operator's skill influenced the performance of weeder. At the end of each pass, operator lifted the machine, placed the machine in another new rows and started operation. This increased the turning time loss which reduced the field capacity of the BPW.

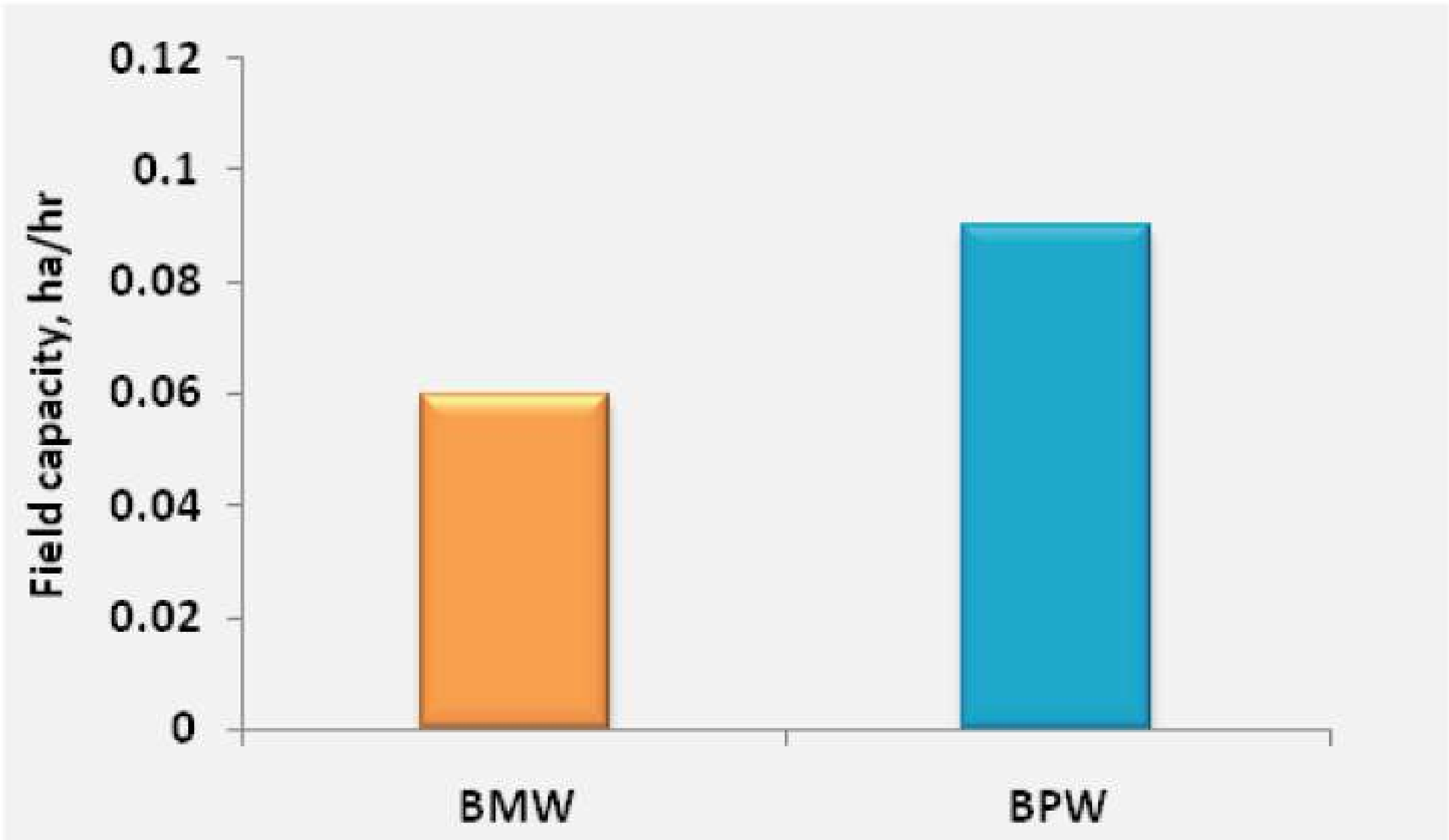


Fig. 4.4 Field capacity of BMW and BPW

4.5.2 Problems with operating the BPW

While operating BPW, operator should pull the machine in every instance and walk slowly while rotor is running to facilitate uprooting of weed. This created fatigue to the operator. As BPW is new machine, operator need to be trained for proper operation of the machine. During operation, some mechanical faults were observed, especially weeds clogged the rotors, machine vibration, weight of the machine etc. Excessive water height impeded the proper operation of the BPW.

4.6 Labor requirement in weeding operation

Effect of weeding method on labor requirement is very important. Labor requirement in HB, BMW and BPW were 86, 22 and 13 man-hr per hectare. Hand weeding appeared as labor intensive works in rice production. BMW and BPW reduced 74% and 85% labor requirement in weeding operation compared to HB. It can be concluded that BPW and BMW drastically reduced the labor requirement in weeding operation.

