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Layered pelleting of seed with nutrient enriched soil enhances seed germination in Dinanath grass (*Pennisetum pedicellatum*)

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Abstract

In the present experiment, a resource poor farmer's recipe with modified process was standardized for grass seed (Dinanath) pelleting that improved the seed germination and vigour with the use of an indigenous, tyre based automatic machine for efficient and quick seed pelleting at farm level. Small beads of pelleting material were prepared initially by controlling the rotation of the tyre and then true seeds of grass were dusted on the beads in the rotating tyre. Soil was proved to be the best pelleting material both economically and technically. A number of seeds ranging from 8-10 per pellet accumulate enough force to come out of the pellet. Soil seed pellets when enriched with combination of nutrient mixture [nitrogen through urea (1%), phosphorous through single super phosphate (10%), potassium through muriate of potash (2%) and other micronutrients in minute concentration], cold solution of KNO_3 (0.2%) and Bavistin as fungicide, resulted in enhanced seed germination, boosted growth and reduced mortality of grass seedling.

Keywords: Germination, Grass seed, Grassland, Nutrient mixture, Pelleting machine, Seed ball

Introduction

Grasses are unanimously blamed for their poor seed germination. Poor ovule-to-seed ratio, nonsynchronous maturity, continuous seed shattering, presence of varied degree of enigmatic dormancy complicates the phenomena by manifold. In natural vegetation, the reality of ovule to seed ratio leading to low germination of grass seeds remains unnoticed due to presence of enormous quantity of seed at a particular place. But, while dealing with commercial sowing in field condition and sowing in inaccessible areas, grass seeds, due to uncertainty in presence of viable seed in the spikelet which is a result of continuous seed shattering and light weight of the seed, pose potential difficulties to raise a good pasture (Parihar, 2010). Dinanath (*Pennisetum pedicellatum* Trin.), an herbaceous annual with luxurious growth, is not an exception of the stated limitations. Total spikelet yield of Dinanath ranges from 665 to 848 kg/ha with 17.5 to 12.0% of PGS (pure germinating seeds). It has regrowth potential if cut during proper vegetative stage (Ramamurthy and Shankar, 1996) and its yield level varies with location and year (Singh and Hazra, 1987). But hull-imposed dormancy is evident in this grass, and removal of husks facilitates germination (Parihar and Shankar, 1997). Other than inherent bottlenecks, Dinanath, like other grasses, is invariably grown in rangeland conditions where every sort of stress is obvious and they often struggle for sufficient vigour to withstand initial stresses. Many times, the tiny seeds of grasses like Dinanath lack sufficient force to emerge out of compact soil in rangelands. Besides it, surface sowing of grasses into existing pasture has always resulted in comparatively lower rates of establishment, may be only 0.5 -3.9% survival in case of ryegrass and cocksfoot (Cullen, 1966) and 0-5% in Dinanath. Pelleting of grasses like Dinanath with soil or clay or earth improved their establishment compared to surface sowing on arid rangelands by manifold (Hull *et al*., 1963; Vartha and Clifford, 1973).

For pelleting of tiny grass seed like Dinanath, efforts were materialized long back in 1940s and '50s when earthen pellets were reported to be very good for desirable sowing of grass seed (Wagner and Kinkor, 1950). Currently, it is proved that other than different types of soil, finely powdered chalk/ charcoal/ feldspar and other materials glued with plastic adhesive may be used for seed pelleting. Booster dose of fertilizers, growth stimulants, fungicides, insecticides etc. can be provided through pellets for better seed performance at field condition (Konstantinov, 1983). The seeds pelleted with soil and other additives showed improved germination, attributed to availability of nutrients in the clay powder (Tisdale and Platt, 1951) and produced more healthy seedlings as compared to unpelleted seeds (Govinden-Soulange and Levantard, 2008). As per need, the size and shape of pellet, number of seeds can be adjusted in a single pellet keeping the germinability and performance at satisfactory level.