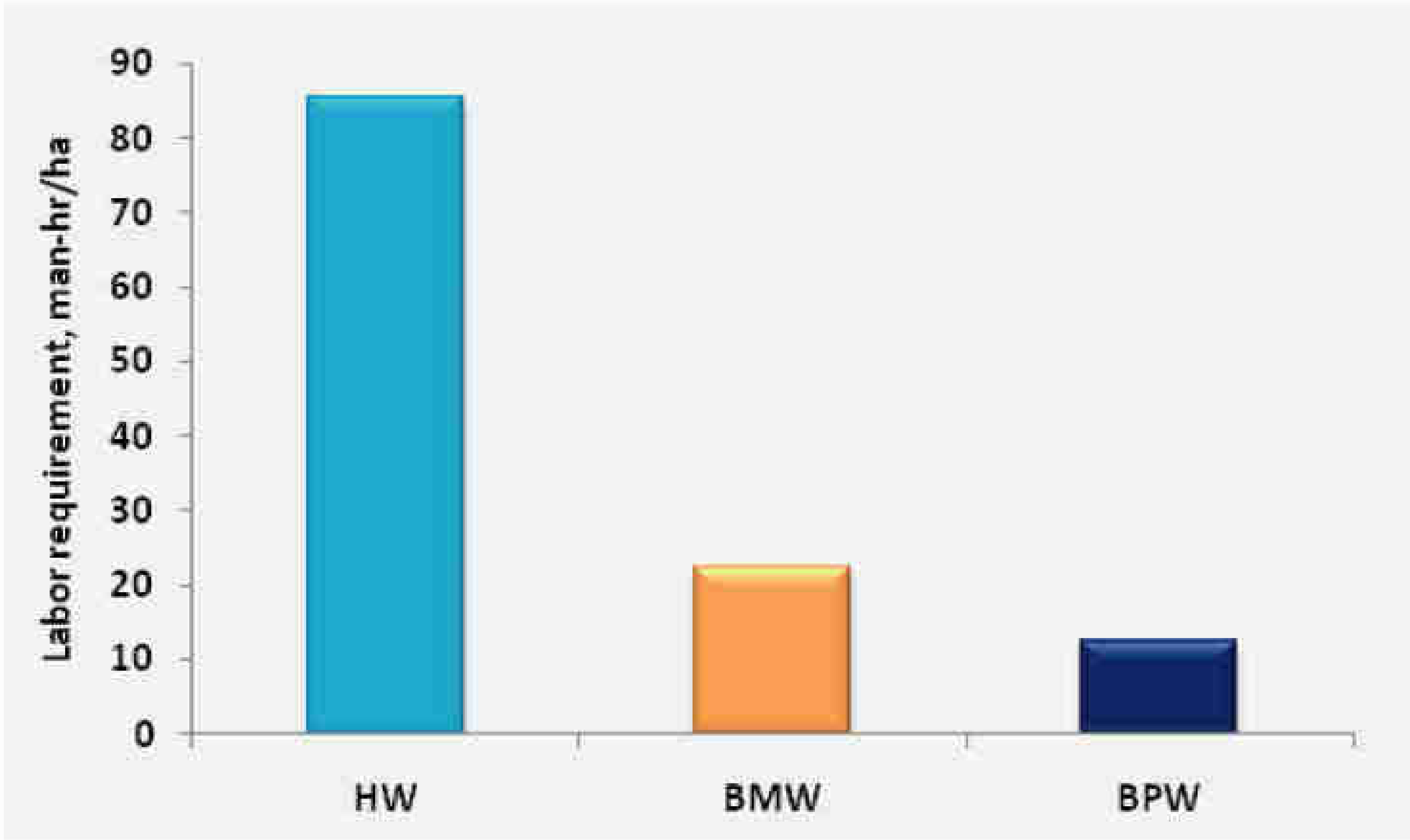


Fig. 4.5 Labor requirement during weeding operation

4.7 Weed control efficiency

Means comparison for weed control efficiency in the experimental treatments is demonstrated in Fig. 4.6. The highest weeding efficiency (78%) obtained in BPW and the lowest (73%) obtained in BMW (Appendix 2 & 3). This could be attributed to utilized active rotors mechanism in the power weeder. It means the engine would provide the required power for rotor caused better blades grips with soil, resulting in higher weeding efficiency of the weeder. The results also showed that for each type of weeding method, the weeding efficiency in power weeder was more than mechanical weeder. This may be due to differences in canopy pattern of the rice varieties in vegetative stage. Generally, weed control efficiency depends on the weeder type, weed species and the weeding time. If weeding is delayed, the weed control efficiency will be decreased for excessive growth of weeds in soil and improper involvement of machine blades in soil depth.

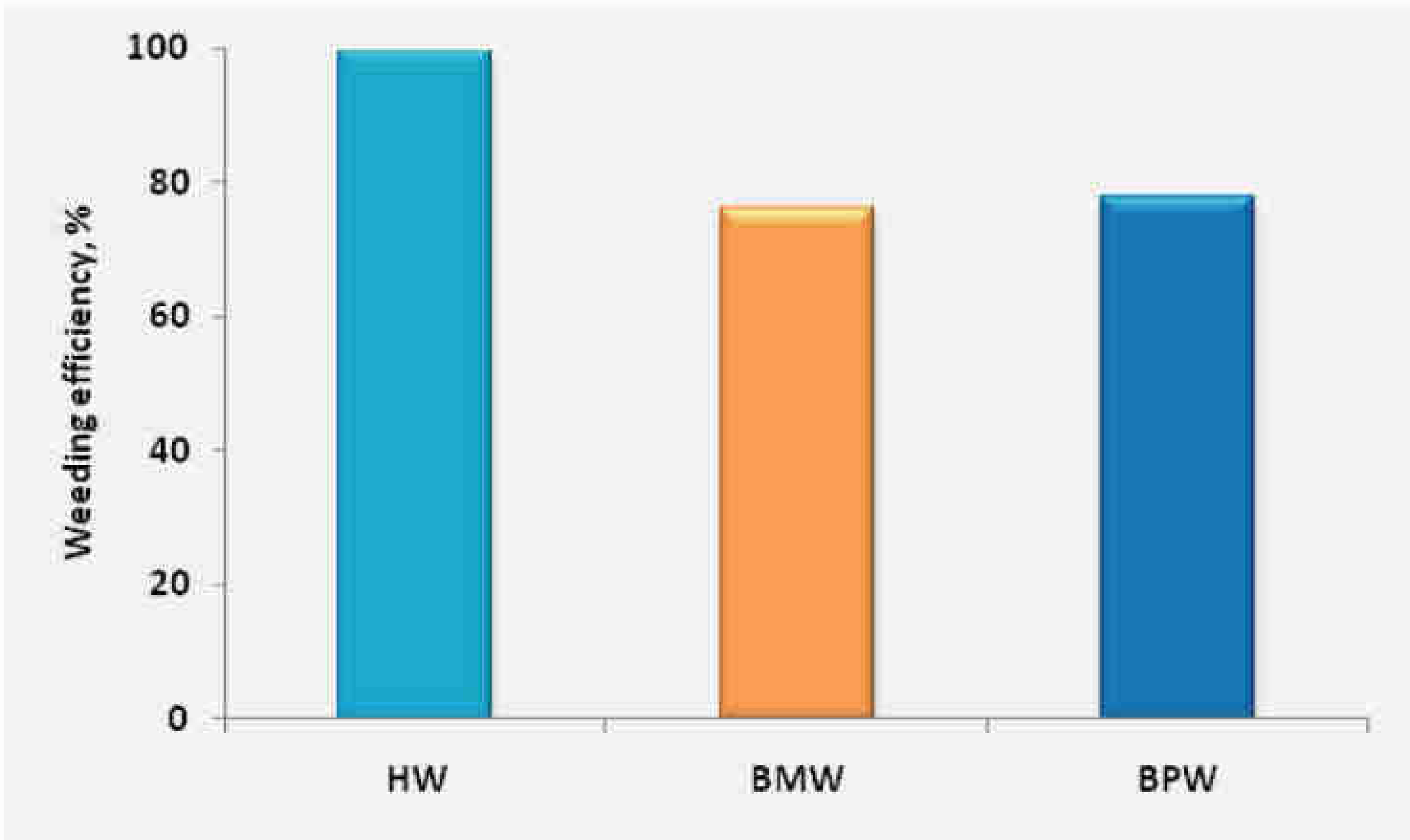


Fig. 4.6 Weed control efficiency

4.8 Tiller damaged

Plant spacing is an important factor for successful weeding operation. In weeder application plot, it is mandatory to maintain exact line to line distance to facilitate the operation of weeder. Farmers were advised to maintain exact spacing as 20 × 20 cm for their weeder plots. Actually, plant to plant spacing depends largely on the skill of the labor. Results on plant spacing were not consistent. From the observation of field, the farmers did not maintain uniform spacing in most cases. As a result, when the machine operates, some plants were damaged. Fig. 4.7 shows the means comparison for damaged plants in the experimental treatments. Results indicated that the least percentage of damaged plants (9%) obtained in BPW. The BPW caused higher damaged plant (11%) although it had high efficiency rather than BMW. The results also revealed that in each weeding method, the percentage of damaged plant in BMW was 2% higher more than BPW due to non-uniformaly in line spacing. The movements of weeder machines encounters difficulties in BPW plot because of the distribution pattern and shading of plant over spaces between the rows and percentage of damaged plant will be consequently occur. In the other hand, in BMW plot, the weeder moved swiftly between the rows caused more damages of plants through weeding.