In the pelleting of range grass seeds for aerial seeding and/or distant broadcasting through pellet gun or hand in semi-arid regions, it is essential that the pellet doesn't disintegrate so as to expose the bare seed, which will eventually lead to death of seed for want of moisture before germination. The technique of mixing the soil and seeds before rotating in the pelleting machine leads to movement of seeds to the centre of the pellet resulting in reduced germination due to thick layer around seeds which acts as a mechanical barrier for radicle protrusion (Durant and Loads, 1986). It was, therefore, essential to make a pellet which contains seed on the outer layers and can absorb sufficient moisture to germination.

Materials and Methods

***Seed material*:** The six-month-old husked or fluffed seeds of annual Dinanath grass (*Pennisetum pedicellatum*) were obtained from division of seed technology, Indian Grassland and Fodder Research Institute, Jhansi, India. The seeds were dehusked (defluffed) through indigenous cotton batting machine and caryopsis (naked seeds) were collected and used for pelleting.

***Fabrication of pelleting machine and materials*:** An indigenous pelleting machine was fabricated with locally available materials. A tractor tyre (size: 12.5 inch outer width and 28 inch inner diameter) was mounted with a rotating shaft which was attached with motor, belt and pulley arrangement to provide automation to eliminate the need of manpower. It is consisted of three-quadrilateral steel frame, one triangular frame, two ball bearing, one motor with speed controller, one belt, two pulleys and 90 cm crank handle made of steel. The prototype of the machine has the overall dimension of 150 cm of total bottom width, 95 cm of total top width and 175 cm of total height. The inner surface of tyre was painted to make it smooth that can deliver round shaped seed balls.

Initially five types of locally available pelleting materials *viz*. soil, saw dust, wheat bran, charcoal, farm yard manure (FYM) and limestone were tried to make seed balls. Regarding soil as a pelleting material, in first method (M1) soil and dehusked seeds were mixed thoroughly with addition of water until a dough texture is achieved as an age-old traditional method. Then the mixture was rotated in rotating tyre until round shaped balls/pellets are formed. In second method (M2), specific quantity of pelleting material was put in the rotating tyre and water was sprayed onto the dry mix until it begins to nucleate and form small beads. When the beads became one centimeter of diameter, desired quantity of seed was dusted slowly over the rotating beads. When the seeds adhered to the bead's surface, again water was sprayed followed by dusting with pelleting material to cover the seeds with another pelleting layer. In case of saw dust and wheat bran diluted solution of gum arabica was used as binding material. For further experiment the soil was selected as pelleting material based on the pellet size (cm), pellet weight (g), number of seeds per pellet, water requirement for pellet dissolving (ml) and dissolving time (min.) in 10 ml water (mean value of 20 random pellets) etc.

***Nutrient solution, chemical growth stimulant and fungicide*:** In a continuous trial and error method, a nutrient mixture [nitrogen through urea (1%), phosphorous through single super phosphate (10%), potassium through muriate of potash (2%) and other micronutrients in minute concentration] was standardised. Seeds were soaked in cold solution of KNO_3 (0.2%) as a pre-treatment before germination to boost germination and vigour of seeds by repeated experiments. Data for standardisation of nutrient mixture and KNO_3 (0.2%) have not been presented here. In present experiment, the water spread during pelleting in tyre was replaced with cold solution of KNO_3 (0.2%) which favours seed germination in many species (Nagar and Meena, 2015). The popular fungicide Bavistin (10 g/kg of pellet) was used to protect the seeds from seed borne and pellet borne biotic stress elements.

***Germination test of seed and seed pellets*:** Seeds with husk and without husk were kept for standard germination test (ISTA, 2012) in which four replications of hundred seed were kept in petridishes at 20°C, whereas for germination of seed pellets, twenty pellets were kept on moistened blotter paper in petridishes with two replications. Daily observation was taken on germination and after final count, germination percentage, shoot length, root length and seedling dry weight were measured.