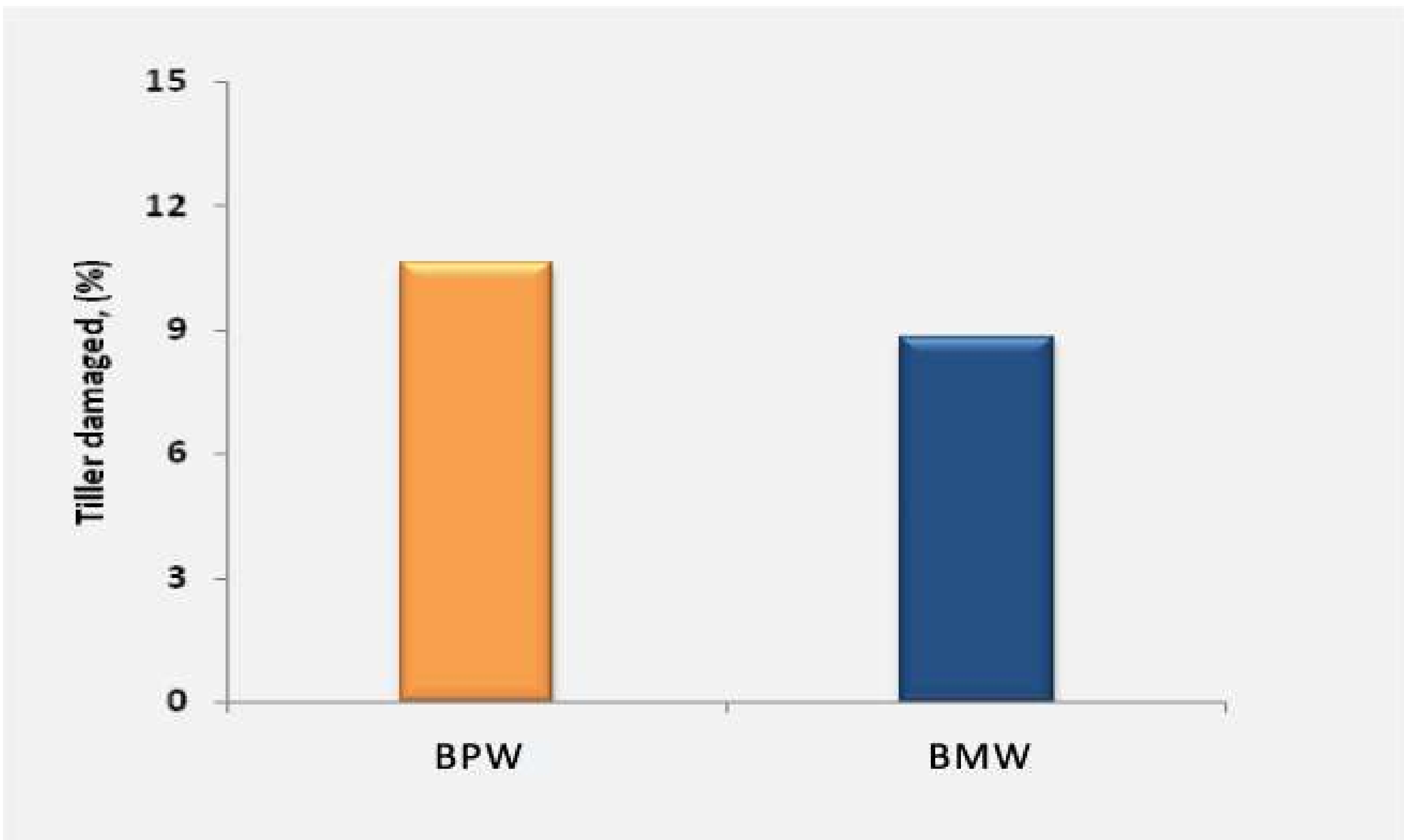


Fig. 4.7 Tiller damaged during weeding operation

4.9 Plant height

The effects of management practices at different days after transplanting gave significant effect on plant height. Plant height observed similar in both practices (Fig. 4.8). Plant height increased progressively overtime. Plant height followed rapid growth from 20 DAT to 60 in both practices.

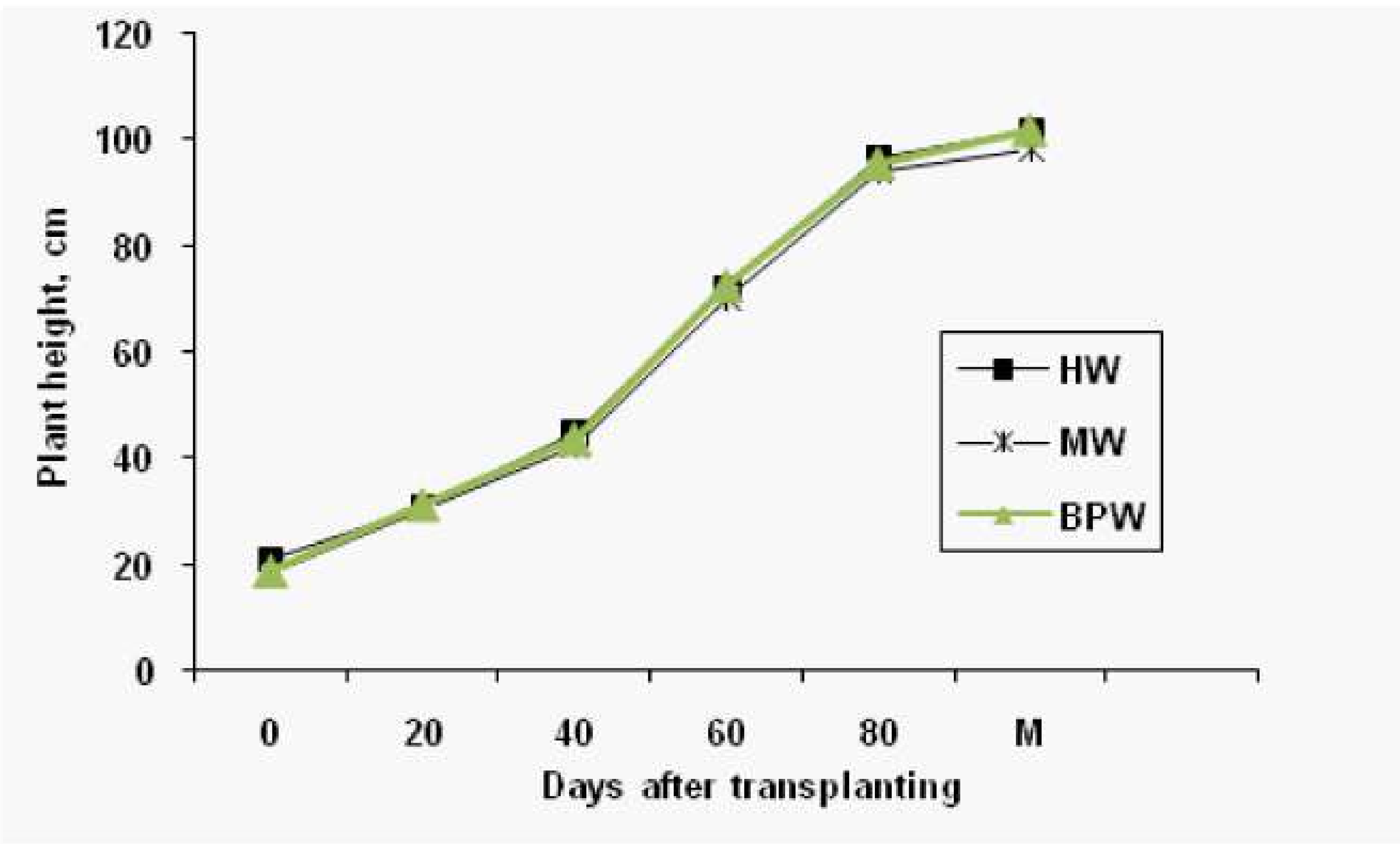


Fig. 4.8 Plant height in the experimental plot

4.10 Tillering pattern

The effect of management practices on tillering pattern in *boro* season rice is shown in Fig. 4.9. Tillering pattern behaved similar throughout the production period. Irrespective of the management practices, tillering pattern followed increasing trend. In both practices, the tiller production sharply increased from 20 DAT.