Results and Discussion

***Standardisation of pelleting materials and process*:** The indigenous and motorized tyre-based machine used in the present study, eliminated the labour required to prepare the seed pellets / balls manually, thus served the purpose very effectively and economically. Seed pellets using different base materials were prepared automatically by putting the materials at desired sequence in the rotating tyre. The rotation speed and duration varied with the type of pelleting materials. Pellets were prepared from soil by rotating the tyre at 20 RPM (rotation per minute) for 250 to 300 seconds, whereas in case of wheat bran it took 350 to 450 seconds at 25 RPM (Table 1) which was highest when compared to other materials. Limestone consumed least time (200-250 seconds) at lowest RPM (20) to develop pellets. Most of the seed pelleting or seed ball programme on pasture grasses focuses on manual preparation of balls, which is certainly a long and labour intensive process. Hence, mechanization of seed pelleting is economically crucial for using grass seed pellets in habitat restoration (Lucas, 2011).

The seed pellets made of soil had maximum diameter (1.73 cm) whereas that of FYM had minimum (1.34 cm) (Fig. 1). Pellet weight was highest in case of soil (M1- 4.1 g; M2- 4.0 g) followed by limestone (3.4 g) and charcoal (3.1 g) and it was lowest for saw dust (1.5 g). Number of seeds per pellet was more or less equal for all cases (7.5 -9.3) except limestone where it was drastically high (18.8). Madsen *et al.* (2012) stated when more seeds are put in single seed ball there is higher chance of grass establishment. Greater seedling emergence in the clay soil is probably the result of having multiple seedlings collectively in the conducive microclimate of pellet. The collective force can supply sufficient potency to the emerging seedlings for penetrating through the soil crust (Edwards, 1966; Awadhwal and Thierstein, 1985).

Water required to dissolve the pellets was maximum for limestone (16 ml) closely followed by charcoal (14 ml), whereas it was found minimum for saw dust (8 ml) and soil (12 ml) (Table 1). Dissolving time of the seed pellets was highest for charcoal (15 min.) followed by soil (14 min.) whereas limestone took minimum time (6 min.) to dissolve the pellet.The water holding capacity, integrity of the materials and other properties of the pellets are also very important for pasture development or reseeding. In dry areas, the shape and microclimate of the pellets or balls actually give enough shade to conserve moisture. The seeds begin to germinate and the ball breaks apart, the small pile of crumbles provides the bed for the root system. Finely ground clay powder, the material used in the present experiment, or diatomaceous earth, by its physical property, favours high rate of water absorption and retention of sufficient moisture around the seed, thus makes the microclimate around seed highly encouraging for seedling emergence and consequent establishment in the field (Li *et al.*, 2000; Shawabkeh and Tutunji, 2003). Presuming this water was thermodynamically available to the seed, increased moisture availability around the seed would enhance seed imbibition, germination and early seedling growth, in a water-limited environment that the seed experiences in stressed field condition. Increased moisture provided by the pelleting also helps to maintain plant turgor pressure in protruding radicle and subsequently promote seedling emergence thrust through the soil. Soil may also support the seedling emergence and its survival by providing silicon source to the growing plantlet (Antonides, 1997).

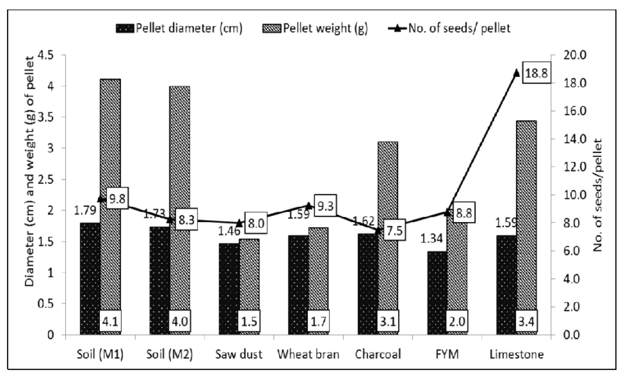

Fig. 1. Characteristics of seed pellets in terms of pellet diameter (cm), pellet weight (g) and number of seeds per pellet

Table 1. Details of the pelleting materials and preparation of pellets

Pelleting materials	Recipe* (pelleting material + 5 g true seed)	Water for pellet dissolving (ml)	Dissolving time in 10 ml water (minute)	RPM of tyre	Duration of rotation (seconds)
Soil (M1, M2)	1 kg	12	14	20	250-300
Saw dust	½ kg + Gum arabic	8	10	25	350-450
Wheat bran	½ kg + Gum arabic	9	11	25	350-450
Charcoal	1 kg	14	15	20	200-250
FYM	1 kg	8	10	20	200-300
Limestone	1 kg	16	6	20	200-250

*Water was sprinkled in alternation with powder on initial beads in the rotating tyre until the desired size and texture was achieved

Based on physical properties of pellets, limestone was likely to be the best pelleting material, but the germinability of seed pellets gave contrasting result which promoted to select soil as pelleting material. Limestone gave only 5.8 percent germination and killed all the seedlings after fifteen days of germination in the present experiment, although few reports supported limestone as a good pelleting material (Hastings and Drake, 1962; Lowther and Johnstone, 1979). The soil pellets prepared through traditional method (M1) showed reduced germination (45.7%) and higher mortality (41.0%). The compactness and hindrance imposed to seeds present in the centre of pellet reduced the germination and enhanced mortality percentage of seeds and seedlings. The second method of layered pelleting (M2), where the seeds were placed towards the outer-surface with just one thin layer of pelleting material resulted in higher germination (91.7%) and reduced seedling mortality (31%) (Fig.2). Thus, this new method of pelleting rectified the problem of non-germination or reduced germination from compact seed pellet. Findings of Yadav *et al.* (2000) supported the present result, where they have reported that seeds pelleted with soil gave significantly higher germination. In our study, the germination of grass seeds pelleted with saw dust and wheat bran was hindered substantially. It may be attributed to the influence of gluing materials which can greatly affect the hygroscopic properties of the seed and thereafter seed performance (Eric, 1979). Pelleting with farmyard manure (FYM) produced satisfactory germination (80%), after soil, and was higher than other materials except charcoal (82.9%). In same line, Abusuwar and Eldin (2013) reported that pelleting with FYM performed well in terms of plant density, numbers of leaves and productivity.

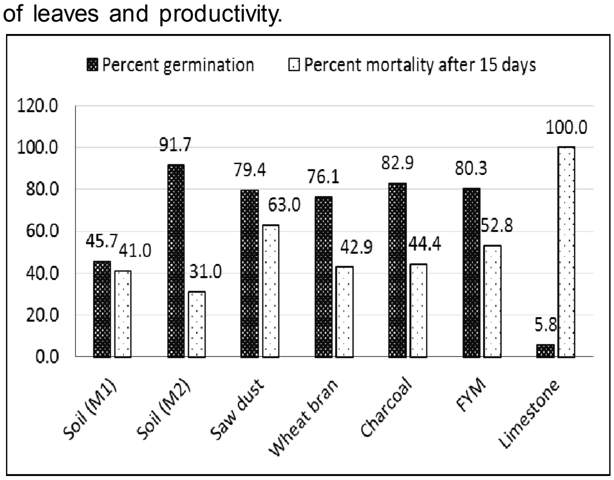

Fig. 2. Performance of seed pellets in terms of percent germination and percent mortality of seedlings after fifteen days

In a country like India, soil of pelleting grade is still available freely in most of the places. But all other materials involved in pelleting hold a minimum cost. Thus soil has an additional benefit to justify its superiority over other pelleting materials. Therefore soil pellets came out as the best among all the pelleting materials. In the present study, cold solution of KNO_3 (0.2%) was sprayed during pelleting, which enhanced seed performance in Dinanath. Darrag and Kareem (1994) observed that seeds pelleted with clay: silt (3:1) along with organic manure and 1% of KNO_3 improved germination rate of grass seeds and it was also substantiated by Kumar (2003) in yellow anjan grass (*Cenchrus setigerus*).