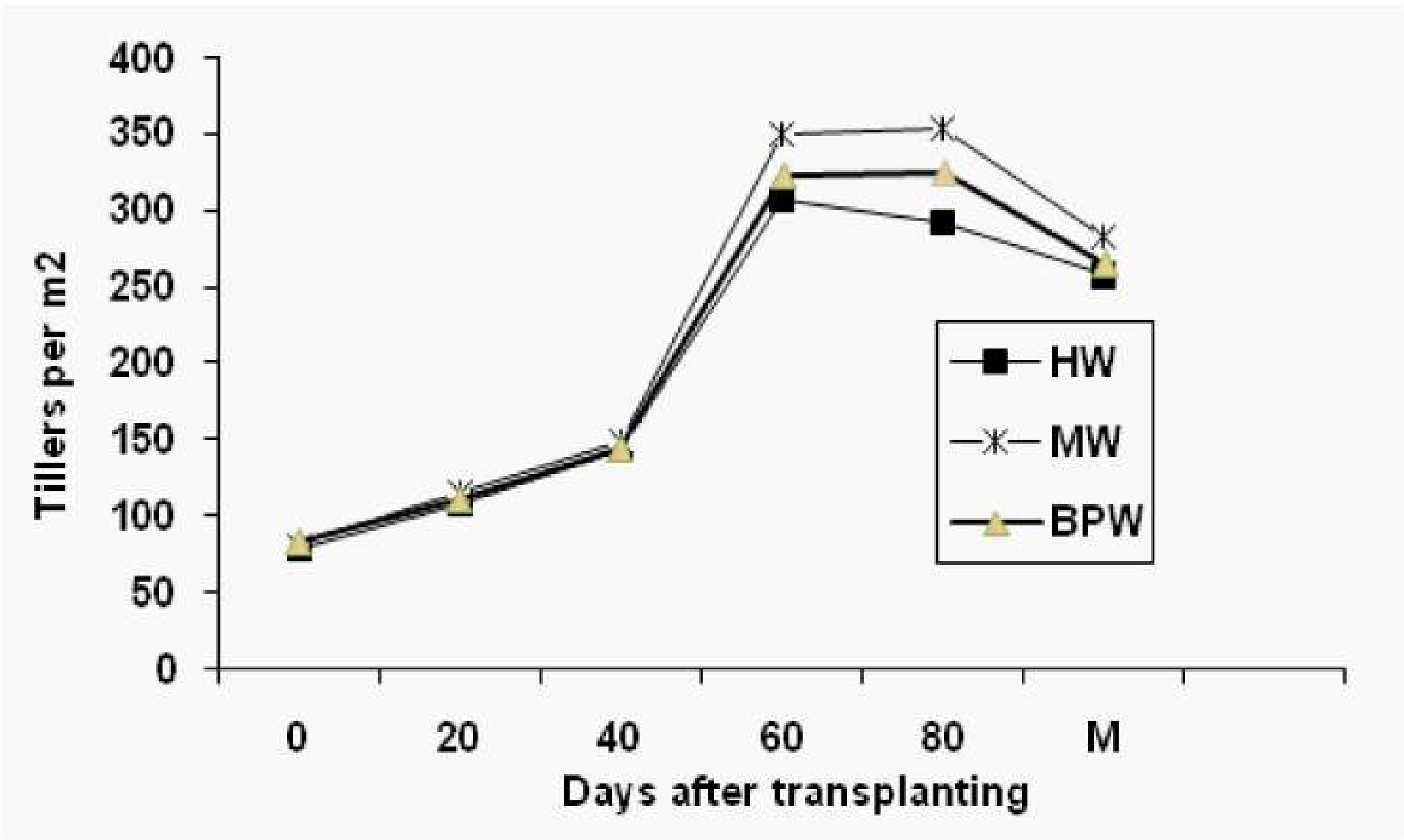


Fig. 4.9 Plant population in the experimental plot

4.11 Stage-wise plant population

Fig. 4.10 showed the stage-wise tiller production under different management practices. Mechanical weeder produced higher tillers at active and maximum tillering stage.

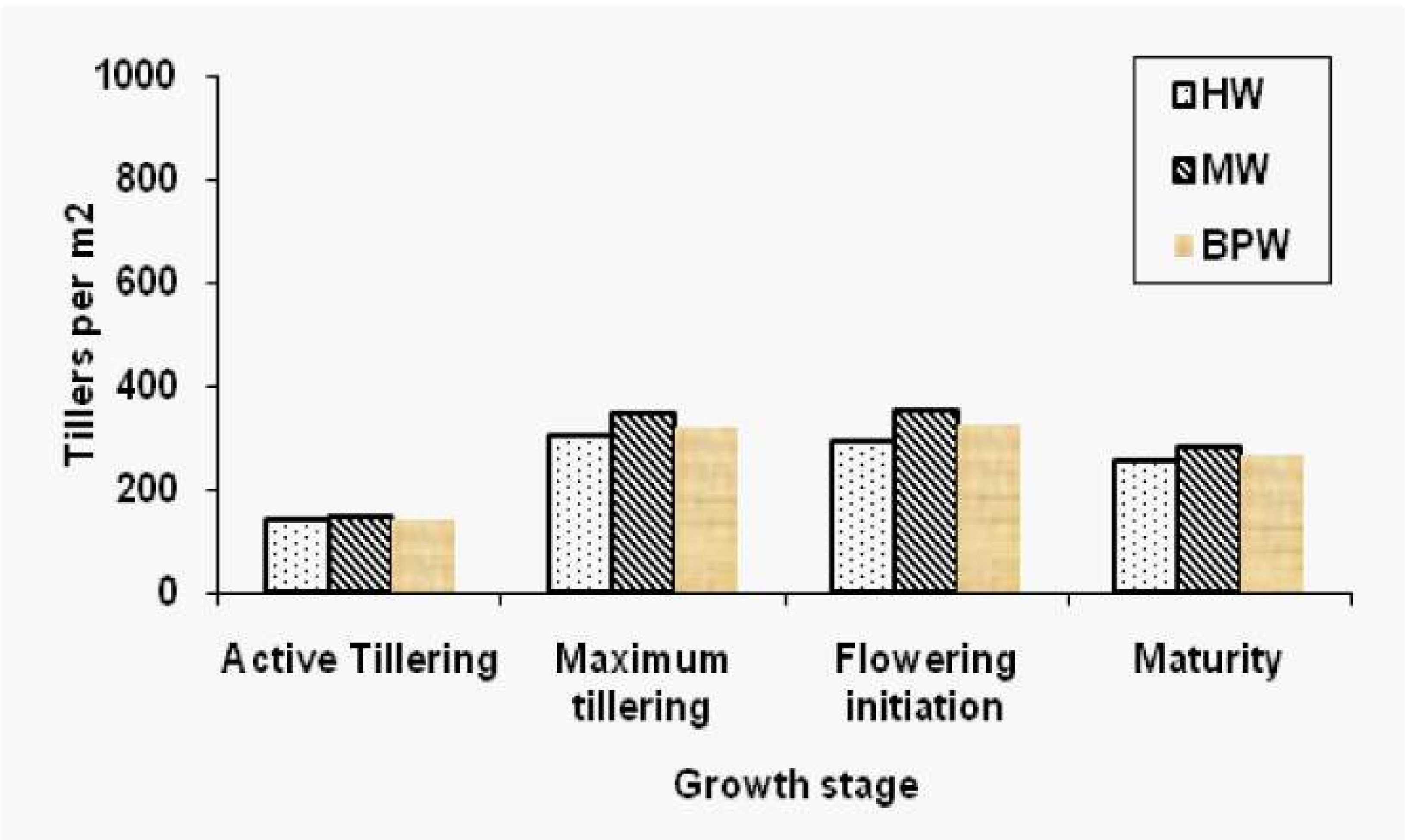


Fig. 4.10 Stage-wise plant population in the experimental plot

4.12 Yield and yield contributing character

Data on yield and yield contributing character were statistically and presented in Table 4.2. The weed control methods showed insignificant effect on yield and yield contributing character except panicle length.

Table 4.2 Yield and yield contribution character

Treatment	Grain yield, t/ha	Panicle, no./m²	Panicle length, cm	Grain, no./m²	Sterility, %	1000-grain mass
HW	5.29	233	21.70	21652	31.72	20.51
BMW	5.33	264	22.28	27147	26.35	21.04
BPW	5.71	240	23.72	25942	24.28	19.28
CV, %	6.39	18.76	3.40	20.10	31.35	7.41
$LSD_{0.05}$	NS	NS	1.12	NS	NS	NS

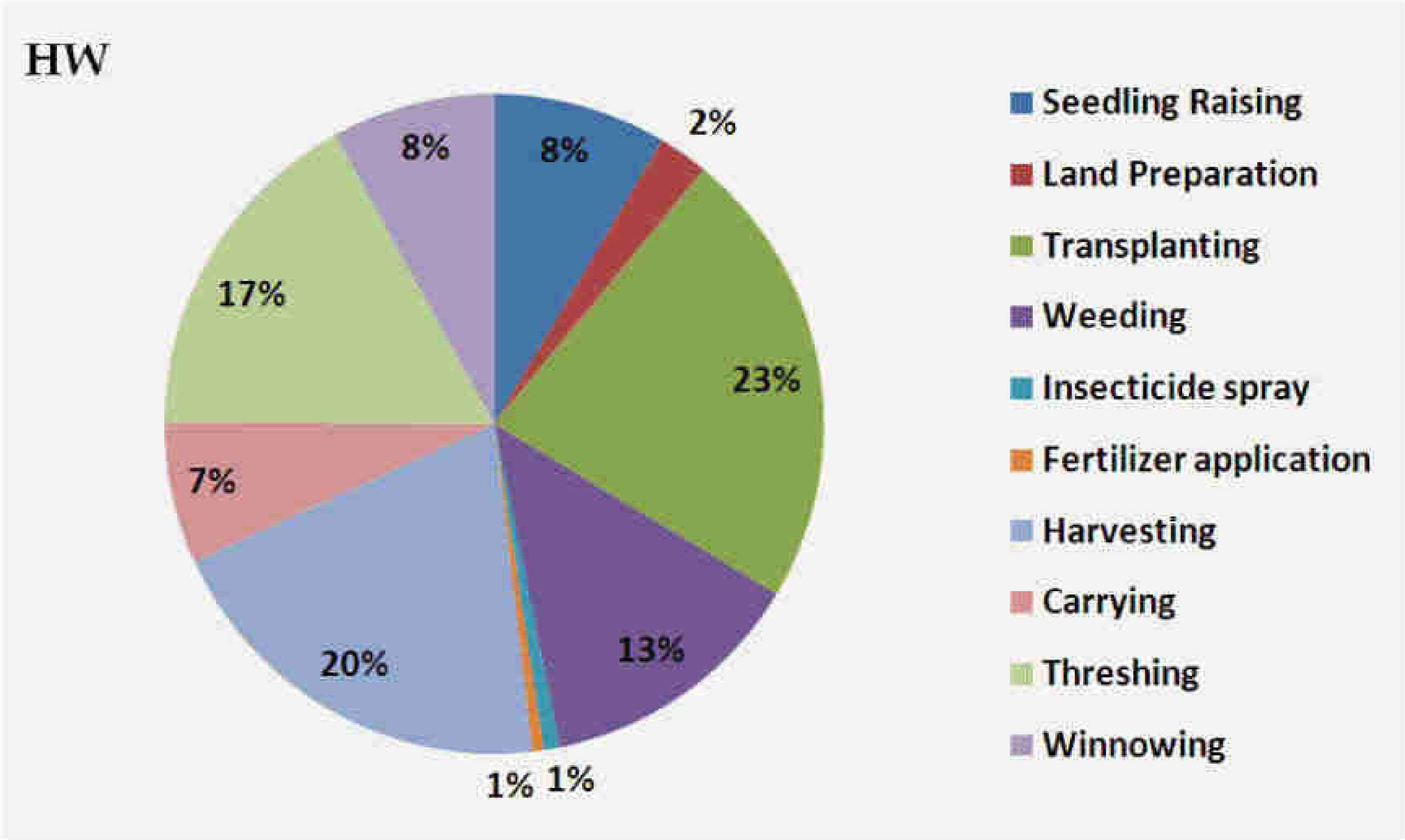
4.13 Labor requirement in crop production