Seed germination and vigour: The performance of the soil pellets without any additives was poor with respect to germination (90%), shoot length (4.2 cm), root length (1.94 cm) and seedling dry-weight (2.33 mg) (Fig. 3). When the soil was fortified with KNO_3, nutrient mix and fungicide the performance of the pellets was increased and best result was achieved when all the said additives were given at right proportion. The soil pellets with KNO_3 nutrient mix (0.2%), [nitrogen through urea (1%), phosphorous through single super phosphate (10%), potassium through muriate of potash (2%) and other micronutrients in minute concentration] and fungicide Bavistin (10 g/kg of pellet) provided maximum germination (94%), shoot length (5.18 cm), root length (4.68 cm) and seedling dry-weight (3.79 mg). Similar trend of result was reported in many studies but with traditional pelleting method (Hull and Stewart, 1948), where degree of improvement in grass seed performance was lesser as compared to the present study. In the present study, the grass seed pellets in presence of the said additives come out as satisfactory combination for Dinanath grass, when pelleted by proposed method (M2). Pelleting of seeds with additives like nutrients, for example, used along with pelleting material raised the yield of many crops through accelerated growth and development (Konstantinov, 1983; Tisdale and Platt, 1951; Hull and Stewart, 1948). Studies reported that seed coated with nutrient and other additives penetrate bermuda and other stubbles for improved seed-soil contact for better and quicker germination and growth (Burns *et al.*, 2002). In 1986, CelPril in New Zealand launched a popular fertilizer mixture named Nutri-Kote, containing N, P, K, S, Zn, and Fe, which became famous seed coating material for pasture and range grass seed. The nutrient mixture under study contains all the essential nutrients including those of the Nutri-Kote and performed satisfactorily.

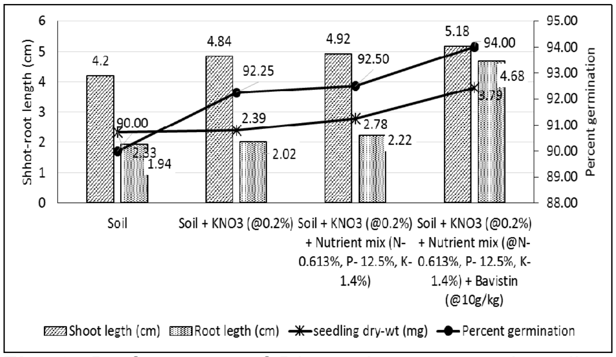

Fig. 3. Performance of Dinanath grass seeds pellets made of different combinations of additives and soil

The study also confirmed that although no binder was used with soil, the only binding agent being water, clay powder could be used for pelleting of grass seed because of the inherent adherence nature of this material onto the seed coat. As reported in earlier studies, the main disadvantage in the use of clay was the development of fungal mould on seed that has been addressed by treatment with fungicide (Bavistin) in the proposed method (M2). The use of fungicides as components of seed pelleting materials has also been recommended by Huijbregts *et al.* (1995). In recent times seed companies are coating/ pelleting the seed increasingly with finely ground clay/ limestone along with germination enhancers to improve seedling establishment. Research has shown that even though seed pelleting reduce the actual number of seed per unit by half in case of small seeds, they improve seedling survival enough so that pelleted seed can be planted at the reduced rate of unpelleted seed with no reduction in stand. The results of our experiment are difficult to compare to other studies (Yadav *et al.,* 2000). Since most studies do not quantify the success of seed germination or survival, but rather qualitatively describe the success of seed balls. For example, one study found that seed balls had better germination than broadcast seeding (which had no germination), but lacked quantifiable results (Bones, 1996). Another study found that seedlings from seed pellets/ balls were larger than seedlings from broadcast seeding (Caplan *et al.*, 1999).

Conclusion

The fabricated motorized pelleting machine is a low-cost input for pelleting grass seeds with soil and other additives. The layered pelleting technique developed is unique and resulted in high germination percentage of pelleted Dinanath grass seed. Hence, the grass seeds sown by making pellets with soil, nutrients, growth stimulant and fungicide results in better germination and vigour along with increased chance of their establishment under range conditions.

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