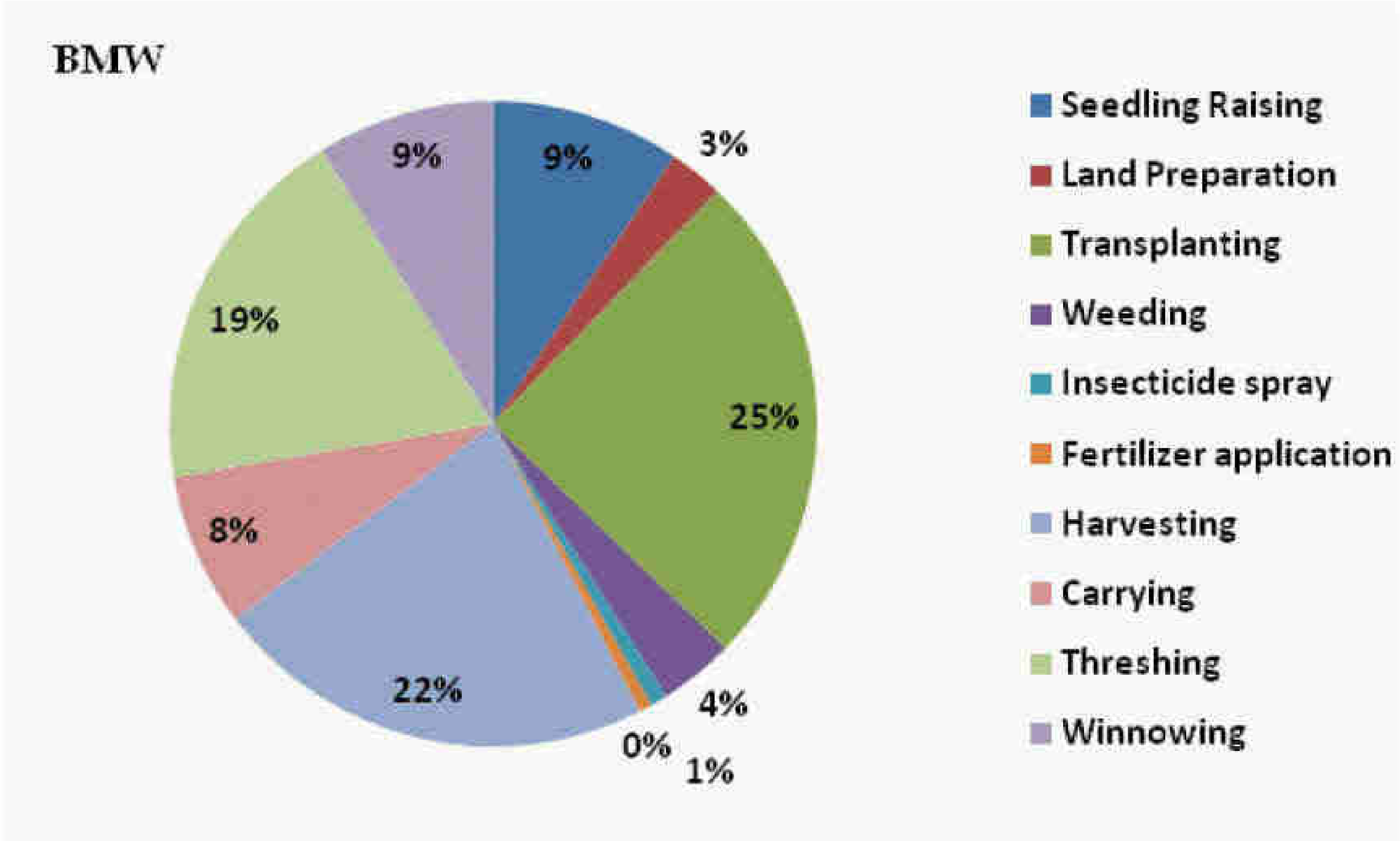
The overall labor requirement in rice production under different weed control method are shown in the Table 4.3. The BPW obtained is lower labor than that in HW. The lowest labor requirement obtained in BPW and highest in HW.

The labor distribution for different treatment is presented in Fig. 4.11. Use of BMW or BPW reduced labor requirement for weeding from 13% of total labor requirement in hand weeding to 4% and 2% for mechanical and power weeding. The total labor requirement showed highest in transplanting operation as 23-25% followed by 20-22% for harvesting, 17-19% for threshing and 4-13% in weeding.

Table 4.3 Labor requirement (man-hr/ha) of different weeding application method

Activity	Treatment		
	HW	BMW	BPW
Seedbed preparation	2.04	2.04	2.04
Seeding	0.32	0.32	0.32
Irrigation	23.97	23.97	23.97
Seedling uprooting	29.02	29.02	29.02
Subtotal	**55.35**	**55.35**	**55.35**
Land preparation			
Tillage	10.3	10.3	10.3
Leveling	5.8	5.8	5.8
Transplanting	147.1	147.1	147.1
Weeding	85.74	22.06	12.43
Insecticide spray	5.1	5.1	5.1
Fertilizer application	3.7	3.7	3.7
Harvesting	130.0	130.0	130.0
Carrying	45.0	45.0	45.0
Threshing	110.0	110.0	110.0
Winnowing	52.0	52.0	52.0
Total, man-hr/ha	**650.03**	**586.35**	**576.86**





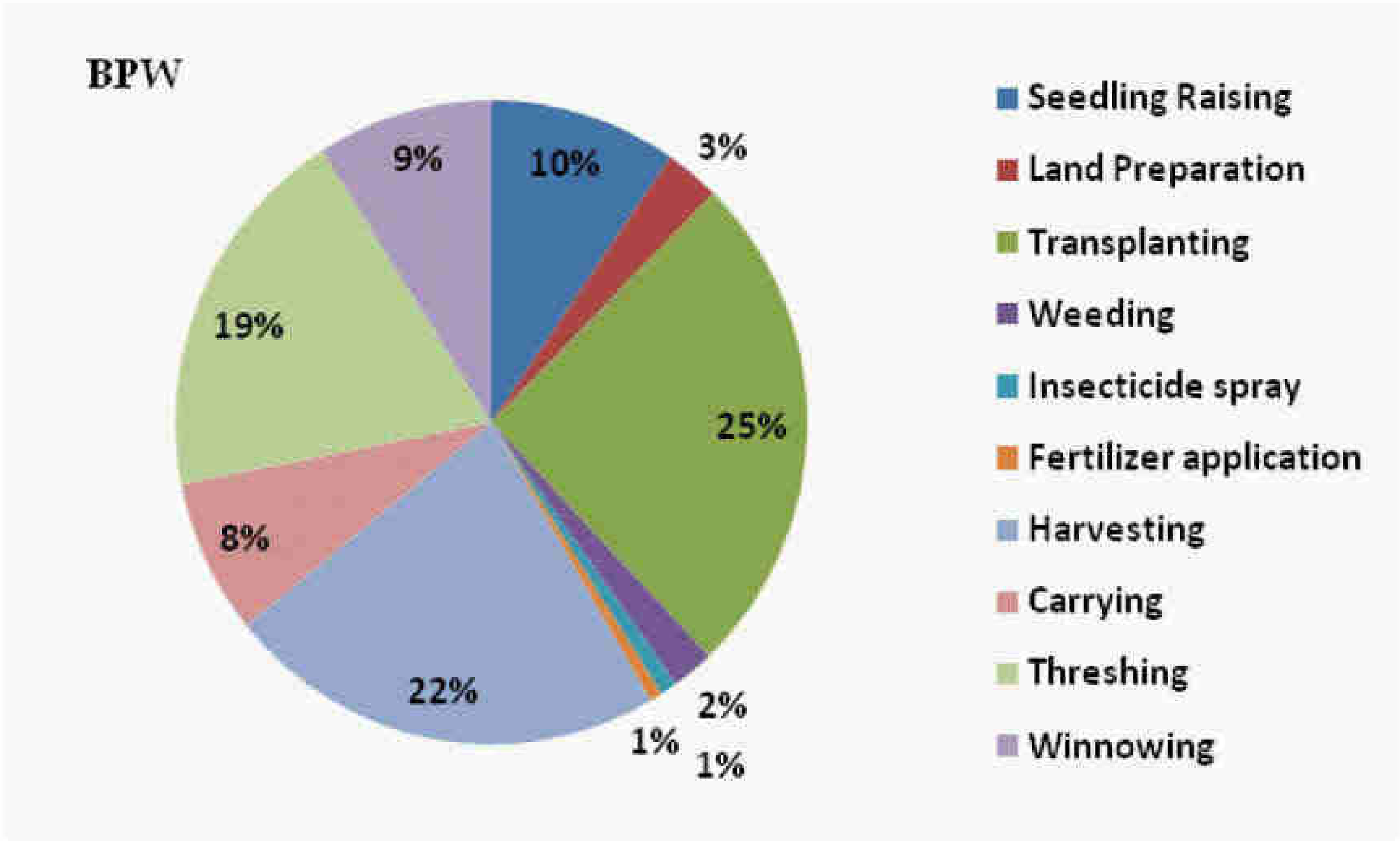


Fig. 4.11: Percent labor distribution of different weed control method in rice production

4.14 Economic analysis

4.14.1 Production cost

Table 4.4 shows that the item wise costs of crop establishment and total production costs. Land preparation, irrigation, transplanting, fertilizer application, harvesting, carrying, threshing and winnowing costs were nearly same for both the weed management method. Price of the inputs and outputs were collected from local market. Weeding costs varied depending upon the weed management method. Weeding cost of HW, BMW and BPW obtained Taka 4287, 1103 and 3143 per hectare. HW showed 36% higher cost compared to BPW. The highest production obtained in HW followed by BMW and BPW.

Table 4.4 Cost of production under different weed control method

Activity	HW, Tk/ha	BMW, Tk/ha	BPW, Tk/ha
Seedling raising	4056	4056	4056
Land preparation	7992	7992	7992
Transplanting	7355	7355	7355
Machine and fuel Charge	-	4	2193
Basal fertilizer	11380	11380	11380
Fertilizer application	183	183	183
Insecticide &Insecticide application	3374	3374	3374
Weeding	4287	1103	950
Irrigation	10500	10500	10500
Harvesting	6502	6502	6502
Carrying	2249	2249	2249
Threshing	5334	5334	5334
Winnowing	2600	2600	2600
Sub total	**65812**	**62632**	**64668**
Land rental charge	20000	20000	20000
Interest	2149	2058	2121
Total production cost	**87961**	**84690**	**86789**

4.14.2 Labor and material cost

Table 4.5 presents the overall input cost for different treatment in the study areas. As it is observed, labor costs have insignificant difference for different treatment whereas, the material cost showed higher in BPW compared to HB due to fuel cost. Input cost is also presented in the bar graph.

Table 4.5 Labor and material cost of different weed control methods

Parameter	HW	BMW	BPW
Labor cost	32336	29152	28999
Tk/ha	(49.13%)	(46.55%)	(44.84%)
Material cost	33476	33480	35669
Tk/ha	(50.87%)	(53.45%)	(55.16%)
Total cost, Tk/ha	**65812**	**62632**	**64668**

*Figure in the parentheses indicate the percentage

4.14.3 Effect of weed control methods on total cost, gross return and net return

Total production cost including all the costs are shown in Fig. 4.14. The gross return was calculated based on the existing market price of paddy and straw. The gross returns obtained Taka 97,866, 98,420 and 1,05,636 per hectare for HW, BMW and BPW, respectively. It was clear that production cost per hectare showed the highest in HB. The net returns obtained Taka 9,905, 13,734 and 18,847 per hectare for HB, BMW and BPW, respectively.

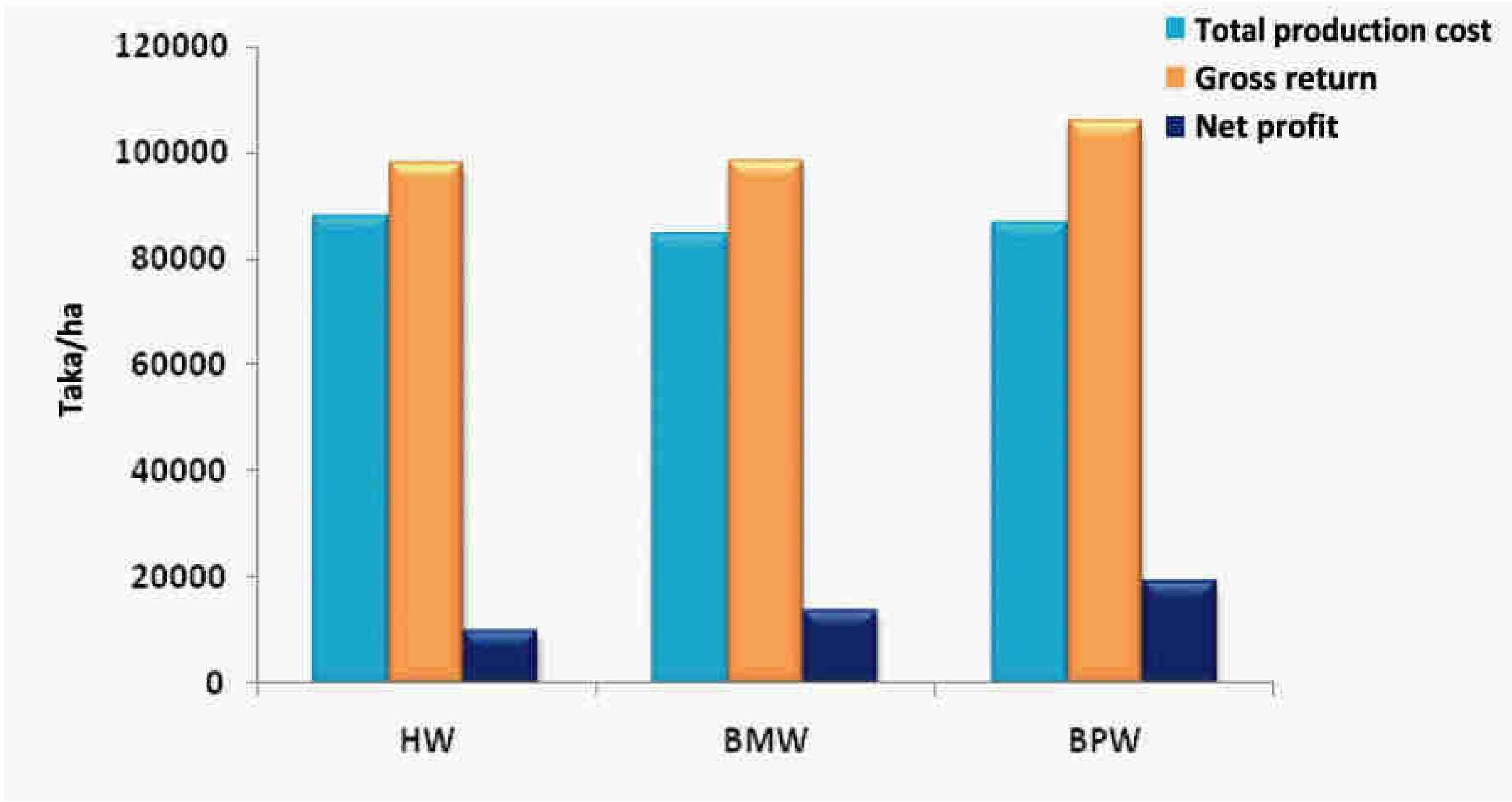


Fig. 4.14 Effect of weed control methods on total production cost, gross return and net profit

4.14.4 Effect of weed control methods on benefit cost ratio (BCR)

The BCR for different weeding application methods are shown in the Fig. 4.16. The BCR obtained highest in BPW (1.22) followed BMW (1.16) and HW (1.11). BCR obtained higher in BPW due to higher grain yield.

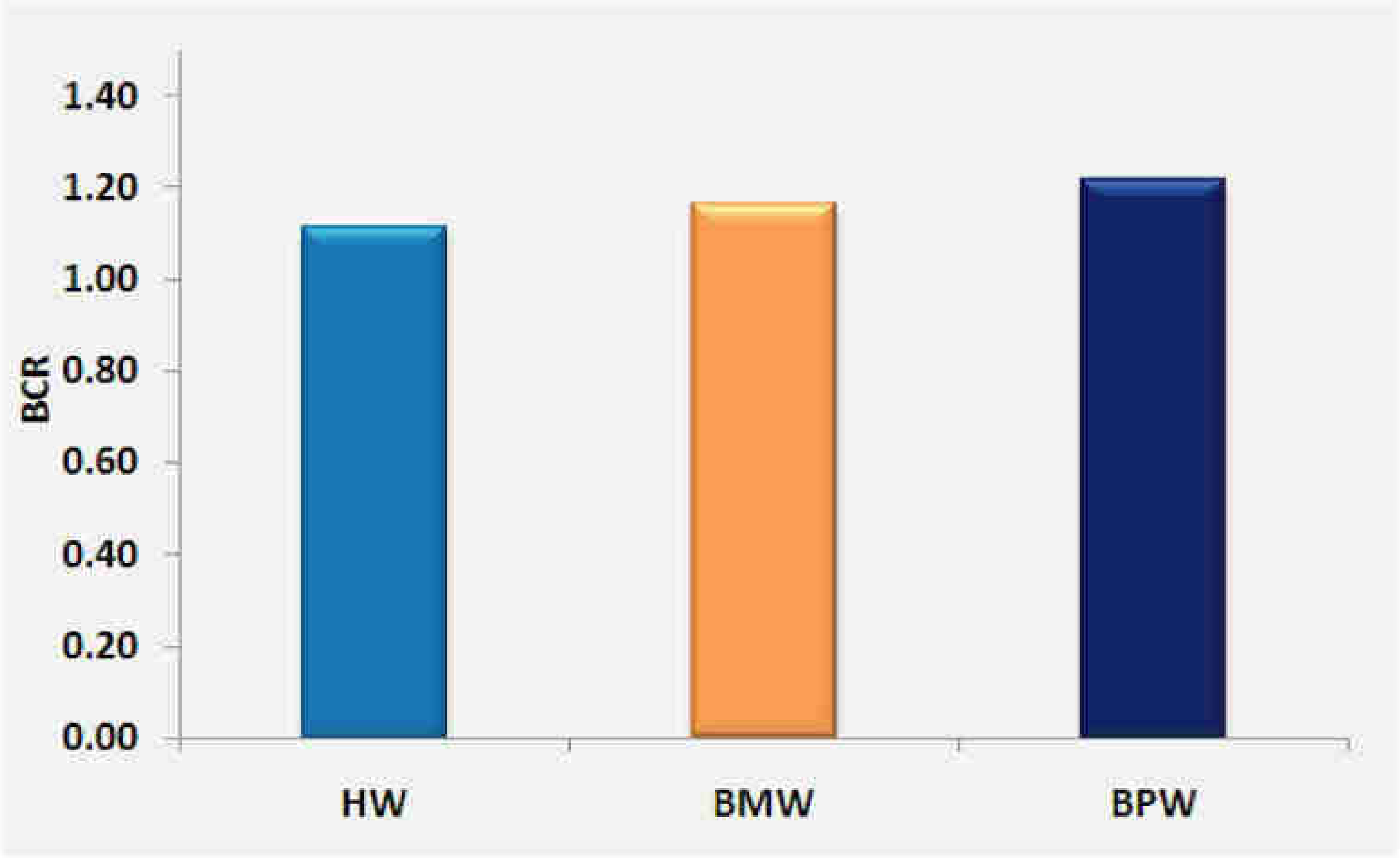


Fig. 4.16 Effect of weed control methods on benefit cost ratio (BCR)

Conclusion

BMW and BPW reduce production cost, faster in weed control and improve labor efficiency without sacrificing grain yield. BMW and BPW appeared as environmentally safe weed control technology than chemical control in low land rice cultivation.

Recommendation

- Research should be undertaken to modify the power weeder
- The use of power weeders should be compared with the use of herbicides.
- This experiment should be continued in different agro-ecological zone in different season to validate the data.

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Appendices

Appendix 1 Field trial of hand weeding, BRRI mechanical &power weeder

Plot No.	Name of the farmer	Treatment	Date of seeding	Date of transplanting	Date of machine operation	Crop duration (Seeding to harvesting), days	Field duration (Transplanting harvesting),days
01	Habib	HW	05/12/14	17/01/15	16/02/15	170	128
02	Taher Ali	BMW	05/12/15	17/01/15	15/02/15	172	130
03	Hafizur	BPW	05/12/15	17/01/15	15/02/15	171	129
04	Dilip	HW	05/12/14	17/01/15	15/02/15	170	128
05	Krisno	BMW	05/12/14	17/01/15	15/02/15	172	130
06	Hudanur	BPW	05/12/14	17/01/15	15/02/15	171	129
07	Hudanur	HW	14/12/14	18/01/15	16/02/15	161	127
08	Hudanur	BMW	14/12/15	18/01/15	15/02/15	163	129
09	Hudanur	BPW	14/12/14	18/01/15	15/02/15	162	128
10	Hudanur	HW	14/12/14	18/01/15	16/02/15	161	127
11	Hudanur	BMW	14/12/14	18/01/15	15/02/15	163	129
12	Modhusudhan	BPW	14/12/14	18/01/15	15/02/15	162	128
13	Hafizur	HW	05/12/14	17/01/15	16/02/15	170	127
14	Modhusudhan	BMW	05/12/14	17/01/15	15/02/15	172	129
15	Hudanur	BPW	05/12/14	17/01/15	15/02/15	171	128

Appendix 2 Weed control efficiency of three methods

Treatment	Weed population				
	Weeds before weeding, no./m^2	Weeds after weeding, no./m^2	Weeding efficiency,%	Weeds after 3 days of Weeding, no./m^2	Weeds after 10 days of weeding, no./m^2
HW	308	-		149	165
BMW	**334**	**75**	**76**	**122**	**109**
BPW	**217**	**75**	**78**	**98**	**107**

Appendix 3 Effect of weeding on dry weight of weed

Treatment	Weed dry weight (g)			
	Weeds biomass before weeding, gm/m^2	Weeds biomass after weeding, gm/m^2	Weeds biomass after 3 days of weeding, gm/m^2	Weeds biomass after 10 days of weeding, gm/m^2
HB	8.19	-	8.47	12.90
BMW	11.89	2.67	7.83	10.84
BPW	6.58	3.05	7.93	12.90

Appendix 4 Effect on weeding operation methods on gross return, net return and benefit cost ratio (BCR)

Treatment	Input cost, Tk/ha	Return from grain, Tk/ha	Return from straw, Tk/ha	Gross return, Tk/ha	Net return, Tk/ha	Benefit Cost Ratio (BCR)
	A	B	C	D=B+C	E	F
HW	88961	85963	11895	97866	9905	1.11
BMW	84686	86450	11970	98420	13734	1.16
BPW	86789	92788	12840	105636	18847	1.22